GOLDER

ATTACHMENT C

NALGE TREATABILITY STUDY REPORT

Report

On the Laboratory Study of the Possibility of Using and Technology of Purification of Quarry Water Obtained from JSC RMG Copper Dumping Sites NN3 and 4

The report is based on the results of the laboratory modeling of quarry waters purification from a wide range of heavy metals.

Laboratory study period: 10.04.2018 - 12.04.2018, repeated 29.05.2018 - 31.05.2018

Objective: Laboratory modeling of process flow by wastewater liming method.

Stream characteristics: The quarry water from dumping sites 3 and 4, hereinafter WD3 and WD4 are characterized by low pH and high concentrations of heavy metals (mainly contamination is determined by Cu, Zn, Fe, Mn), high hardness both general and by calcium. According to analytical data, the content of Cd <2 mg/l. Sulfates content <19000 mg/l. The maximum formation of stream is WD3 – 10 m^3/h, WD4 – 8 m^3/h.

JSC RMG Copper specialists have selected water samples from both streams for laboratory works.

Maximum permissible norms of quarry waters discharge to the surface water body are presented in the table below:

Table 01

Element	**Norm, mg/l**
Suspended matters	60
Chrome (6+)	0.1
Nickel (2+)	1.0
Iron	0.3
Copper	1.0
Magnesium	0.1
pH	6.5 – 8.5
Cadmium	less than 0.001
Sulfates	less than 500
Manganese	less than 0.02

The content of the metals in the streams is many times higher than the maximum permissible norm of discharge in a surface water body, which makes the repeated use of water unsuitable. On the other hand, the content of metals is not high enough to make cost-effective their recovery from water. Therefore, the only acceptable method is to clean the water by transiting metals to the insoluble state with its further sedimentation in kind of slurry.

Work progress

Selected method – liming with further coagulation and flocculation. When selecting the mixing method (mechanical mixing or aeration mixing) during the lime treatment the choice was made on the aeration mixing, because during the mechanical mixing the sediment crystals mature unevenly, making difficult their sedimentation and resulting in a significant amount of content of suspended matters in the water. In addition, Mn content in the water is high and its sedimentation requires the oxidative reaction that is provided only by the aeration mixing.

Materials:

- Construction lime, with up to 80% of CaO + MgO in the primary product.
- coagulant "Nalco 77139"
- "Nalco" flocculants set

For liming there were prepared the 12% working solution of the construction lime (the lime milk) expressed as CaO + MgO, the 1% iron-containing coagulant "Nalco 77139" and working solutions with 0.1% and 0.05% flocculant.

The use of lime milk of relatively low concentrations is permitted in the technological process. As a result the solution is prepared with a relatively low exothermic reaction, but the initial amount of lime increases.

The use of iron-containing coagulant depends on the demand for additional formation of sediment crystals.

Course of operations:

- Determination of the demand for lime content in the treatment solution. During the first test, pH was brought to 9.8-10.1. Bringing pH to this value is conditioned by the demand for sedimentation of not only the heavy metals but also magnesium, which removal requires the excess of calcium in the mixture. In the course of the second test in kind of the experiment, pH was reduced to 9.6 – 9.8, which did not affect the efficiency of removing metals from the wastewater.
- The volume of samples is 1 liter. Before supply of the lime milk the samples WD3 and WD4 were aerated. Aeration (see photo 1) was carried out with compressor, with air flow of 2 l/min on each sample. Two samples were treated simultaneously. Exposure time - 30 minutes. This exposure time ensures the in-depth neutralization of the stream,

sedimentation of metals in kind of hydroxides and enables pH adjustment if its value is insufficient. At the first stage of the conducted experiments, the detected demand for lime milk in the two streams of water was 54-56 ml/l. During the repeated study, the demand for lime amounted to 61-66 ml/l per sample, taking into account the increase of sulfates in the stream.

