

POSSIBILITIES OF TREATMENT AND UTILIZATION OF SLUDGES FROM DESULPHATION OF MINE WATERS

MOŽNOSTI ÚPRAVY A DALŠÍHO VYUČITÍ KALŮ Z PROCESU DESULFATACE DŮLNÍCH VOD

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Abstrakt

In this contribution problems of sludges produced during the desulphation process of mine waters is solved, developed in the Institute of Environmental Engineering, Faculty of Mining and Geology, VSB-TU Ostrava. The sludge comes from chemical precipitation of sulphate ions during their reaction with a combination of ions Ca^{2+} , Al^{3+} , OH^- , AlO_2^- . The laboratory tests were done on the mine water samples from the locality of the pit Jiří, Sokolovská uhelná, právní nástupce a.s.. These waters are loaded by a high concentration of sulphate ions ($1\ 100\ \text{mg.l}^{-1}$) and low pH (2,8).

The first part was specialized on testing of efficiency of the desulphation method of IEI-HGF, VSB-TU. The next part was focused on a possibility of utilization of the sludges as donors of aluminium ions, repeatedly usable in the process of desulphation.

Abstrakt

V předloženém příspěvku je řešena problematika kalů, vznikajících při procesu desulfatace důlních vod, vyvinutém na Institutu environmentálního inženýrství Hornicko-geologické fakulty, VŠB-TU Ostrava (dále jen IEI-HGF, VŠB-TU Ostrava). Jde o kal vznikající chemickým srážením síranů, při reakci síranů s kombinací vnesených iontů Ca^{2+} , Al^{3+} , OH^- , AlO_2^- . Testy byly provedeny na vzorcích důlních vod lokality velkolomu Jiří, Sokolovská uhelná, právní nástupce a.s. Tyto vody jsou zatíženy vysokou koncentrací síranů (cca $1\ 100\ \text{mg.l}^{-1}$) a nízkým pH (2,8).

První část byla zaměřena na testování účinnosti desulfatace dle metody IEI-HGF, VŠB-TU Ostrava. Další část byla zaměřena na možnost využití vzniklého kalu jako donoru hlinitých iontů, opětovně využitelných v procesu desulfatace.

Key words: mine water, desulphation, sewage sludge, desulphation sludge, recovery

1 INTRODUCTION

In the areas with an intensive mineral working the issue of Acid Mine Drainage (AMD) is solved. The occurrence of acid mine waters is bound to the process of decomposition of sulphide ores whose gist is chemical and biological oxidation of sulphide minerals. Mine waters are enriched by

metal cations, predominantly Fe^{2+} , Fe^{3+} , Mn^{2+} , Cu^{2+} and others, depending on the type of the mined raw material. Anions are represented the most by SO_4^{2-} ions.

One of the significant producers of acid mine waters in the Czech republic is the company Sokolovská uhelná, právní nástupce a.s., Sokolov. The company deals with brown coal mining, manufacture and distribution of electric and heat energy. Today the brown coal mining runs wholly in a way of surface workings in two pits - Jiří and Družba. The area of research was acid mine water from the pit Jiří that is distinguished especially by low pH and a high concentration of SO_4^{2-} ions. Those waters are piped to the mine water treatment plant Svatava (hereinafter referred to as ÚVD Svatava) together with mine waters of the pit Medard.

Contemporary treatment processes (or purification) of mine waters at ÚVD Svatava are:

- water alkalization and subsequent oxidation
- gravity-operated separation and mechanical dewatering of sewage sludge

The treated mine water is drained into the Svatava river. The method and conditions of the draining of mine waters are regulated by the decision of the Regional Authority of the Karlové Vary Region, Department of Environment and Agriculture, ref no. 3899/ZZ/05.

Pursuant to an assessment of the data available it can be stated that treated mine water at the drainage from ÚVD Svatava shows higher concentrations of SO_4^{2-} than the maximum concentration of sulphates for surface waters permitted (300 mg.l^{-1}). In some cases the sulphates concentration (annual maximum) is at the very boundary of the limit regulated by the permission for water using.

1.1 CHEMICAL PRECIPITATION OF SULPHATES ACCORDING TO METHODOLOGY OF IEI-HGF, VSB-TU OSTRAVA

In the research workplace of IEI-HGF, VSB-TU Ostrava the technology of removal of over-limit contents of sulphates from mine waters and other sulphate waste waters by chemical precipitation was in the past developed and operationally verified.

