

INNOVATION SCIENCE AND TECHNOLOGY

ISSUE 10, PART I / OCTOBER 2026

 **Acceptance of papers**



**Acceptance of
papers**

Published monthly



Topics

economics,
technology, social
sciences



EDITOR-IN-CHIEF:

Mirzaliyev Sanjar Makhamatjon ugli

DEPUTY EDITOR-IN-CHIEF:

Makhmudov Nosir Makhmudovich
DSc., Prof., Academician

DEPUTY EDITOR-IN-CHIEF:

Ochilov Bobur Bakhtiyor ugli – Senior
lecturer at TSUI

THE SCIENTIFIC-POPULAR ELECTRONIC
JOURNAL **"INNOVATION SCIENCE AND
TECHNOLOGY"** HAS BEEN REGISTERED
UNDER THE NUMBER **C-5669633** BY THE
AGENCY FOR INFORMATION AND MASS
COMMUNICATIONS (AOKA) OF THE
REPUBLIC OF UZBEKISTAN, EFFECTIVE
FROM OCTOBER 9, 2024.

CONTACTS

Phone: **+998 50 737 87 88**

Website: <https://ist-journal.uz>

Email: innovationist2025@gmail.com

The scientific electronic journal "Innovation Science and Technology" has been included in the list of scientific publications recommended for the publication of main scientific results of dissertations for the award of PhD and DSc degrees in economics and technical sciences, in accordance with the Resolution No. 370 of the Presidium of the Higher Attestation Commission of the Republic of Uzbekistan, dated May 8, 2025.

Editorial board:



Sharipov Kongiratbay Avezimbetovich,
Doctor of Technical Sciences (DSc), Professor



Abdurakhmanova Gulnora Kalandarovna, Doctor of
Economic Sciences (DSc), Professor



Cham Tat Huei,
Doctor of Philosophy (PhD), Professor (Malaysia)



Muhammad Imran Sadiq
Doctor of Philosophy in Economics (PhD), Professor,
Malaysia



Ahmed Aziz Ismail
Doctor of Technical Sciences (DSc),
Professor (Egypt)



Lee Chin
Doctor of Philosophy in Economics (PhD), (Malaysia)



Asongu Simplicie
Doctor of Philosophy in Economics (PhD), Cameroon



Rui Dang
Doctor of Chemistry (DSc), Professor, China



Zahoor Ahmed
Doctor of Philosophy in Economics (PhD), Turkey



Shujaat Abbas
Doctor of Philosophy in Economics (PhD), Russia



Tina A Coffelt
Doctor of Philosophy in Educational Sciences (PhD),
USA



Abdikarimova Dinara Rustamxanovna
Doctor of Economic Sciences (DSc), Professor

Kurbonbekova Mohichehra Turobjonovna
Doctor of Economic Sciences (DSc), Professor

Alimardonov Ilkhom Muzrabshokovich
Doctor of Economic Sciences (DSc), Professor



Razakova Barno Sayfiyeva
Doctor of Philosophy in Economics (PhD)



Khasanov Sarvar Ulugbek ugli
Doctor of Philosophy in Economics (PhD)



Kholikova Rukhsora Sanjarovna
Associate Professor (PhD)



Xoliyorova Shoxista Qahramon qizi
PhD in Economics, Assistant Lecturer at the Department TSUE