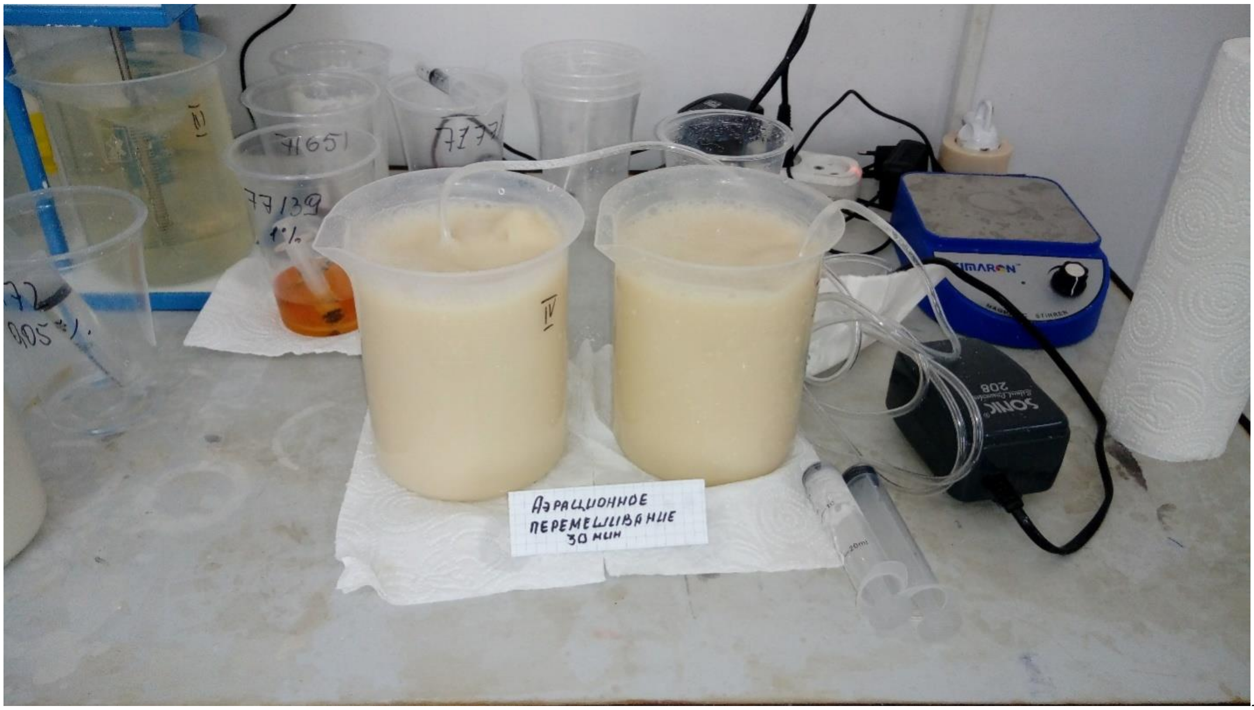


Photo 1. Aeration mixing of samples with lime milk

- 5 minutes before the end of the aeration 1% solution of coagulant 77139 was added, with the dose of 150 ppm. Comparing the samples with and without coagulants, it is revealed that the process of coarsening of the sediment crystals is much faster as a result of addition of coagulant that make the further treatment of streams easier. The concentration of suspended matters in neutralized streams is given in the table below:

Table 02

Parameters	WD3		WD4	
Date	12.04.18	29.05.18	12.04.18	29.05.18
Suspended particles, g/l	31.83	37.083	27.04	33.998

Increase in the concentrations of suspended particles, which have been produced in the repeated test, can be explained by the increased content of sulfates in the streams, and hence, the increase in the lime milk consumption.

- The flocculant was selected to increase the effectiveness of the process. Concentration of the working solution – 0.05%; the use of more concentrated solution has resulted in improper flaking, which in turn results from the inadequate mixing of slurry and flocculant. Selection of flocculants was done by a flocculating test method. The optimal product was selected according to the residual content of the suspended mattes in the samples and transparency of supernatant liquid which was saturated with lime as a result of mechanical and aerated mixing. The results are presented in the table below:

