

Brief information about the project

Name of the project	AP09260116 «Development of agents based on mineral raw materials of Kazakhstan for the desalination of saline water»
Relevance	Clean drinking water is one of the most important human needs. According to the UN, more than 1.2 billion people already live in conditions of constant freshwater shortage, and about 2 billion suffer from it regularly. According to FAO forecasts, by the middle of the third decade of the 21st century, the number of people living with permanent water shortages will exceed 4 billion. According to the forecasts of the Ministry of Environment of the Republic of Kazakhstan, there will be a water shortage in Kazakhstan in 2040. Therefore, the development of new accessible methods for obtaining fresh water using mineral raw materials of Kazakhstan origin is an urgent task.
Purpose	The goal of the Project is to develop effective and affordable agents based on mineral raw materials for the desalination of saline water, as well as to study the optimal conditions for the production and use of these agents.
Objectives	To achieve the goal of the Project, it is necessary to solve the following tasks: <ol style="list-style-type: none"> 1) preparation of desalination agents based on mineral raw materials (zeolite, clay) through treatment with various chemical reagents (acids, bases, salts); 2) study of the efficiency of Na⁺, K⁺, Cl⁻ ions adsorption (the main components of saline water) by the obtained desalination agents in a static mode; 3) encapsulation of the obtained agents into polymer matrices for the possibility of their use in dynamic mode (in a water flow); 4) study of the efficiency of Na⁺, K⁺, Cl⁻ ions adsorption (the main components of saline water) by the obtained capsules for desalination in dynamic mode; 5) study of the possibility of regeneration of the obtained agents and capsules based on mineral raw materials; 6) study of the possibility of recycling spent agents as a source of microelements for plants.
Expected and achieved results	According to the calendar plan the following results were obtained during the Project implementation period: <ol style="list-style-type: none"> 1. Optimal conditions for the production of agents for desalination based on zeolite from the Shankanai deposit, clay from the Kyzylsok deposit, as well as the adsorption of Na⁺, K⁺, Cl⁻ ions from saline water have been developed: agent mass 0.1 g per 10 mL of solution, T = 298 K, pH = 7, reagent contact time is 24 hours (for zeolite-based agents), 3 hours (for clay-based agents). 2. Optimal conditions for obtaining encapsulated agents for desalination have been developed: effective capsule composition: zeolite treated with 1 M NH₄Cl solution and zeolite treated with 1 M HNO₃, as well as clay treated with 1 M HNO₃; polymer matrix composition – a mixture of sodium alginate (NaAlg) and polyvinyl alcohol (PVA) (component ratio: agent:NaAlg:PVA = 1.5:1:2). Optimal conditions for the adsorption of Na⁺, K⁺, Cl⁻ ions by encapsulated agents based on zeolite and clay from saline water in static and dynamic modes have been established.