Nasiba G'anjon qizi Sattorova
PhD, Senior Lecturer at the Department of Banking

CONTENTS

IMPLEMENTATION OF THE IMPROVED METHODOLOGY IN PRACTICE AND ASSESSMENT OF ITS ECONOMIC EFFICIENCY	8
Eshniyazova Yulduz Yuldashbayevna	
EXPERIMENTAL OPTIMIZATION OF DESIGN AND ENERGY PARAMETERS OF A GARLAND-TURBINE MOBILE MICRO HYDROPOWER PLANT FOR FREE-FLOWING WATER	13
Sultonov Sanjarbe, Zokirov Islomjon, Nurillaev Ahadullo, Abdullaev Shavkat	
METHODOLOGY FOR INCREASING THE EFFICIENCY OF CREDIT OPERATIONS IN COMMERCIAL BANKS	19
Djumaniyazov Ikram Karimbaevich	
COMPARATIVE ANALYSIS OF A COMPACT RESIDUAL CONVOLUTIONAL MODEL AND LINEAR REGRESSION FOR IMAGE SUPER-RESOLUTION	27
Husan Arziqulov Normurod o'g'li	
COMPARATIVE EVALUATION OF MACHINE LEARNING ALGORITHMS AND CLASS IMBALANCE HANDLING STRATEGIES FOR CREDIT CARD FRAUD DETECTION	33
Mahmudova Dilnoza Avaz qizi	
DIGITAL TRANSFORMATION OF FINANCIAL RESOURCE MANAGEMENT IN PUBLIC SOCIAL SECTOR INSTITUTIONS	39
Khasanov Tulkin Axmatovich	
WAYS TO ENSURE THE STABILITY OF THE CAPITAL BASE OF COMMERCIAL BANKS	45
Isakov Isobek Janabay's son	
CROSS-DAY EXPERIMENTAL EVIDENCE OF THERMAL-LOAD SHIFTING IN A SOLAR-DRIVEN HYDRONIC RADIANT FLOOR WITH MACROENCAPSULATED RT52 PHASE CHANGE MATERIAL	50
Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova	
STUDY OF THE TRACTION DYNAMICS OF AN AGGREGATE CONSISTING OF A FRUIT-HARVESTING MACHINE AND ITS TWO-AXLE CONTAINER-CARRYING TRAILER PLATFORM	59
Norchayev Davron, Sardor Nigmatjonov, Norchayev Jaloliddin, Norchayev Rustam	
PRIORITY DIRECTIONS FOR STRENGTHENING THE FINANCIAL STABILITY OF AGRICULTURAL ENTERPRISES	67
Kulmatov Zafar Jumanazarovich	
METHODOLOGICAL APPROACHES TO DEVELOPING UNIVERSITY STUDENTS' DIGITAL COMMUNICATIVE COMPETENCE BASED ON EMOTIONAL INTELLIGENCE	73
Malikakhon Kamiljanova	
SIMULTANEOUS REMOVAL CHARACTERISTICS OF OIL AND HEAVY METAL IONS BY BIOFLOCCULANTS BASED ON THE CELLULOSE-DMAEMA/PEPA COMPOSITE	80
Xayitboeva Dilshoda, Ibragimov Nasrilla, Jumaev Anvarbek	
ECONOMIC ANALYSIS AND DEVELOPMENT STRATEGY OF THE WOOD-POLYMER COMPOSITES MARKET	84
Abdumalikova Zarnigor, Ayubova Indira, Jumaev Anvarbek	
ENERGY UTILIZATION ANALYSIS OF AGRICULTURAL DRYING BASED ON INTEGRATED SOLAR THERMAL AND PHOTOVOLTAIC ENERGY SUPPLY	89
Ibragimov Umidjon, Mirzayarova Sevara, Khujayorova Aziza	
RECENT ADVANCES IN THE SYNTHESIS OF NANOSTRUCTURED MATERIALS FOR ZINC-ION BATTERIES	96
Diyorbek Absattorov, Dilnoza Erimbatova, Murodjon Samadiy	
ENTHALPY-MODEL SELECTION AND PRACTICAL IDENTIFIABILITY OF A MACROENCAPSULATED RT52 RADIANT FLOOR UNDER UNCERTAIN BRANCH FLOW	101
Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova	
THE IMPORTANCE OF THERMAL ENERGY STORAGE SYSTEMS IN ENHANCING THE EFFICIENCY OF SOLAR DRYERS	110
B. A. Hikmatov, M. S. Mirzaev,	