The technology developed by IEI-HGF involves the operations as follows [1]:

- *Alkalization of mine waters* to $\text{pH}=11-12,6$ with calcium hydroxide and separation of the sludge occurred by the sedimentation and filtration processes
- *Chemical precipitation of sulphates by aluminium salts* (containing ions Al^{3+} or AlO_2^-) and separation of the desulphation sludge occurred by the sedimentation and pressure filtration processes
- *Neutralization of desulphated water* by liquid CO_2 and separation of the neutralization sludge by the sedimentation and pressure filtration processes

By the technology above several types of the sewage sludge are produced [15]:

- *Alkaline sludge* - contains besides $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ also the solid phase of $\text{Ca}(\text{OH})_2$ and hydroxides of next metals. The sludge is medium-disperse and fast settling even without an addition of flocculating agents.
- *Desulphation sludge* - contains predominantly a solid ettringitic component and hydrated calcium aluminates. It is gently disperse and viscous, very hard to settle down. The settling speed can be increased twice by addition of a selected flocculant.
- *Neutralization sludge* - contains calcium carbonates and calcium bicarbonates. It is medium-disperse and fast settling even without an addition of flocculating agents.

New precipitated desulphation sludge is gently disperse, viscous and very hard to settle. The settling speed can be increased twice by addition of a selected flocculant. The sludges alkaline and

neutralization are predominantly medium-disperse and fast settling even without an addition of flocculating agents [1].

An advantage of the precipitating procedure is a reduction of the concentration of sulphate ions together with a reduction of the concentration of metals present.

One of the goals of the research was to verify efficiency of mine waters desulphation according to the methodology of IEI-HGF, VSB-TU Ostrava.

The next goal of the research is a way of handling with all sewage sludge occurring during the process of desulphation of the mine waters in question. Today in our workplace physical and physico-chemical properties of the sludge are studied in detail focused on a possibility assessment of its further technological utilization and closing the treatment technology of the objective mine waters as wasteless technology.

In this contribution the main attention is paid to some results of the research connected with the assessment of a possibility to recover the sewage sludge for own precipitating reaction of sulphates. The sludge was tested in two directions. The first was desulphating effect testing of the raw and heat-treated sewage sludge and desulphation sludge in crude mine water. The next area was to obtain aluminous ions by leaching of the sewage sludge in 10% H_2SO_4 and their reuse in the desulphation process.

2 SAMPLES AND METHODS USED

Samples of mine water from the locality of the company Sokolovská uhelná, právní nástupce a.s. were used for testing, in particular the samples of mine water from the pit Jiří taken from the fuel filling station Lomnice. The analysis of the mine waters samples was performed in the laboratory of IEI-HGF. The average results of the analyses are presented in Tab.1.

Tab.1: Analysis of mine waters of the pit Jiří

<i>pH</i>	<i>c(Mn)</i> [mg.l ⁻¹]	<i>c(Fe)</i> [mg.l ⁻¹]	<i>c(Al³⁺)</i> [mg.l ⁻¹]	<i>c(SO₄²⁻)</i> [mg.l ⁻¹]	<i>c(RL)</i> [mg.l ⁻¹]
2,8	6,79	12,90	12,52	1 117	2 260

2.1 MINE WATERS DESULPHATION

The laboratory tests of chemical desulphation of mine water according to the method of IEI-HGF, VSB-TU Ostrava were running in the following steps:

1. Alkalinization of the sample of mine water to pH=12,5 (±0,1) with calcium hydroxide
 - its output is the alkaline sludge
2. Chemical precipitation of sulphates by aluminium salts
 - its output is the desulphation sludge
3. Filtration

In the filtrate pH, concentrations of sulphate ions (SO_4^{2-}) and concentrations of aluminium ions (Al^{3+}) were determined. Referentially the desulphation effect was verified by the mere alkalinization of mine water with calcium hydroxide. The precipitating tests were performed with the 500 ml mine water samples.

The sewage sludge and the desulphation sludge occurred were further tested as donors of aluminium ions and also as Al-reactant in the process of the mine waters desulphation. In total 6 types of sludges were tested differing in a way of their preparation and their thermal treatment (see Tab.2).