	<p>3. Based on the analysis of the results of physical and chemical studies, the possibility of regeneration and utilization of the resulting agents for desalination of saline water has been established. It has been shown that spent agents in desalination processes can be used as effective potassium fertilizers to increase the yield of vegetable crops.</p> <p>4. Based on the obtained results 2 articles were published in editions included in the first quartile (Q1, percentile on the Scopus database is 92%) and in the second quartile (Q2, percentile on the Scopus database is 67%) of the Web of Science and Scopus databases; 1 article in a publication with a percentile in the Scopus database of 12%, 1 article in a domestic publication recommended by CQAES, as well as 12 publications in the proceedings of International conferences, including 1 article in the proceedings of a conference indexed in the Web of Science database (MATEC Web of Conferences). 16 works have been published during the Project implementation period of 2021–2023.</p>
<p>Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles</p>	<ol style="list-style-type: none"> 1. Seilkhanova G.A., d.ch.sc., professor, Project supervisor, https://scholar.google.ru/citations?hl=ru&pli=1&user=mEPpha0AAAAJ https://www.scopus.com/authid/detail.uri?authorId=56652160000 2. Rakhym A.B., Master's degree in specialty 6M060600 – Chemistry, PhD degree applicant, responsible executor of the Project, https://www.scopus.com/authid/detail.uri?authorId=57208575069 3. Ussipbekova Ye.Zh., PhD in specialty Chemical technology of inorganic substances (CTIS), acting associate Professor, https://www.scopus.com/authid/detail.uri?authorId=56010544200 4. Kenessova A.K., Master's degree in CTIS, PhD-student in specialty Chemical engineering, https://www.scopus.com/authid/detail.uri?authorId=57220024671 5. Kurmanbayeva T.S., Master's degree in specialty 7M05301-Chemistry, https://www.scopus.com/authid/detail.uri?authorId=57220036264 6. Baranchiyeva Z.Ye., Master's degree in specialty 7M05301-Chemistry, https://www.scopus.com/authid/detail.uri?authorId=58781604100 7. Zhaksybay B.B., Bachelor's degree in specialty 6B05301 – Chemistry, 1st year Master's student in specialty 7M05301 – Chemistry, https://www.scopus.com/authid/detail.uri?authorId=58601293600
<p>List of publications with links to them</p>	<p><u>16 works have been published during the Project implementation period of 2021–2023.</u></p> <p><i>Articles in editions included in the Web of Science and/or Scopus databases:</i></p> <ol style="list-style-type: none"> 1. Rakhym A.B., Seilkhanova G.A., Mastai Y. Physicochemical evaluation of the effect of natural zeolite modification with didodecyldimethylammonium bromide on the adsorption of Bisphenol-A and Propranolol Hydrochloride // Microporous and Mesoporous Materials. - 2021. - Vol. 318. - P. 111020 https://doi.org/10.1016/j.micromeso.2021.111020 (IF = 5.45, Q1, 92%). 2. Baranchiyeva Z., Seilkhanova G., Rakhym A. Analysis of the physicochemical and sorption characteristics of composites based on zeolite and chamotte clay // MATEC Web of Conferences 340, 01027, 2021. https://doi.org/10.1051/mateconf/202134001027 3. Сейлханова Г.А., Рахым А.Б., Кан А.В., Кенесова А.К., Мастай Ицхак Применение сорбентов на основе природного цеолита и

шамотной глины для извлечения ионов натрия и калия из соленой воды: предварительное исследование// Вестник КазНУ. Серия химическая. № 2 (105). 2022. – С. 44–53.
<https://doi.org/10.15328/cb1276>

4. Rakhym Akmaral B., Baranchiyeva Zarina Ye., Kenessova Aruzhan K., Zhakysybai Bagashar B., Dauzhanova Diana N., Yitzhak Mastai, Seilkhanova Gulziya A. Recyclable Adsorbents for Potash Brine Desalination Based on Silicate Powder: Application, Regeneration and Utilization// Colloids Interfaces 2023, 7, 61.
<https://doi.org/10.3390/colloids7040061> (Q2, 67%).

5. Kenessova A.K., Rakhym A.B., Zhakysybay B.B., Seilkhanova G.A. The effect of ammonia activation on the desalination potential of natural zeolite//Chimica Techno Acta 2023, vol. 10(4), No. 202310402. DOI: 10.15826/chimtech.2023.10.3.05 (Q4, 12%).

Publications in materials of International conferences:

6. Шиянова Р.А., Рахым А.Б., рук-ль Сейлханова Г.А. Разработка композиционных материалов на основе минерального сырья для опреснения соленой воды // Материалы Международной научной конференции студентов и молодых ученых «Фараби Әлемі», Алматы, Казахстан, 6-8 апреля 2021. – С. 78.

7. Кан. А.В., Рахым А.Б., рук-ль Сейлханова Г.А. Разработка агентов на основе природного цеолита и шамотной глины для опреснения соленой воды // Материалы Международной научной конференции студентов и молодых ученых «Фараби Әлемі», Алматы, Казахстан, 6-8 апреля 2021. – С. 90.