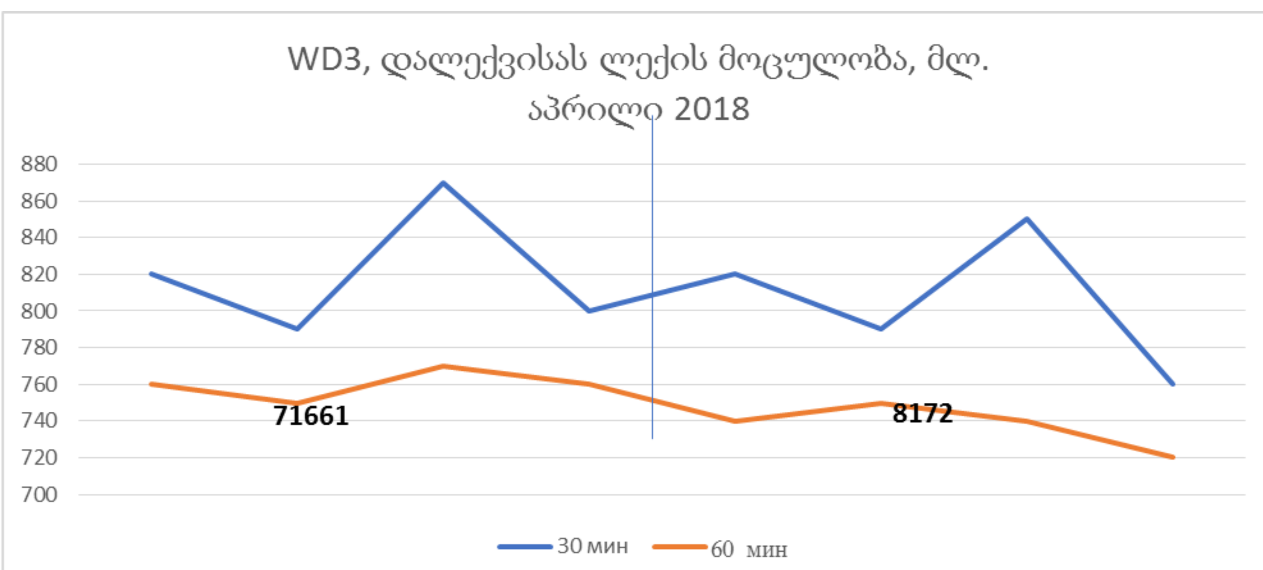
Table 03

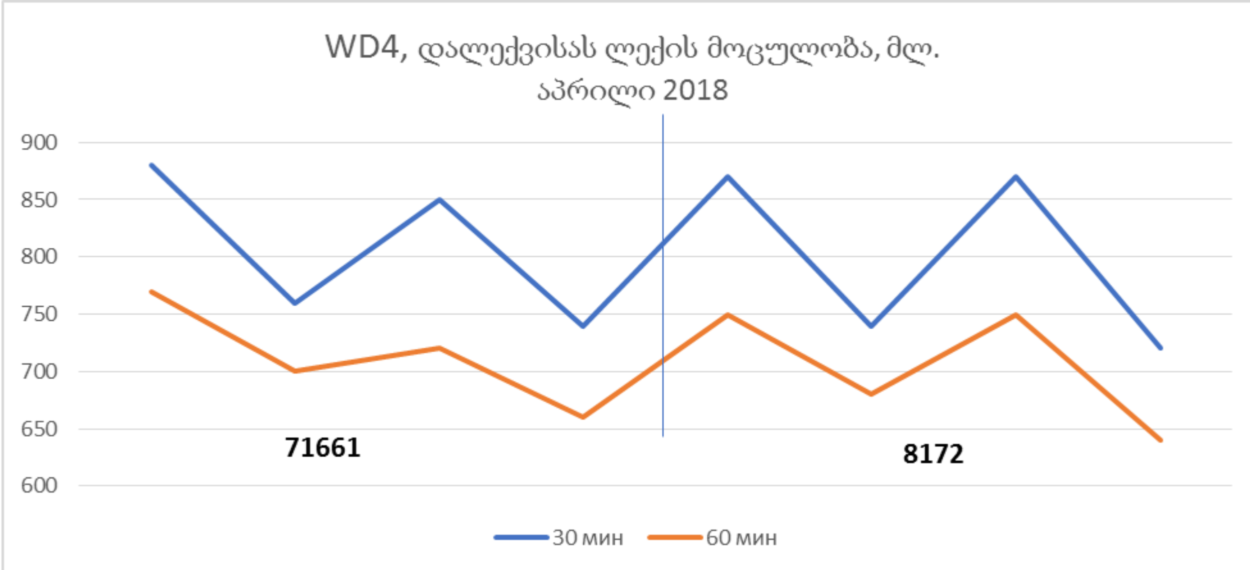
Product	Dosing mg/l	Parameters	Mechanical mixing		Aerated mixing	
			WD3	WD4	WD3	WD4
9601	16.5	Suspended matters, mg/l	2	4	2	8
		Transparency FAU	10	6	4	10
71661	16.5	Suspended matters, mg/l	8	3	4	3
		Transparency FAU	8	3	3	4
8172	16.5	Suspended matters, mg/l	3	4	2	3
		Transparency FAU	3	4	3	3

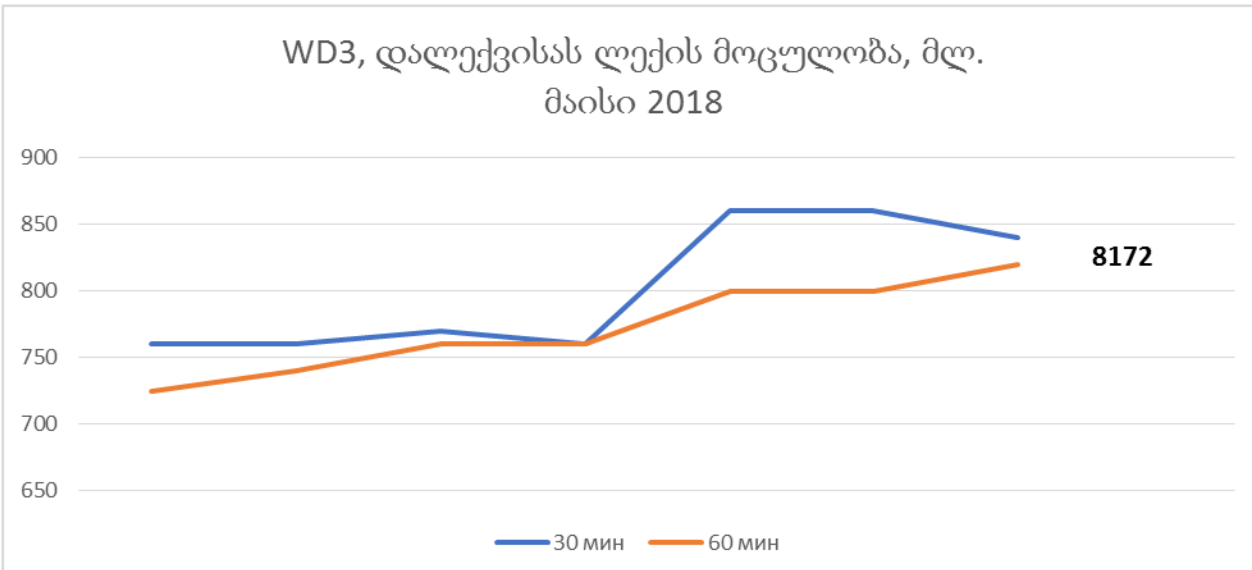
Based on the results obtained, flocculants 71661 and 8172 were used for aerated mixing in the further studies.

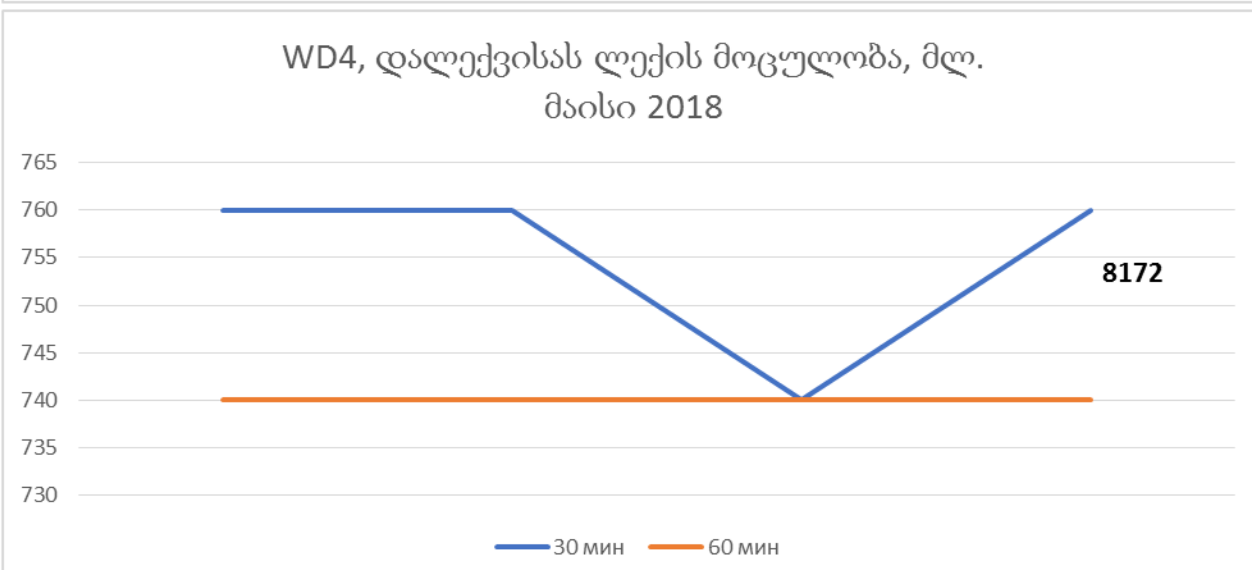
- In the process of simulating the sedimentation process, the treated samples were settled totally in 11 graduated measuring cylinders and 11 graduated measuring jars.