Tab.2: Desulphation sludge and sewage sludge, description of preparation and further treatment

Sludge sample identification	Preparation of DS and SS (desulphatation process)	Thermal treatment [°C]
DS	- alkalinization of mine water - filtration of alkaline sludge - chemical precipitation - filtration of desulphation sludge	-
DS 105		105
DS 600		600
SS	- alkalinization of mine water - chemical precipitation - filtration of sewage sludge	-
SS 105		105
SS 600		600

Note: DS - desulphation sludge, SS - sewage sludge

Sludge samples were analyzed by the method of X-ray fluorescence spectrometry (XRFS) according to SOP no.OAA-07-01. The results are given in Tab.3.

Tab.3: Composition of desulphation and sewage sludge dried at 105°C

XRFS		DS 105	SS 105
Parameter			
Na₂O	%mass	<1	<1
MgO	%mass	<0,3	2,2±0,4
Al₂O₃	%mass	13,7±1,4	13,7±1,4
SiO₂	%mass	<0,2	0,31±0,04
P₂O₅	%mass	<0,05	<0,05
SO₃	%mass	18,1±1,9	26,8±2,7
K₂O	%mass	<0,04	<0,04
CaO	%mass	32,3±3,3	34,3±3,5
TiO₂	%mass	0,0062±0,0007	0,0070±0,0007
MnO	%mass	<0,002	0,117±0,012
Fe₂O₃	%mass	0,037±0,004	0,190±0,019

2.2 TESTING OF DESULPHATION SLUDGE AND SEWAGE SLUDGE

A goal of the testing of the desulphation sludge and the sewage sludge utilization as reactants for primary precipitation of sulphates namely in the form of a solid phase sample and in the form of a recovered Al-solution sample. The samples of the desulphation sludge and the sewage sludge were tested on crude mine water according to the following procedure:

- a) Testing of the desulphation sludge and the sewage sludge on crude mine water - without pH treatment
 - Dosing of a measured sample of the sludge into 500 ml mine water
 - Fast mixing for the period of 30 minutes
 - Filtration and analysis of the filtrate

- b) Testing of the desulphation sludge and the sewage sludge on crude mine water - with pH

treatment by up to 12,5 ($\pm 0,1$)

- Dosing of a measured sample of the sludge into 500 ml mine water
 - Fast mixing for the period of 10 minutes
 - Alkalinization with calcium hydroxide
 - Fast mixing for the period of 20 minutes
 - Filtration and analysis of the filtrate
- c) Recovery of aluminium ions by leaching of the fresh sewage sludge in 10% H_2SO_4
- Transfer of Al^{3+} ions into the solution by leaching of the fresh sewage sludge in 10% H_2SO_4 (pH below 4)
 - Filtration of the solid residue
 - Filtrate treatment (pH below 4) by the NaOH solution by up to pH 7 (precipitation of Al^{3+} ions)
 - Filtration of the occurred precipitate
 - Dissolution of the precipitate by NaOH solution (into the state close to saturation)
 - Dosing of occurred sodium aluminate into the desulphation process

3 RESULTS

3.1 MINE WATERS DESULPHATION

Precipitation of SO_4^{2-} ions by high alkalinization using $\text{Ca}(\text{OH})_2$ is confirmed as ineffective. Sulphates are eliminated at pH=12,6 only with efficiency about 17 %.

When using the IEI-HGF method nearly one hundred percent efficiency (99%) of SO_4^{2-} ions elimination was achieved. Into the desulphation process 0.6 g of crystalline sodium aluminate was put per 500 ml of mine water. The quantity matches to 160 mg of Al^{3+} (i.e. 320 mg Al^{3+} per 1 liter of treated mine water).

It follows from the results of the filtrate analysis after desulphation (see Tab.4) that in the sewage sludge are bound nearly all introduced Al^{3+} ions.

Tab.4: Filtrate analysis after desulphation

TRIAL	filtrate pH	$c(\text{SO}_4^{2-})$ [mg.l ⁻¹]	$c(\text{Al}^{3+})$ [mg.l ⁻¹]	η [%]
1	12,56	18,2	0,9	98,36
2	12,58	7,8	0	99,30
3	12,54	21,8	0,4	98,05
4	12,58	13,4	1	98,81
5	12,57	8,6	0	99,23
6	12,56	10,6	0,35	99,05

Note: $c(\text{SO}_4^{2-})$ – concentration of sulphate ions in filtrate, $c(\text{Al}^{3+})$ – concentration of aluminium ions in filtrate, η – efficiency of sulphate ions separation

3.2 TESTING OF DESULPHATION SLUDGE AND SEWAGE SLUDGE IN CRUDE MINE WATER

Based on the above mentioned results of the desulphation samples of the sewage sludge and the desulphation sludge (with 99% desulphation efficiency) were prepared. The samples were homogenized and treated (see Tab.2). This way prepared and treated samples were tested in crude mine water. The desulphation efficiency was tracked.