8. Шиянова Р.А., Рахым А.Б., Сейлханова Г.А. Композиционный материал на основе шамотной глины для опреснения соленой воды // Материалы VII международной Российско-Казахстанской научно-практической конференции «Химические технологии функциональных материалов», 28-29 апреля 2021 года. – Новосибирск 2021. – С. 299.

9. Баранчиева З.Е., Сейлханова Г.А., Рахым А.Б. Сорбционные характеристики материалов на основе цеолита и шамотной глины // Материалы VII международной Российско-Казахстанской научно-практической конференции «Химические технологии функциональных материалов», 28-29 апреля 2021 года. – Новосибирск 2021. – С. 87.

10. Рахым А.Б., Сейлханова Г.А. Оценка влияния обработки хлоридом натрия и соляной кислотой на физико-химические характеристики шамотной глины // Материалы VII международной Российско-Казахстанской научно-практической конференции «Химические технологии функциональных материалов», 28-29 апреля 2021 года. – Новосибирск 2021. – С. 111.

11. Жақсыбай Б.Б., Кенесова А.К., Рахым А.Б., Сейлханова Г.А. Тұзды суды тұщыландыруға арналған табиғи цеолит негізіндегі сорбентпен Na^+ , K^+ , Cl^- иондарын адсорбциялау// Материалы Международной научной конференции студентов и молодых ученых «Фараби Әлемі», Алматы, Казахстан, 6-8 апреля 2022. – С. 60.

12. Ерсайын Р.С., Баранчиева З.Е., Рахым А.Б. Сейлханова Г.А. Разработка сорбента на основе глины Кызылсок для опреснения соленой воды// Материалы Международной научной конференции

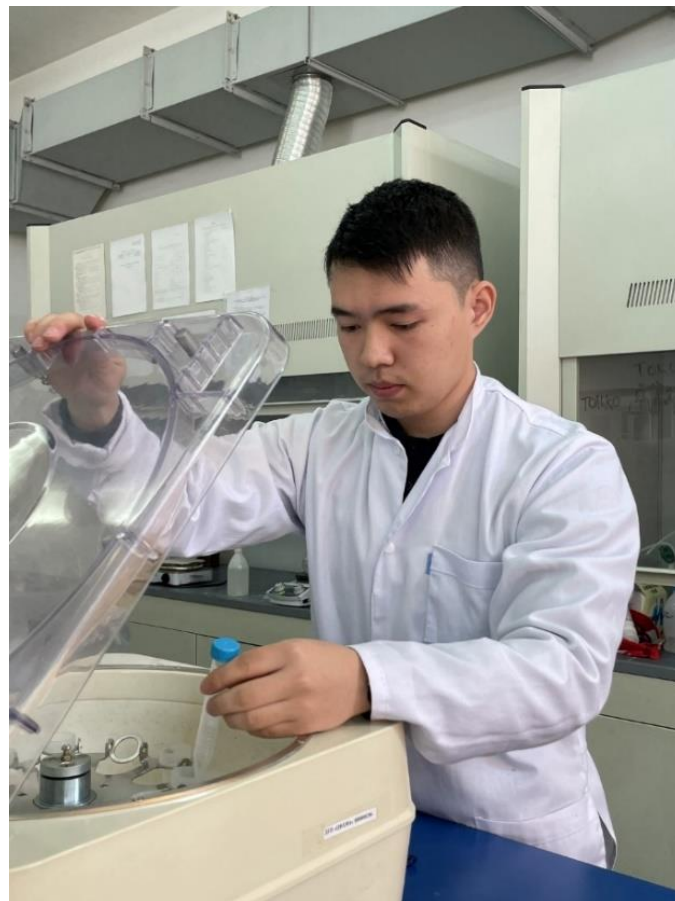
	<p>студентов и молодых ученых «Фараби Әлемі», Алматы, Казахстан, 6-8 апреля 2022. – С. 88.</p> <p>13. Даужанова Д.Н., Рахым А.Б., Сейлханова Г.А. Извлечение и адресная доставка диклофенака сорбентами на основе глины и цеолита// Материалы Международной научной конференции студентов и молодых ученых «Фараби Әлемі», Алматы, Казахстан, 6-8 апреля 2023. – С. 232.</p> <p>14. Жақсыбай Б.Б., Кенесова А.К., Рахым А.Б., Сейлханова Г.А. Тұзды суды тущыландыру мақсатында цеолит негізінде гранулалар дайындау// Материалы Международной научной конференции студентов и молодых ученых «Фараби Әлемі», Алматы, Казахстан, 6-8 апреля 2023. – С. 188.</p> <p>15. Dauzhanova D.N., Rakhym A.B., Seilkhanova G.A. A new composite material based on kaolinite clay and polyvinylpyrrolidone as an adsorbent, drug carrier and releaser of diclofenac// Материалы IX Международной Российско-Казахстанской научно-практической конференции «Химические технологии функциональных материалов», 25-27 мая 2023 года. – Новосибирск 2023. – С. 216–219.</p> <p>16. Kenessova A.K., Rakhym A.B., Zhaksybay B.B., Seilkhanova G.A. Physicochemical study of the effect of NH₄Cl modification of zeolite for Na⁺ and K⁺ removal from saline water // Материалы IX Международной Российско-Казахстанской научно-практической конференции «Химические технологии функциональных материалов», 25-27 мая 2023 года. – Новосибирск 2023. – С. 193-196.</p>
Patents	