The sediment amount and supernatant benchmarks after 30 and 60 minutes




WD4, დალექვისას ლექის მოცულობა, მლ.
აპრილი 2018
900
850
800
750
700
650
600
71661
8172
30 мин
60 мин


WD3, დალექვისას ლექის მოცულობა, მლ.
მაისი 2018
900
850
800
750
700
650
8172
30 мин
60 мин


WD4, დალექვისას ლექის მოცულობა, მლ.
მაისი 2018
765
760
755
750
745
740
735
730
8172
30 мин
60 мин

During the settling in the cylinders, the volume of the sediment is practically always higher than during settling in the jars. In fact, all the peaks in charts are the result of the sedimentation in cylinders in April 2018. Compared to the average volume of the sediment produced as a result of the use of flocculants 71661 and 8172, it was found that product 8172 better hardens the sediment. The aforementioned flocculant also shows optimal results according to the suspended matters in the cleaned stream and transparency. The repeated study was carried out using flocculant 8172 and settling in the graduated jar.

The average volume of sediment formation for the stream after 1 hour hardening is :

- WD3 - 730 - 770 l/m^3 stream, the total volume of slurry formation is 7.3 to 7.7 m^3/h or 176 - 185 m^3/day.
- WD4 - 660 - 740 l/m^3 stream, the total volume of slurry formation is 5.3-5.9 m^3/h or 127 - 142 m^3/day.

The pulp moisture after the liming process is: WD3 - 96.8 - 96.3%, WD4 - 96 – 97.3%. Preliminary hardening is necessary to reduce the volume of the output sediment. The content of solids in the hardened sediment after 1 hour is: WD3 – 50.82 g/l, humidity 94.92%, WD4 - 46.14 g/l, humidity 95.4%.

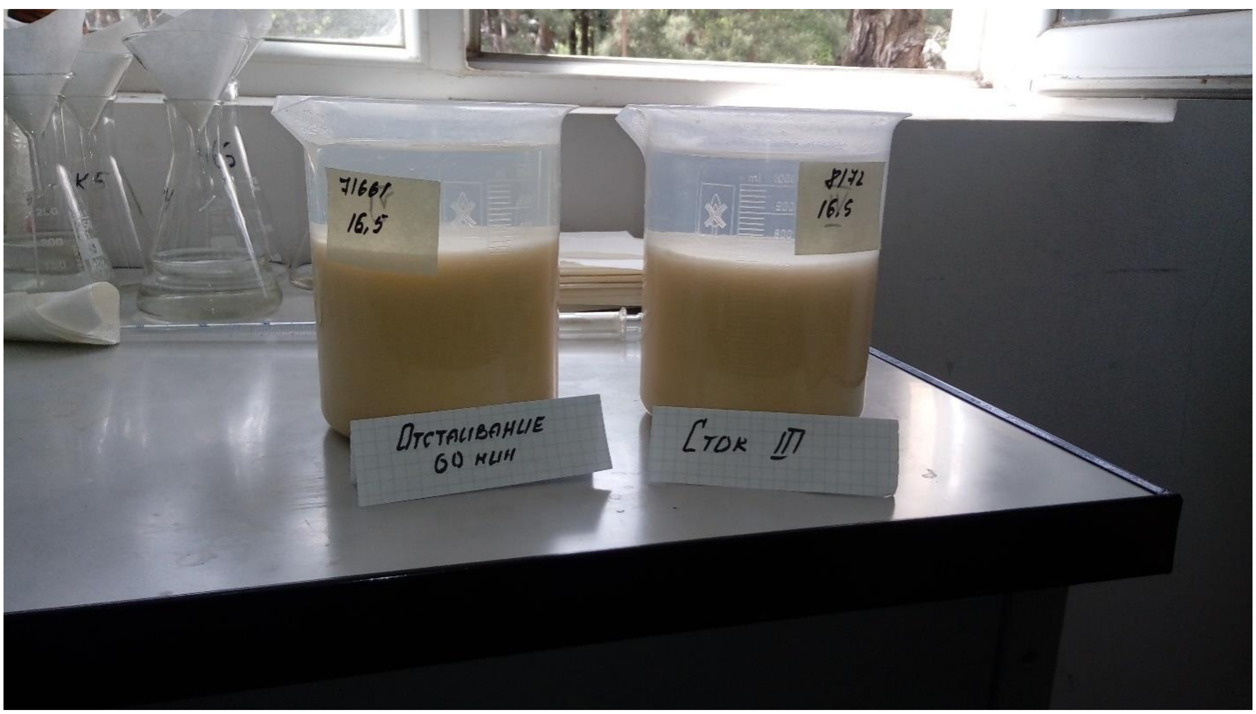


Photo 2. The sedimentation process in jars. Cleaned water is above, slurry is below.