METHODOLOGY AND PRINCIPLES FOR THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN ADAPTIVE ECONOMIC MODELS OF HIGHER EDUCATION.....	117
O'lmasxo'jayev Zoirxo'ja Abbos o'g'li	
FORECASTING ECONOMIC EFFECTS OF GREEN INNOVATION IN MINING THROUGH COST REDUCTION, ENERGY SAVINGS AND LONG-TERM COMPETITIVENESS.....	122
Kurbanova Mehriniso Nematjanovna	
AN INTELLECTUAL HYBRID MODEL AND FEATURE SPACE FOR NAMED ENTITY RECOGNITION IN KARAKALPAK TEXTS	127
Kalmuratov Bekbosin Kushkinbaevich, Uzakbaev Jangeldi Sabit-uli, Rzambetova Suliwxan Baxtiyarovna	
COMPARATIVE ANALYSIS OF EXISTING METHODOLOGIES FOR ASSESSING THE EFFICIENCY OF LENDING PRACTICE	133
Turdiyev Eralijon Muxtarovich	
STRATEGIC MANAGEMENT OF SERVICE QUALITY: ADAPTING THE GAP MODEL TO SERVICE ENTERPRISES.....	140
Tuxliyev Baxtiyor Maxmaziyayevich	
ORGANISATIONAL AND LEGAL FOUNDATIONS FOR THE DEVELOPMENT OF ISLAMIC FINANCE IN UZBEKISTAN	145
Khodjaev Aziz Shovkatovich	
REGIONAL TRANSMISSION OF MACROECONOMIC SHOCKS AND THE DYNAMICS OF ECONOMIC CONVERGENCE	153
Elyor Nazarov	
PRIORITY DIRECTIONS FOR INCREASING SECTORAL DIVERSIFICATION IN THE ECONOMY OF UZBEKISTAN'S REGIONS	159
Mamarasulov Nozimjon Mamajonovich	
THE ROLE OF STATE STRATEGIC RESERVES IN ENSURING FOOD SECURITY: POLICY EVOLUTION AND REASSESSMENT OF THE MILITARY SUPPLY SYSTEM IN THE CASE OF UZBEKISTAN.....	165
Bazarov Nazirjon Sobirovich	
LOCAL ADAPTATION OF MRA-FW FOR CARDIOVASCULAR RISK ASSESSMENT IN ARAL SEA REGION INPATIENTS.....	170
Uteuliev Niyetbay, Saytov Aralbek, Saytov Kamiljan	
GREEN FINANCE IN UZBEKISTAN: FROM SOVEREIGN BONDS TO FOREIGN DIRECT INVESTMENT IN RENEWABLE ENERGY (2021–2026).....	176
Temirova Nozima Shuhrat qizi	
IMPROVING THE ACCOUNTING OF REVENUE, EXPENSES AND FINANCIAL RESULTS IN PRIVATE HIGHER EDUCATION INSTITUTIONS	182
Saidova Kamolat Farhodovna	
THE IMPACT OF DIGITAL TRANSFORMATION ON SERVICE DELIVERY EFFICIENCY IN LOCAL HIGHER EDUCATION INSTITUTIONS.....	187
Masaidova Marguba Muratovna	
INVESTIGATION OF METAL REFINING DURING ELECTRIC ARC WELDING.....	195
Ermatov Ziyadulla, Rakhmatullaeva Nozima, Galperin Leonid	
STATE AND INSTITUTIONAL SUPPORT FOR THE EXPORT ACTIVITIES OF CONSTRUCTION ENTERPRISES.....	200
Mirzayeva Khulkar Abduladjon kizi	
ECONOMIC DIPLOMACY AS THE EXTERNAL TIER OF INVESTMENT GOVERNANCE: INSTITUTIONAL DESIGN AND IMPLEMENTATION GAPS IN UZBEKISTAN.....	207
Imamov Javokhir	
METHODS FOR IMPROVING THE EFFICIENCY OF PRODUCTION RESOURCE UTILIZATION IN AGRICULTURE	213
Nurxonov Nurkomil Qahramon ugli	
COMPARATIVE ANALYSIS OF MACHINE LEARNING ALGORITHMS FOR AUTOMATIC TOPIC CLASSIFICATION OF KARAKALPAK NEWS TEXTS.....	218
Asenbayev Nurbek Adilbayevich	

JOINT OPTIMISATION OF EXTERNAL-WALL INSULATION THICKNESS AND RADIANT-FLOOR HEAT OUTPUT FOR A SOLAR-CONCENTRATOR-HEATED DWELLING IN THE CLIMATE OF BUKHARA.....	223
Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova	
IMPROVING THE METHODOLOGY FOR ECONOMIC ANALYSIS OF CONSTRUCTION SERVICE COSTS AT SOCIAL FACILITIES	234
Gapparov Azim Kayumovich	
SPATIOTEMPORAL TRENDS IN WATER QUALITY ALONG THE TASHKENT URBAN REACH OF THE CHIRCHIK RIVER: A PAIRED MONITORING ANALYSIS FOR 2017–2024	241
Ruziev Dilmurod, Matkaziyev Dilshod, Begzod Burkhonov, Abdurakhimova Durdona, Yuldosheva Saodat	
ECONOMIC REGULATION OF ENVIRONMENTAL EXTERNALITIES IN CONSTRUCTION INDUSTRY ENTERPRISES: A GRADUATED PAYMENT-SUBSIDY MECHANISM AND FORECASTING APPROACH	251
Xolov Xamza Tojiddinovich	
DIFFERENTIATED APPROACHES TO INCENTIVIZING THE TRANSITION OF SMALL BUSINESSES TO THE FORMAL ECONOMY	260
Yunusov Marat Erkinovich	
THE EFFECTIVENESS OF CORPORATE GOVERNANCE IN BANKS AND ITS IMPACT ON FINANCIAL PERFORMANCE AND RISKS	266
Susanna S. Alieva	
GREEN INNOVATION-INVESTMENT EFFECTIVENESS AND STRATEGIC FORECASTING IN THE CABLE INDUSTRY: EVIDENCE FROM UZKABEL.....	273
Igamberdiev Karimberdi	
LEVEL OF ADAPTATION OF PUBLIC INFRASTRUCTURE FOR PERSONS WITH DISABILITIES IN BUKHARA.....	280
Bomurodova Madina Voxidjon qizi	
FREQUENCY-DEPENDENT ASSESSMENT OF FACADE SOUND INSULATION REQUIREMENTS UNDER NOISE EXPOSURE FROM ABOVE-GROUND METRO SYSTEMS.....	285
Zafar Tulaganov, Rakhmatullo Pirmatov	
ADAPTIVE TIKHONOV REGULARIZATION FOR ROBUST ENERGY BALANCE OPTIMIZATION IN PV-BESS SYSTEMS UNDER SEVERE ENVIRONMENTAL DISTURBANCES.....	294
Gulayim Baymuratova Tajimurat kizi	
EFFECT OF SODIUM CHLORIDE DOSAGE ON THE ROASTING AND HYDROCHLORIC ACID LEACHING OF LEAD CAKE FROM ZINC PRODUCTION	301
Haqberdiyev Dilshod, Eshonkulov Uchkun	