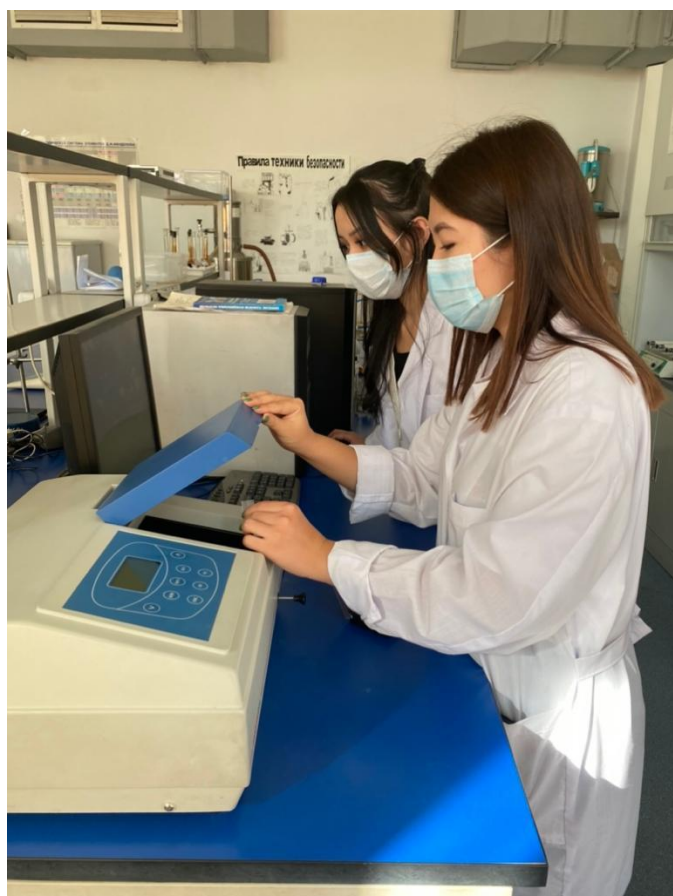
Desalination of saline water



Encapsulated agents for desalination of saline water



Bachelor Zhaksybay Bagashar in the process of synthesis of sorption agents for desalination



Doctoral students Rakhym Akmaral and Kenessova Aruzhan during spectral analysis of the reaction mixture



Discussion of the obtained results