When comparing sedimentation the hardening during settling in the jars is more effective than in cylinders due to a relatively large space.

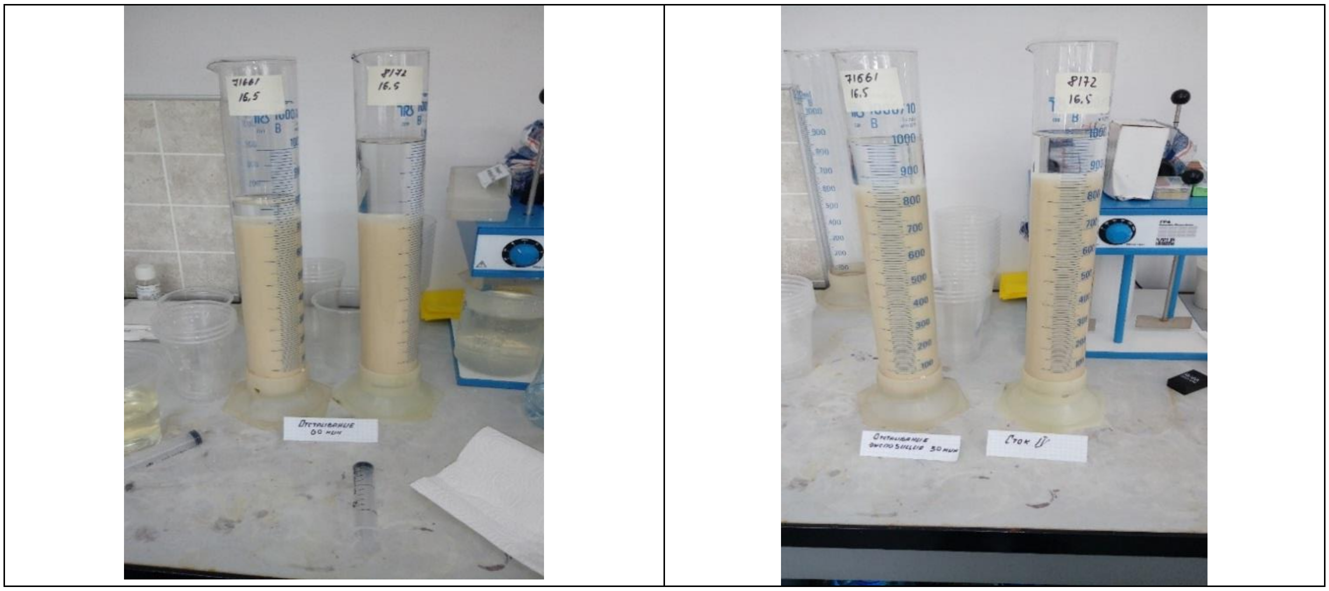


Photo 2. Sedimentation process in cylinders. Cleaned water is above, slurry is below.

The analytical data according to the initial and averaged, treated samples are given in the table below:

Table 04

WD3 - sample volume 1l, April 2018.

Benchmarks	Initial stream	Sample	Initial stream	Sample	Effectiveness, %
Selection date	10.04.2018	11.04.2018	12.04.2018	12.04.2018	
Lime milk amount, ml/l	-	57	-	56 - 58	-
Dose 77139, mg/l	-	150	-	150	-
Focculant dose mg/l	-	16.5	-	16.5	-
Exposition time in aeration, min	-	30	-	30	-
Settling time, min	-	60	-	60	-
pH	2.8	9.9 – 10.1	3.3	9.9 – 10.2	-
Turbulence FAU	3	2	12	3	-
Suspended matters, mg/l	4	2	8	3	-
Sulfates, mg/l	18400	2100	17200	3050	85.427
Zn, mg/l	580.0	0.02	470.0	0.02	99.996
Cu, mg/l	49.,3	0.006	57.1	0.006	99.989
Ni, mg/l	0.81	<0.003	0.79	<0.003	99.625
Cd, mg/l	1.57	<0.001	1.6	<0.001	99.937
Fe total, mg/l	70.0	<0.2	63.0	<0.2	99.698

Mn, mg/l	170.0	<0.2	176.0	<0.2	99.884
Cr total, mg/l	<0.2	-	-	-	-
Total hardness, mg-eq/l	-	35.12	-		-
Ca, mg/l	-	692.6	-	-	-

Table 05

WD3 - sample volume 1l, May 2018.

Benchmarks	Initial stream	Sample	Sample	Effectiveness, %
Selection date	28.05.2018	29.05.2018	30.05.2018	
Lime milk amount, ml/l	-	65	66	-
Dose 77139, ppm	-	150	150	-
Focculant dose, ppm	-	16.5	16.5	-
Exposition time in aeration, min	-	30	30	-
Holding time, min	-	60	60	-
pH	3.3	10.2	9,5	-
Density FAU	13	9	9	-
Suspended matters, mg/l	11	9	9	-
Electric conductivity, mcm/cm	13.48	2.65	1.41	84.94
Sulfates, mg/l	19000	1700	1700	91.05
Zn, mg/l	484.0	0.02	0.02	99.996
Cu, mg/l	55.3	0.006	0.006	99.989
Ni, mg/l	0.79	<0.003	<0.003	99.620
Cd, mg/l	1.64	<0.001	<0.001	99.939
Total Fe, mg/l	75.0	<0.2	<0.2	99.733
Mn, mg/l	182.5	<0.2	<0.2	99.89
Ca, mg/l	-	721	1122	84.941

Table 06

WD4 - sample volume 1l, April 2018.