EFFECT OF SODIUM CHLORIDE DOSAGE ON THE ROASTING AND HYDROCHLORIC ACID LEACHING OF LEAD CAKE FROM ZINC PRODUCTION

Haqberdiyev Dilshod Qodir ugli

Karshi State Technical University

Assistant, Department of Geology and Mining Engineering

E-mail: dilshodhaqberdiyev5@gmail.com

Eshonkulov Uchkun Khudaynazar ugli

Karshi State Technical University

Head of the Department of Geology and Mining Engineering

E-mail: uchqun.eshonkulov91@mail.ru

Abstract: This study investigates the processing of lead cake generated at the Zinc Plant of the Almalyk Mining and Metallurgical Complex (AMMC), Uzbekistan, using sodium chloride roasting followed by hydrochloric acid leaching. The research aims to evaluate the influence of sodium chloride dosage on the processing of lead-bearing metallurgical residues and the potential recovery of valuable components. Laboratory experiments were conducted using lead cake-to-NaCl mass ratios of 1:0.5, 1:1, 1:2, and 1:3. The samples were roasted at 550°C for 1.5 hours, followed by leaching with hydrochloric acid solution and precipitation using sodium carbonate. Experimental results demonstrated variations in the masses of roasted products, leaching residues, and dried precipitates depending on the reagent ratio. The highest dried precipitate mass of 130 g was obtained at a ratio of 1:3, while the lowest mass of 43 g was recorded at 1:1. These findings indicate that sodium chloride dosage influences the distribution of products during lead cake processing. However, further chemical and mineralogical analyses are necessary to determine individual metal recovery efficiencies and product purity. The study provides preliminary experimental evidence supporting the development and optimization of technologies for processing lead-bearing industrial residues and improving the utilization of secondary metallurgical resources.

Keywords: lead cake, sodium chloride roasting, hydrochloric acid leaching, hydrometallurgy, metal recovery, sodium carbonate precipitation, metallurgical waste.

Annotatsiya: Ushbu tadqiqotda O'zbekistonning Olmaliq kon-metallurgiya kombinati (OKMK) Rux zavodida hosil bo'ladigan qo'rg'oshinli kekni natriy xlorid yordamida kuydirish va undan keyin xlorid kislota bilan tanlab eritish usuli orqali qayta ishlash jarayoni o'rganilgan. Tadqiqotning maqsadi natriy xlorid miqdorining qo'rg'oshin saqlovchi metallurgiya chiqindilarini qayta ishlash va qimmatli komponentlarni ajratib olish imkoniyatlariga ta'sirini baholashdan iborat. Laboratoriya tajribalari qo'rg'oshinli kek va NaCl ning 1:0,5, 1:1, 1:2 hamda 1:3 massa nisbatlarida amalga oshirildi. Namunalar 550 °C haroratda 1,5 soat davomida kuydirildi. Shundan so'ng xlorid kislota eritmasi bilan tanlab eritish va natriy karbonat yordamida cho'ktirish jarayonlari bajarildi. Tajriba natijalari reagentlar nisbatiga qarab kuydirilgan mahsulotlar, tanlab eritishdan qolgan qoldiqlar va quritilgan cho'kmalar massasi o'zgarishini ko'rsatdi. Quritilgan cho'kmaning eng yuqori massasi 130 g bo'lib, reagentlar nisbati 1:3 bo'lganda olindi. Eng past massa — 43 g — esa 1:1 nisbatda qayd etildi. Olingan natijalar natriy xlorid miqdori qo'rg'oshinli kekni qayta ishlash jarayonida hosil bo'ladigan mahsulotlarning taqsimlanishiga ta'sir ko'rsatishini tasdiqlaydi. Biroq alohida metallarning ajratib olish samaradorligi va olingan mahsulotlarning tozaligini aniqlash uchun qo'shimcha kimyoviy hamda mineralogik tahlillar o'tkazish zarur. Tadqiqot qo'rg'oshin saqlovchi sanoat chiqindilarini qayta ishlash texnologiyalarini ishlab chiqish va takomillashtirish, shuningdek, ikkilamchi metallurgiya resurslaridan samarali foydalanishni oshirish uchun dastlabki eksperimental asos yaratadi.