It followed from the tests performed that the heat-treated desulphation sludge (DS 105, DS 600) and the sewage sludge (SS 105, SS 600) have no positive effect to sulphates elimination from waters. On the contrary the increase of sulphates concentrations by 50% and therewith associated increase of concentrations of solutes (back release of sulphates) occurred.

The test results of the fresh desulphation sludge (DS) and the fresh sewage sludge (SS) are given in Tab.5. Into mine water weighed portions of the fresh sludge were dosed.

Tab.5: Test results of fresh desulphation sludge (DS) and fresh sewage sludge (SS) in crude mine water

TRIAL	Sludge [g of solids]	filtrate pH	$c(\text{SO}_4^{2-})$ [mg.l ⁻¹]	$c(\text{Al}^{3+})$ [mg.l ⁻¹]	$c(\text{RL})$ [mg.l ⁻¹]
DS					
1	0,27	4,89	1 150	7,5	2 356
2	0,65	9,01	1 170	11,5	2 674
3	1,63	9,37	928	15,0	2 834
4	2,34	9,45	945	10,0	2 680
5	3,60	9,47	920	15,0	2 548
6	5,15	9,57	890	0,0	2 670
SS					
1	0,18	4,09	901	1,5	2 340
2	0,58	9,24	1 087	15,0	2 492
3	0,86	9,47	818	15,0	2 462
4	1,03	9,67	673	20,0	2 260
5	2,13	9,97	650	10,0	2 174
6	3,50	10,70	620	15,0	2 114
7	4,35	11,01	470	15,0	1 624
8	5,65	11,09	382	22,5	1 580

Note: Sludge - sludge dose, $c(\text{SO}_4^{2-})$ – concentration of sulphate ions, $c(\text{Al}^{3+})$ – concentration of aluminium ions in filtrate, $c(\text{RL})$ –

concentration of solutes in filtrate

Based on the results above it can be stated that the fresh prepared desulphation sludge and especially the sewage sludge have a positive effect to sulphates elimination from mine water. In case of the fresh desulphation sludge the decrease of the sulphates concentration occurred from 1 117 mg.l⁻¹ to 890 mg.l⁻¹ (20.32% desulphation efficiency). When using the fresh sewage sludge the sulphates concentration decreased from 1 117 mg.l⁻¹ to 382 mg.l⁻¹ (65.8% desulphation efficiency), which approaches to the maximum permitted sulphates concentration for surface waters (300 mg.l⁻¹).

From the measured pH values it is obvious that in any case the optimum pH for desulphation was not observed (which is 12.5±0.1). For this reason in the next step the desulphation of mine waters was tested using the fresh desulphation sludge and the sewage sludge also with simultaneous alkalization. The results are shown in Tables 6 and 7.

Tab.6: Test results of fresh sewage sludge (SS) in crude mine water with adjustment of pH

TRIAL	Sludge [g of solids]	Ca (OH) ₂ [g]	filtrate pH	c(SO ₄ ²⁻) [mg.l ⁻¹]	η [%]
1	2,14	-	10,92	623	44,23
2	2,29	-	11,00	613	45,12
3	2,45	-	11,47	612	45,21
4	3,94	-	12,38	540	51,66
5	4,38	-	12,42	503	54,97
6	4,99	-	12,46	463	58,55
1	2,57	1	12,08	603	46,02
2	2,67	1	12,34	562	49,69
3	2,75	1	12,44	555	50,27
4	3,72	0,15	12,15	475	57,48
5	3,72	0,28	12,40	400	64,19
6	3,72	0,35	12,50	289	74,13

Note: Sludge - sludge dose, Ca(OH)₂ - dose of calcium hydroxide, c(SO₄²⁻) – concentration of sulphate ions in filtrate, η – efficiency of separation of sulphate ions

Tab.7: Results of fresh sewage sludge (SS) in crude mine water with adjustment of pH