Benchmarks	Initial stream	Sample	Initial stream	Sample	Effectiveness, %
Selection date	10.04.2018	11.04.2018	12.04.2018	12.04.2018	
Lime milk amount, ml/l	-	56	-	56	-
Dose 77139, mg/l	-	150	-	150	-
Focculant dose mg/l	-	16.5	-	16.5	-
Exposition time in aeration, min	-	30	-	30	-
Holding time, min	-	60	-	60	-
pH	2.95	9.9 – 10.1	3.4	10.0 – 10.1	-

Turbulence FAU	10	2	20	3	-
Suspended matters, mg/l	9	2	11	3	-
Sulfates, mg/l	14800	2250	13600	2000	85.046
Zn, mg/l	273.0	0.01	292.0	0.01	99.995
Cu, mg/l	101.0	0.006	89.0	0.006	99.994
Ni, mg/l	0.64	<0.003	0.69	<0.003	99.548
Cd, mg/l	1.08	<0.001	1.05	<0.001	99.906
Fe total, mg/l	115.0	<0.2	87.0	<0.2	99.789
Mn, mg/l	147.0	<0.2	154.0	<0.2	99.867
Cr total, mg/l	<0.2	-	-	-	-
Total hardness, mg-eq/l	-	33.6	-	-	-
Ca, mg/l	-	673.3	-	-	-

Table 07

WD4 - sample volume 1l, May 2018.

Benchmarks	Initial stream	Sample	Effectiveness, %
Selection time	28.05.2018	30.05.2018	
Lime milk amount, ml/l	-	61	-
Dose 77139, mg/l	-	150	-
Flocculant dose, mg/l	-	16,5	-
Exposition time in aeration, min	-	30	-
Settling time, min	-	60	-
pH	3.2	9.9 – 10.1	-
Turbulence FAU	58	2	-
Suspended matters, mg/l	44	2	-
Elelctric conductivity, mcm/cm	11.67	2.67	77.12
Sulfates, mg/l	16400	1800	89.02
Zn, mg/l	293.0	0.01	99.997
Cu, mg/l	99.0	0.006	99.994
Ni, ∂ mg/l	0.69	<0.003	99.565
Cd, mg/l	1.04	<0.001	99.904
Total Fe, mg/l	165	<0.2	99.879
Mn, mg/l	155	<0.2	99.871
Ca, mg/l	-	737.3	-

“<” - means that the content of the component is less than the sensitivity of method of its determination.

The effectiveness of purification from heavy metals is almost 100%. The effectiveness of purification from sulfates is 85% for each stream; for neutralization of given streams the excess lime milk consumption is caused by sedimentation of sulfates in kind of gypsum, because as the result of the addition of the lime milk the gypsum begins to settle at first and partially the heavy metals hydroxides which content is high in the streams, and only thereafter the metals of relatively low concentration are settled. Nevertheless, treatment with lime does not provide approximation of the wastewater to the parameters that allow it to be discharged to the surface water body. Therefore, purification of the filtrate generated from cleaned water and sediment dehydration plant requires additional cleansing stages by preliminary neutralization via sulfuric acid to the desired value of PH, subsequent filtration or possible reverse osmosis whereby the generated concentrate should be returned to the neutralization reactor.

Ca content is quite high in the cleansing stream, and depending on the necessity of its concentration reduction it is recommended to use sodium carbonate in the equivalent quantity. In this case, this will require the additional field for preparation of 10% sodium carbonate treatment solution. The sodium carbonate solution is delivered to the neutralization reactor before the supply of coagulant 77139.

In the repeated laboratory studies the stream is also neutralized with 9.6% sulfuric acid solution, to bring the pH parameter to the maximum permissible limit of the discharge to the surface water body. With adding the sulfuric acid the finely divided gypsum sediment is formed; calcium content is reduced slightly. Results of neutralization of streams are shown in the table below.

Table 08

	WD3	WD4
Sulfuric acid consumption (concentration 9.6%), l/m^3	0.12	0.33
pH after neutralization	6.7	7.0
Electric conductivity before neutralization, mkcm/cm	1.41	2.67
Electric conductivity after neutralization, mkcm/cm	1.38	1.49

The obtained results show that the electrical conductivity is reduced after neutralization, which can be explained by the formation and sedimentation of gypsum.

Based on the obtained laboratory results we offer the following process flow:

Stage 01: Preliminary stream treatment

Wastewater contains a significant number of heavy mechanical impurities (pebbles, sand, etc.) that prevent the water purification process. Therefore, preliminary sedimentary tank is required to separate mechanical impurities, which in parallel performs the function of the buffer tank. The tank must include 2 sections with the overflow from the first section to the second. The preliminary holding shall take place in the first section. The second section shall be equipped with 2 suspended pumps – one operating and one backup with maximum capacity of 15 m^3/h each for WD3 and 11 m^3/h for WD4. The tank capacity shall be :

- For WD3 - First Section 10 m^3, Second Section – 5 m^3.
- For WD4 - First Section 8 m3, Second Section – 4 m^3.

The tank width to length ratio for the first section is 1:3. The second section should be designed as a pumping pit.

After the preliminary treatment, the streams shall be channeled to the neutralization reactor for treatment with lime .

Stage 02. Treatment with lime

Treatment with lime takes place in the corridor type reactors in which the constant aeration mixing is conducted in parallel and enables aeration of water treated with lime for 30-40 minutes. It is recommended to have the reactors with holding time of 40 minutes; if the volume of the streams increases, it will make possible to maintain the necessary mode of neutralization process.

The total volume of reactors shall take into consideration the lime milk volume. It is possible to disregard the coagulant 77139 volume. When calculating the volume of reactors in case of using the reverse osmosis, the volume of concentrate, which returns from the reverse osmosis stage must be taken into consideration.