Kalit so'zlar: qo'rg'oshinli kek, natriy xlorid bilan kuydirish, xlorid kislota bilan tanlab eritish, gidrometallurgiya, metallarni ajratib olish, natriy karbonat yordamida cho'ktirish, metallurgiya chiqindilari.

Аннотация: В данном исследовании рассматривается переработка свинцового кека, образующегося на цинковом заводе Алмалыкского горно-металлургического комбината (АГМК), Узбекистан, с использованием обжига с хлоридом натрия с последующим выщелачиванием соляной кислотой. Цель исследования заключается в оценке влияния расхода хлорида натрия на переработку свинецсодержащих металлургических отходов и потенциальное извлечение ценных компонентов. Лабораторные эксперименты проводились при массовых соотношениях свинцового кека и NaCl 1:0,5, 1:1, 1:2 и 1:3. Образцы обжигали при температуре 550 °C в течение

1,5 часа, после чего проводили выщелачивание раствором соляной кислоты и осаждение с использованием карбоната натрия. Экспериментальные результаты показали, что массы обожжённых продуктов, остатков выщелачивания и высушенных осадков изменялись в зависимости от соотношения реагентов. Наибольшая масса высушенного осадка, составившая 130 г, была получена при соотношении 1:3, тогда как наименьшая масса — 43 г — наблюдалась при соотношении 1:1. Полученные результаты свидетельствуют о влиянии количества хлорида натрия на распределение продуктов в процессе переработки свинцового кек. Вместе с тем для определения эффективности извлечения отдельных металлов и чистоты получаемых продуктов необходимы дополнительные химические и минералогические исследования. Работа представляет предварительные экспериментальные результаты, которые могут быть использованы при разработке и оптимизации технологий переработки свинецсодержащих промышленных отходов и повышении эффективности использования вторичных металлургических ресурсов.

Ключевые слова: свинцовый кек, обжиг с хлоридом натрия, выщелачивание соляной кислотой, гидрометаллургия, извлечение металлов, осаждение карбонатом натрия, металлургические отходы.

INTRODUCTION

The processing of metallurgical waste is an important aspect of sustainable resource management and the efficient recovery of valuable metals. The lead cake generated at the Zinc Plant of Almalyk Mining and Metallurgical Complex (AMMC), Uzbekistan, represents a potential secondary raw material for recovering lead and other valuable components. Improving the processing of this residue can contribute to more efficient utilization of industrial resources and reduce the environmental burden associated with metallurgical waste.

However, the recovery of valuable metals from lead cake is influenced by its chemical and mineralogical composition, which can limit the effectiveness of conventional processing methods [2]. Therefore, developing and optimizing suitable pretreatment and leaching techniques is essential for improving metal recovery and the overall efficiency of the process.

Sodium chloride-assisted roasting followed by hydrochloric acid leaching represents a potential approach to processing lead-bearing residues. Investigating the influence of the sodium chloride dosage on the process may help establish suitable conditions for subsequent metal separation and recovery [6]. Accordingly, this study aims to evaluate the processing of lead cake from the AMMC Zinc Plant using sodium chloride roasting and hydrochloric acid leaching, with particular emphasis on the effect of different reagent ratios on the resulting products and the potential recovery of valuable components [11].

REVIEW OF LITERATURE ON THE SUBJECT

Biserka Lucheva, Peter Iliev, and Nadezhda Kazakova investigated the recovery of lead and silver from lead cake using sodium chloride roasting followed by acid leaching. Their research demonstrated the potential of this method for recovering valuable metals from metallurgical residues.

Deniz Turan, H. Soner Altundoğan, and Fikret Tümen studied the recovery of zinc and lead from zinc plant residues using roasting and leaching techniques. Their findings highlighted the importance of selecting suitable processing conditions to improve metal recovery.

R. Raghavan, P. K. Mohanan, and S. C. Patnaik examined the recovery of lead and silver from zinc leaching residues. Their study emphasized the potential of hydrometallurgical techniques for recovering valuable metals from industrial waste.

These studies provide a scientific basis for investigating sodium chloride roasting and hydrochloric acid leaching to improve the recovery of valuable components from lead cake generated at the AMMC Zinc Plant.

RESEARCH METHODOLOGY

The study investigated the processing of lead cake generated at the Zinc Plant of the Almalyk Mining and Metallurgical Complex (AMMC). Laboratory experiments were conducted using different lead cake-to-sodium chloride (NaCl) mass ratios of 1:0.5, 1:1, 1:2, and 1:3. The samples were roasted in a muffle furnace at 550°C for 1.5 hours. After roasting, the materials were ground and sieved through a 0.400 mm sieve.