TRIAL	Sludge [g of solids]	Ca (OH) ₂ [g]	Filtrate pH	c(SO ₄ ²⁻) [mg.l ⁻¹]	η [%]
1	2,24	-	9,88	1 059	5,19
2	2,32	-	9,90	985	11,82
3	2,63	-	10,03	946	15,31
4	4,87	-	10,53	986	11,73
5	4,95	-	10,78	922	17,46
6	5,06	-	10,93	857	23,28
1	3,54	1,0	12,49	872	21,93
2	3,69	1,0	12,34	843	24,53
3	3,89	1,0	12,68	782	29,99
4	4,28	0,6	12,29	615	44,94
5	4,58	1,2	12,66	477	57,30

Note: Sludge - sludge dose, Ca(OH)₂ - dose of calcium hydroxide, c(SO₄²⁻) – concentration of sulphate ions in filtrate, η – efficiency of separation of sulphate ions

It is obvious from the results that when observing the optimum pH of the desulphation process (i.e. 12.5±0.1) a higher efficiency of the sulphate ions separation can be achieved.

3.3 RECOVERY OF SEWAGE SLUDGE AS DONOR OF ALUMINIUM IONS BY LEACHING IN 10% H₂SO₄

For these tests the fresh sewage sludge was used prepared according to the IEI-HGF method with 99% desulphation efficiency. As mentioned above into the desulphation process 160 mg of aluminium ions were put per 500 ml of mine water. In the occurred sewage sludge nearly all Al³⁺ ions put into the reaction were represented (see Tab.4).

For release of aluminium ions into the solution 10% H₂SO₄ was used. The doses were selected so slurry pH to reach the limit of the selective release of Al³⁺ ions (i.e. close below pH=4) [2]. The solid residue after leaching was filtrated and in the filtrate (ca 100 ml) pH, c(Al³⁺) and c(SO₄²⁻) were determined (see Tab.8).

Tab.8: Filtrate analysis results after leaching of sewage sludge in 10% H₂SO₄

TRIAL	Sludge [g]	Distilled water [ml]	10% H ₂ SO ₄ [ml]	Filtrate pH	c(Al ³⁺) [mg.l ⁻¹]	c(SO ₄ ²⁻) [mg.l ⁻¹]
1	32,27	88	12	3,60	1 600	9 550
2	33,21	88	12	3,66	1 600	10 070
3	21,54	88	12	3,67	1 600	9 528
4	22,43	89	11	3,93	1 600	9 126
5	27,02	89	11	3,96	1 600	9 989
6	28,17	89	11	3,94	1 600	10 000

Note: sludge – sludge dose, 10% H₂SO₄ - sulphuric acid dose, c(Al³⁺) – concentration of aluminium ions in filtrate, c(SO₄²⁻) – concentration of sulphate ions in filtrate

The samples of the sewage sludge and its solid residue after leaching in 10% H₂SO₄ were analyzed using the X-ray fluorescence spectrometry (XRFS) according to SOP no.OAA-07-01. The results are presented in Tab.9.

Tab.9: Composition of sewage sludge and solid residue after its leaching in 10% H₂SO₄

XRFS		SS 105	SLUDGE AFTER LEACHING IN 10% H ₂ SO ₄ (dried at 105°C)
Parameter			
Na ₂ O	% mass	<1	<1
MgO	% mass	2,2±0,4	<0,3
Al ₂ O ₃	% mass	13,7±1,4	<0,2
SiO ₂	% mass	0,31±0,04	<0,1
P ₂ O ₅	% mass	<0,05	<0,05
SO ₃	% mass	26,8±2,7	48,2±4,9
K ₂ O	% mass	<0,04	<0,03
CaO	% mass	34,3±3,5	27,9±2,8
TiO ₂	% mass	0,0070±0,0007	0,0033±0,0004
MnO	% mass	0,117±0,012	0,047±0,005
Fe ₂ O ₃	% mass	0,190±0,019	0,168±0,017

From Tab.8 it is obvious that when leaching the sewage sludge in 10% H₂SO₄ release of all Al³⁺ ions that were put into the desulphation process occurred.

The aluminium ions were further precipitated by 30% NaOH. A sodium hydroxide dose was chosen so the slurry pH to be about 7. The precipitate was filtrated and in the filtrate (100 ml) the residual concentrations of Al³⁺ and SO₄²⁻ were determined. The results are presented in Tab.10.