Table 09

Stream	Volume, m^3/h	Lime milk consumption, m^3/h	Total stream volume on reactor, m^3	Holding time, min	Working volume of reactor, m^3
WD3	10	0.588 – 0.66	10.66	40	8.0
WD4	8	0.47 – 0.488	8.49	40	6.0

The final calculation of the reactor should be carried out during the design, after specification of all technological streams, including the amount of water used in the technological processes. Household and industrial and drainage water flows that are generated in the area of the plant must not be included in the technological process of stream treatment,

For the process of liming it is necessary to provide 2 points of the lime milk supply:

- The main point of supply should be placed at the beginning of the reactor directly at the point of stream supply - 55-56 l lime milk for 1 m^3 of wastewater.
- The second point of supply, the benchmark, should be placed at the reactor section so as to provide the like milk supply 10 minutes before the stream is discharged.

The process of treatment with lime milk should be carried out under the strict control of pH:

- The first measurement of pH – in the wastewater before its supply to the neutralization reactor, before adding the lime milk.
- The second measurement - before the benchmark of the lime milk supply to determine the demand for additional dosage of the lime milk.
- The third measurement - directly from the reactor to the stream outlet place, to control the effective level of pH.

Stage 03. Sediment hardness

The treated stream from neutralization reactors is transferred for hardening of the sediment. For the uninterrupted operation of the system it is advisable to arrange two parallel operating slurry concentrators. Hardening is carried out in vertical concentrators with a cone bottom, angle of slope 60°, with central supply of neutralized stream and channeling the purified water to peripherals, through the sided delivery chambers. The volume of the cylindrical part for each slurry concentrator should be: for WD3 - 10 m^3, stream for WD4 - 8 m^3. In front of the slurry concentrators there shall be installed a distribution chamber which distributes the stream between the slurry concentrators. Flocculant should be supplied directly to the distribution chamber, since the chamber is a zone of high turbulence.

The level of accumulated slurry should be controlled. After accumulation, the sediment should be pumped to the slurry collector, which is equipped with the intensive mechanical mixer to equalize the sediment homogenization and suspended matters concentration. In the given case, the use of aeration is not allowed due to the high content of solids. The capacity of the slurry collector shall not be less than 100m^3, which shall be specified when selecting the type of equipment and dehydration plant operation mode.

Stage 04. Dehydration of sediment

In order to reduce the moisture of the sediment, the sediment from the slurry collector should be directed to a dehydration plant.

The average hourly slurry consumption in the dehydration plant:

- WD3 -7.3 – 7.7 m^3/h or 176 - 185 m^3/day.

- WD4 -5.3 – 5.9 m^3/h or 127 - 142 m^3/day.

The chamber press filter is optimal for dehydration process, it is permissible to use vacuum filters as well. A team of JSC RMG Copper specialists will discuss the location of further placing of the dehydrated sediment and/or its further use.

The selection of capacity of the chamber press-filter depends on its operation mode. The continuous mode requires a relatively low-capacity plant and therefore less financial expenses. In addition, the volume of the slurry collector is reduced. However, in this case it is necessary to operate the plant continuously. In the case of periodic operation mode, a high-performance press-filter and a large volume of slurry collector should be required.

Stage 05. PH adjustment and final filtration

The water from the filtrates of the dehydrating plant and slurry concentrators is supplied to the cleaned streams receiving tank, which is equipped with mechanical mixers for equalizing the streams by concentrations and volumes. The time of holding in the receiving tank is equal to the hourly volume of the supplied stream. Average hourly water consumptions are given in the table below.

Table 10

Stream	Cleaned water consumption, m^3/h	Dehydration plant filtrate consumption, m^3/h	Total consumption, m^3/h	Tank volume, m^3
WD3	3.1	6.9	10	10
WD4	2.6	5.4	8	8

Further use of purified streams is recommended in technological processes, which eliminates the expenses for the further water cleansing. If necessary, in the receiving tank it is possible to adjust pH using sulfuric acid. In addition to pH adjustment, sulfuric acid will bind a certain amount of excess lime, and gypsum will be formed in the suspended state. This originates a need for additional filtration, e.g. a cartridge filtration system that can be used to separate the solid gypsum.

Stage 06. Cleansing from sulfates

The effectiveness of sulfates removal by lime treatment method is 85-90%. Using this method the further cleansing is not possible, since the whole gypsum (calcium sulfate), which is formed during the lime treatment, settles and the concentration of maximum solubility of gypsum in the water is achieved. As a result, the unsolvable gypsum is not formed in the water. Therefore, additional water cleansing to the maximum permissible levels of sulfates can be achieved only by the membrane method. At first the water should undergo ultrafiltration and afterwards the reverse osmosis. These are expensive technologies and therefore it is recommended to use the cleaned water in technologic processes.

Reagents:

- Lime milk - the high quality granulated quicklime was used for studies, with the content of active ingredients of at least 80% expressed as CaO + MgO, the content of CO_2 - 6%. Preparation of lime milk from such lime is accompanied by an exothermic reaction, which excludes preparation of lime milk in plastic containers. In this case the closed reinforced concrete reservoirs should be used with intensive mechanical mixing or automatic preparation of lime milk. In case of using the lime of different composition, it is necessary to recalculate the lime consumption through laboratory tests or to establish new norms in the process of initial release of the structure.

Lime and lime milk consumption are given in the table below.