The roasted samples were leached with hydrochloric acid (HCl) solution at a concentration of 20 g/L. A liquid-to-solid ratio of approximately 3:1 was used, and the mixtures were stirred for 1.5 hours at temperatures of 70–85°C, depending on the experimental conditions [2]. After leaching, the solid residues were separated by decantation and filtration. The resulting solutions were treated with sodium carbonate (Na₂CO₃) to precipitate dissolved components. The pH was adjusted to approximately 7–8, depending on the experiment, followed by stirring, settling, filtration, and drying of the precipitates [10].

The experimental results were evaluated by comparing the masses of the roasted materials, leaching

residues, and dried precipitates obtained under different NaCl ratios [5]. This approach was used to assess the influence of sodium chloride dosage on the processing of lead cake and the potential recovery of valuable components.

ANALYSIS AND RESULTS

The laboratory experiments investigated the effect of different sodium chloride (NaCl) dosages on the roasting and subsequent leaching of lead cake generated at the Zinc Plant of the Almalyk Mining and Metallurgical Complex (AMMC). Four lead cake-to-NaCl mass ratios were examined: 1:0.5, 1:1, 1:2, and 1:3. All samples were roasted at 550°C for 1.5 hours (Figure 1).

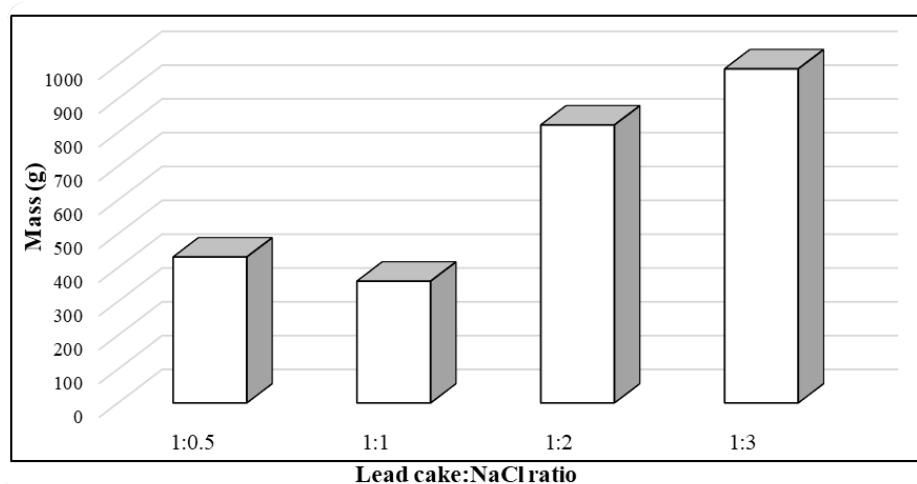


Figure 1. Effect of the lead cake-to-NaCl mass ratio on the mass of the roasted product¹

The experimental results showed that the mass of the roasted material increased with increasing NaCl dosage. For the 1:0.5 ratio, 300 g of lead cake produced approximately 431–432 g of roasted material. At a ratio of 1:1, 200 g of lead cake yielded 360 g. For the 1:2 and 1:3 ratios, 300 g of lead cake produced 822 g and 988 g of roasted material, respectively. These results reflect the increasing contribution of added sodium chloride to the total mass of the roasted mixture (Table 1).

Table 1. Comparative Results of Lead Cake Processing at Different NaCl Ratios²

Lead cake:NaCl ratio	Initial lead cake (g)	Roasted material (g)	Leaching residue (g)	Dried precipitate (g)
1:0.5	300	431–432	163	95
1:1	200	360	147	43
1:2	300	822	228	64
1:3	300	988	147	130

Following roasting, the samples were leached with hydrochloric acid (HCl) solution. The solid residues obtained after leaching weighed 163 g, 147 g, 228 g, and 147 g for the 1:0.5, 1:1, 1:2, and 1:3 ratios, respectively. The variation in residue mass indicates differences in the quantities of insoluble components remaining after leaching. However, chemical analysis is required to determine the extent of metal dissolution and the composition of these residues (Figure 2).