Tab.10: Filtrate specification after precipitation of Al^{3+} ions from 30% NaOH solution

TRIAL	pH after dosing of 30% NaOH	$c(\text{Al}^{3+})$ [mg.l^{-1}]	$c(\text{SO}_4^{2-})$ [mg.l^{-1}]
1	6,82	0	9 450
2	6,47	0	10 000
3	6,42	0	9 516
4	7,05	0	9 115
5	6,32	0	9 962
6	6,55	0	9 978

From the solution (containing 100% of aluminium ions that were put into the desulphation process) 100% of Al^{3+} ions was precipitated. The precipitate (containing Al^{3+} ions) was further solved by a minimum required addition of 30% NaOH. The occurred concentrated solution of sodium aluminate was then volumetrically dosed into the desulphation process of mine water:

- Alkalinization of mine water with calcium hydroxide by up to $\text{pH}=12,5\pm 0,1$
 - mixing for the period of 10 minutes at 250 rpm
- Dosing of sodium aluminate solution (recovered)
 - mixing for the period of 30 minutes at 250 rpm
- Filtration of sewage sludge
 - determination of pH and $c(\text{SO}_4^{2-})$ in filtrate

The results of the desulphation using recovered sodium aluminate are given in Tab.11.

Tab.11: Results of desulphation using recovered sodium aluminate

TRIAL	Filtrate pH	$c(\text{SO}_4^{2-})$ (mg.l^{-1})	η (%)
1	12,58	742	49,18
2	12,53	716	50,59
3	12,49	667	54,32
4	12,59	689	52,81
5	12,55	725	50,34
6	12,58	659	54,87

Note: $c(\text{SO}_4^{2-})$ – concentration of sulphate ions in filtrate, η – efficiency of sulphate ions separation

4 CONCLUSION

It follows from the results found out that the chemical precipitation of sulphates according to the described desulphation methodology of IEI-HGF, VSB-TU Ostrava is for mine waters from the locality of the pit Jiří, Sokolovská uhelná, právní nástupce a.s. highly efficient (sulphates reduction efficiency achieves nearly 100%).

The research results confirm also the possibility of resolving the sludge terminal of the desulphation technology. Considering the composition of the occurring sludges a possibility of their reutilization (as donors of aluminium ions) in the desulphation process was proved.

The positive effect onto the desulphation revealed itself when using the fresh sewage sludge and the desulphation sludge without any previous treatment. Further, it can be said that from the fresh sewage sludge virtually 100% of aluminium ions put into the desulphation process can be

acquired by a chemical treatment. These ions in the form of recovered sodium aluminate can be reutilized in the desulphation process and so a significant part of the initial agent can be replaced.

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RESUMÉ

Kyselé důlní vody (AMD) jsou jedním z negativních vlivů těžby na životní prostředí. Jedním z významných producentů kyselých důlních vod v ČR je Sokolovská uhelná, právní nástupce a.s., Sokolov. Tyto vody jsou zatíženy především vysokou koncentrací iontů SO_4^{2-} .

Na Institutu environmentálního inženýrství byla vyvinuta metoda desulfatace důlních vod, založená na chemickém srážení, využívající kombinaci iontů Ca^{2+} , OH^- , AlO_2^- (mohou být vysráženy jako Al^{3+}). Produktem je vyčištěná voda a čistírenský kal, jehož dominantní složkou je hydratovaný síran hlinitovápenatý (ettringit).

Cílem dalšího výzkumu je způsob nakládání s veškerým čistírenským kalem, vznikajícím při procesu desulfatace důlních vod. V současnosti jsou na našem pracovišti podrobně studovány fyzikální a fyzikálně chemické vlastnosti tohoto kalu se záměrem posoudit možnosti jeho dalšího technologického využití a uzavření technologie úpravy předmětných důlních vod jako technologie bezodpadové.

Článek se zabývá posouzením možnosti regenerace ettringitového kalu pro vlastní srážecí reakci síranů. Kal byl testován dvěma směry. Prvním bylo testování desulfatačního účinku surového a tepelně upraveného čistírenského a desulfatačního kalu v surové důlní vodě. Druhou oblastí bylo získání hlinitých iontů loužením čistírenského kalu v 10% H_2SO_4 a jejich zpětné využití v procesu desulfatace.

Positivních výsledků bylo dosaženo při použití čerstvého čistírenského a desulfatačního kalu, bez jakékoliv jeho předešlé úpravy. Dále lze konstatovat, že z čerstvého čistírenského kalu lze chemickou úpravou získat prakticky 100% hlinitých iontů, vnesených do procesu desulfatace. Tyto ionty lze ve formě regenerovaného hlinitanu sodného zpět použít v procesu desulfatace a nahradit tak významnou část prvotního činidla.