¹ Source: Author's elaboration

² Source: Author's elaboration

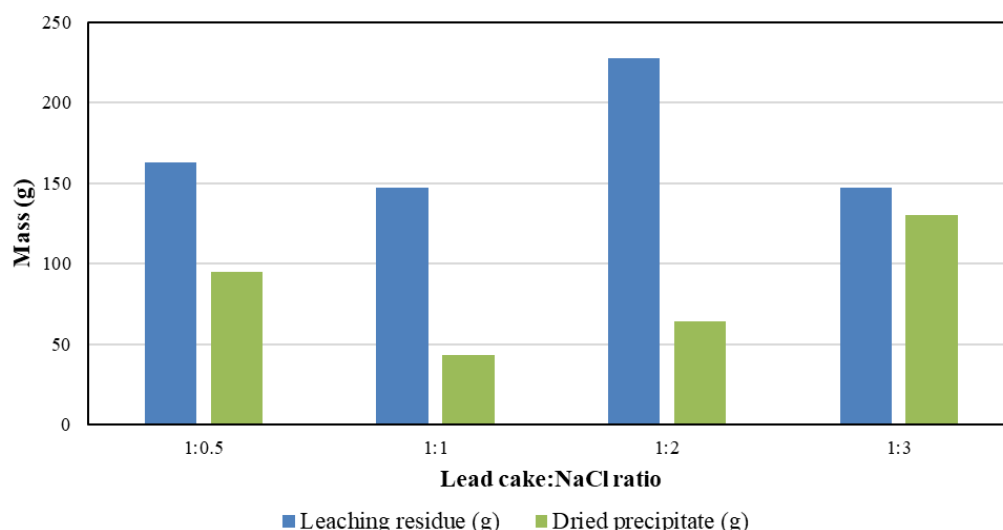


Figure 2. Comparison of leaching residue and dried precipitate masses at different lead cake-to-NaCl ratios³

The leach solutions were subsequently treated with sodium carbonate (Na_2CO_3) to precipitate dissolved components. The dried precipitates weighed 95 g, 43 g, 64 g, and 130 g for the respective NaCl ratios. The highest precipitate mass was obtained at a ratio of 1:3, while the lowest was recorded at 1:1. Nevertheless, precipitate mass alone cannot establish the recovery efficiency of lead or other valuable metals because the precipitates may contain several chemical compounds and impurities.

Overall, the results demonstrate that the NaCl dosage influenced the mass of the roasted material, the quantity of leaching residue, and the mass of the final precipitate. Among the tested conditions, the 1:3 ratio produced the largest precipitate mass. Further chemical analysis of the initial lead cake, leaching residues, and precipitates is necessary to determine metal recovery rates and identify the most effective processing conditions. Differences in leaching temperature and final pH between the experiments should also be considered when comparing the results.

CONCLUSIONS AND SUGGESTIONS

The results of this study demonstrate that sodium chloride (NaCl) dosage influences the processing of lead cake generated at the Zinc Plant of the Almalyk Mining and Metallurgical Complex (AMMC). Roasting at 550°C for 1.5 hours, followed by hydrochloric acid leaching and sodium carbonate precipitation, produced different quantities of roasted material, leaching residues, and dried precipitates at the investigated lead cake-to-NaCl ratios. Among the tested conditions, the 1:3 ratio yielded the highest dried precipitate mass of 130 g, whereas the 1:1 ratio produced the lowest mass of 43 g. These findings indicate that the NaCl ratio affects the mass distribution of the products obtained during processing.

However, the mass of the final precipitate alone is insufficient to determine the recovery efficiency of lead, silver, or other valuable metals. Further chemical and mineralogical analyses of the initial feed, leaching residues, and precipitates are required to establish metal recovery rates and product purity. In addition, optimizing the roasting and leaching conditions may help improve process efficiency and resource utilization. The findings provide a preliminary experimental basis for further development of a suitable technology for recovering valuable components from lead cake generated at the AMMC Zinc Plant.

REFERENCES:

1. Aparajith, B., Mohanty, D. B., & Gupta, M. L. (2011). Recovery of enriched lead–silver residue from silver-rich concentrate of hydrometallurgical zinc smelter. *Hydrometallurgy*, 109(3–4), 228–234. <https://doi.org/10.1016/j.hydromet.2010.08.010>
2. Farahmand, F., Moradkhani, D., Safarzadeh, M. S., & Rashchi, F. (2009). Brine leaching of lead-bearing zinc plant residues: Process optimization using orthogonal array design methodology. *Hydrometallurgy*, 95(3–4), 316–324. <https://doi.org/10.1016/j.hydromet.2008.07.012>
3. Haghighi, H. K., Hoseinian, F. S., & Sastre, A. M. (2024). A new feasible opportunity for recycling lead and silver from zinc plant residues by flotation. *Materials*, 17(21), Article 5218. <https://doi.org/10.3390/ma17215218>

3 Source: Author's elaboration

4. Höber, L., & Steinlechner, S. (2021). A comprehensive review of processing strategies for iron precipitation residues from zinc hydrometallurgy. *Cleaner Engineering and Technology*, 4, Article 100214. <https://doi.org/10.1016/j.clet.2021.100214>
5. Jiménez-Lugos, C., Flores-Favela, M., Romero-Serrano, A., Hernández-Ramírez, A., Cruz-Ramírez, A., Sanchez-Vite, E., Ortiz-Landeros, J., & Colin-García, E. (2025). Pyrometallurgical process to recover lead and silver from zinc leaching residue. *Recycling*, 10(5), Article 167. <https://doi.org/10.3390/recycling10050167>
6. Liu, F., Wang, J., Peng, C., Liu, Z., Wilson, B. P., & Lundström, M. (2019). Recovery and separation of silver and mercury from hazardous zinc refinery residues produced by zinc oxygen pressure leaching. *Hydrometallurgy*, 185, 38–45. <https://doi.org/10.1016/j.hydromet.2018.12.016>
7. Lucheva, B., Iliev, P., & Kazakova, N. (2026). Combined process of chlorination roasting and acid leaching of lead and silver from lead cake. *Materials*, 19(1), Article 170. <https://doi.org/10.3390/ma19010170>
8. Onghena, B., & Binnemans, K. (2019). Recovery of lead and silver from zinc leaching residue using methanesulfonic acid. *ACS Sustainable Chemistry & Engineering*, 7(24), 19807–19815. <https://doi.org/10.1021/acssuschemeng.9b05116>
9. Raghavan, R., Mohanan, P. K., & Patnaik, S. C. (1998). Innovative processing technique to produce zinc concentrate from zinc leach residue with simultaneous recovery of lead and silver. *Hydrometallurgy*, 48(2), 225–237. [https://doi.org/10.1016/S0304-386X\(97\)00082-0](https://doi.org/10.1016/S0304-386X(97)00082-0)
10. Raghavan, R., Mohanan, P. K., & Swarnkar, S. R. (2000). Hydrometallurgical processing of lead-bearing materials for the recovery of lead and silver as lead concentrate and lead metal. *Hydrometallurgy*, 58(2), 103–116. [https://doi.org/10.1016/S0304-386X\(00\)00108-0](https://doi.org/10.1016/S0304-386X(00)00108-0)
11. Rashchi, F., Dashti, A., Arabpour-Yazdi, M., & Abdizadeh, H. (2005). Anglesite flotation: A study for lead recovery from zinc leach residue. *Minerals Engineering*, 18(2), 205–212. <https://doi.org/10.1016/j.mineng.2004.10.014>
12. Turan, M. D., Altundoğan, H. S., & Tümen, F. (2004). Recovery of zinc and lead from zinc plant residue. *Hydrometallurgy*, 75(1–4), 169–176. <https://doi.org/10.1016/j.hydromet.2004.07.008>
13. Wang, R., Yang, Y., Liu, C., Zhou, J., Fang, Z., Yan, K., Tian, L., & Xu, Z. (2020). Recovery of lead and silver from zinc acid-leaching residue via a sulfation roasting and oxygen-rich chlorination leaching method. *Journal of Central South University*, 27(12), 3567–3580. <https://doi.org/10.1007/s11771-020-4569-6>
14. Zhang, Y., Yu, X., & Li, X. (2012). Kinetics of simultaneous leaching of Ag and Pb from hydrometallurgical zinc residues by chloride. *Rare Metals*, 31, 402–409. <https://doi.org/10.1007/s12598-012-0528-1>
15. Qiang, L., Cun-xiong, L., Zhi-hui, G., Chang-wen, L., & Qi-liang, W. (2024). Study on pre-oxidation of silver concentrate and leaching behaviour of Zn, Cu and In during oxygen-pressure leaching. *Hydrometallurgy*, 228, Article 106358. <https://doi.org/10.1016/j.hydromet.2024.106358>

Proofreader: Zokir ALIBEKOV

Layout and Designer: Oloviddin Sobir ugli

2026. № 10

© When materials are reproduced, the INNOVATION SCIENCE AND TECHNOLOGY journal must be cited as the source. Authors are responsible for the accuracy of the information in materials and advertisements published in the journal. Editorial opinions may not always align with those of the authors. Submitted materials will not be returned to the editorial office.

To publish articles in this journal, you may submit articles, advertisements, stories, and other creative materials through the following links. Materials and advertisements are published on a paid basis.

You may subscribe to the journal at any time using the following details. Once subscribed, please send a screenshot or photo of your payment confirmation to our Telegram page @iqtisodiyot_77. Based on this, we will send the latest issue of the journal to your address each month.

“The journal “INNOVATION SCIENCE AND TECHNOLOGY” has been registered by the Agency for Information and Mass Communications under the Administration of the President of the Republic of Uzbekistan from 09.10.2024 under the registration number №390637. License number: C-5669633. PNFL: 30407832680027

Our address: Tashkent city, Yunusobod district, 19th block,
House 17.



Acceptance of articles

Published every
monthly



Directions

Social, economic, political,
technological, scientific



Scopus || Scientific electronic journal specializing in Scopus

CERTIFICATE NUMBER: №390637

**ORDER NUMBER ACCORDING TO
THE LICENSE REGISTER: C-5669633**

CONTACT:



Contact us
+998 50 737 87 88



Telegram channel
t.me/scopus_IST2100



Journal official website
<https://ist-journal.uz/index.php/IST>