Table 11

Stream	Volume, m^3/l	Volume m^3/day	Solution consumption, l/h	Solution consumption m^3/day	Solution consumption, $m^3/month$	Lime consumption, kg/m^3	Lime consumption, kg/h	Lime consumption, kg/day	Lime consumption, kg/month
WD3	10	240	624	14.976	449.28	9.36	93.6	2246.4	67392
WD4	8	192	540	12.96	388.8	10.125	81	1944	58320

It should be taken into consideration that the consumption of lime milk is likely to be changed due instability of the stream (according to metals, sulfates content, and pH), so the consumption of lime milk in the table above is shown with a 5% surplus.

For the stable operation of the lime milk preparation unit, the following equipment is necessary: one lime milk preparation tank and one supply tank from which the finished solution is supplied to the neutralization reactor. In order to transfer the finished solution from the preparation tank to the supply tank it is desirable to install pumps. Depending on the quality of the selected lime to be used, the issue of preliminary filtration of the lime milk from mechanical impurities should be solved before its supply to the pump. The tank should be equipped with the intensive mechanical mixer to ensure the safety of the lime milk suspension in the suspended state.

Stream	Lime milk consumption per 1 shift, m^3	Lime consumption per 1 shift, kg	Lime milk storage tank, m^3	Lime milk consumption tank, m^3
WD3	7.488	1123.2	8	8
WD4	6.48	972	7	7

In the case of using the automatic lime milk preparation plant, the manufacturer shall determine its type and size. In both cases, a separate building equipped with air supply and vent system must be allocated for the preparation of the lime milk.

- Supply of coagulant 77139 is permitted in the commodity form. In this case there is no need to arrange additional unit for the preparation of the solution.

  Coagulant consumption with the dose 150 ppm is shown in the table below:

Stream	Volume, m^3/h	Volume m^3/day	Dosing, ppm	Consumption, l/h	Consumption, kg/h	Consumption, kg/day	Consumption, kg/month
WD3	10	240	150	1	1.5	36	1080
WD4	8	192	150	0.8	1.2	28.8	864

Optionally, instead of preparing coagulant solution, it is possible to supply water directly to the pipe and make an incision to supply coagulant to the pipe. Water consumption depends on the concentration required for working solutions. It is possible to use 10% solution; in this case the solvent water consumption for WD3 stream is 13.5 l/h, the working solution consumption is 14.5 l/h; for WD4 stream – 10.8 l/h, the working solution – 11.6 l/h. When calculating the volume of neutralization reactor these volumes may be ignored.

The product 77139 may be supplied in 1 m^3 capacity barrels, net mass 1380 kg; the tare is not disposable. Depending on the WD3 demand, 1 barrel is required for 38 days. For WD4 - 1 barrel for 48 days. In case of using the products packed in a commodity tare, the barrels storage area should be arranged without additional stationary storage tanks.

- Flocculant supply is recommended in kind of 0.05% working solution, before hardening of sediment in the slurry concentrator and press filtration. The selected flocculant NALCO 8172 is supplied in a dry form; for preparation of a working solution, the arrangement of automatic preparation plant is required.

  The consumption of flocculant and its working solution is given in the table below:

Stream	Volume, m^3/h	Volume m^3/day	Dosing, ppm	0.05 % solution consumpti on l/h	0.05 % solution consumpti on, l/day	Commodi ty product consumpti on, kg/h	Consumpt ion, kg/h	Consumpt ion, kg/month
WD3	10.66	255.84	16.5	351.78	8442.72	0.176	4.22136	126.641
WD4	8.49	192	16.5	280.17	6724.08	0.140	3.36204	100.861

Flocculant consumption for dehydration process is given in the table below:

Stream	Volume, m^3/h	Volume m^3/day	Dosing, ppm	0.05 % solution consumpti on l/h	0.05 % solution consumpti on, l/day	Commodi ty product consumpti on, kg/h	Consumpt ion, kg/h	Consumpt ion, kg/month
WD3	7.7	184.8	45	693	16632	0.347	8.316	249.48
WD4	5.9	192	45	531	12744	0.266	6.372	191.16

The capacity of flocculants preparation unit for each stream should be 1 m^3/h in case of 0.05% concentration. When using 0.15% working solution the capacity of 0.5 m^3/h is sufficient, with the total consumption of the flocculant solution: WD3 - 350 l/h and WD4 - 270 l/h.

The use of solutions with more than 0.3% concentration is not recommended because of their high viscosity. However, it is possible in case the forced mixing when using the mixer before the slurry concentrator and press-filter. The company NALCO produces mixers for streams Flocmaster, which are used in dehydration process and allow the use of 1% concentration flocculants.

Water quality required for preparing flocculants:

- Total hardness - no more than 300 ppm $CaCO_3$ (or 6 mg-eq/l)
- Total iron - no more than 1 mg/l
- pH - no more than 9.0

For storage and dosing of the sulfuric acid a storage unit equipped with a ventilation system shall be allocated.

Sulfuric acid consumption for neutralization of the stream of up to pH 6.5 - 8.5 is shown in the table below:

Stream	Volume m^3/h	Volume m^3/day	Sulfuric acid solution consumption, 9.6%, l/m^3	Sulfuric acid solution consumption, 9.6%, l/h	Sulfuric acid solution consumption, 9.6%, l/day	Sulfuric acid solution consumption, 9.6%, l/month	Sulfuric acid consumption, 72%, l/month	Sulfuric acid consumption, 72%, l/h	Sulfuric acid consumption 96%, l/month	Sulfuric acid consumption 96%, l/h
WD3	10.66	255.84	0.12	1.28	30.70	921.02	122.80	0.17	92.10	0.13
WD4	8.49	192	0.33	2.80	67.24	2017.22	268.96	0.37	201.72	0.28

It is noteworthy that dosage of high concentration acid is difficult due to the adjustments to be made in its supply and low consumption. Therefore, it is recommended to supply low concentration acid.

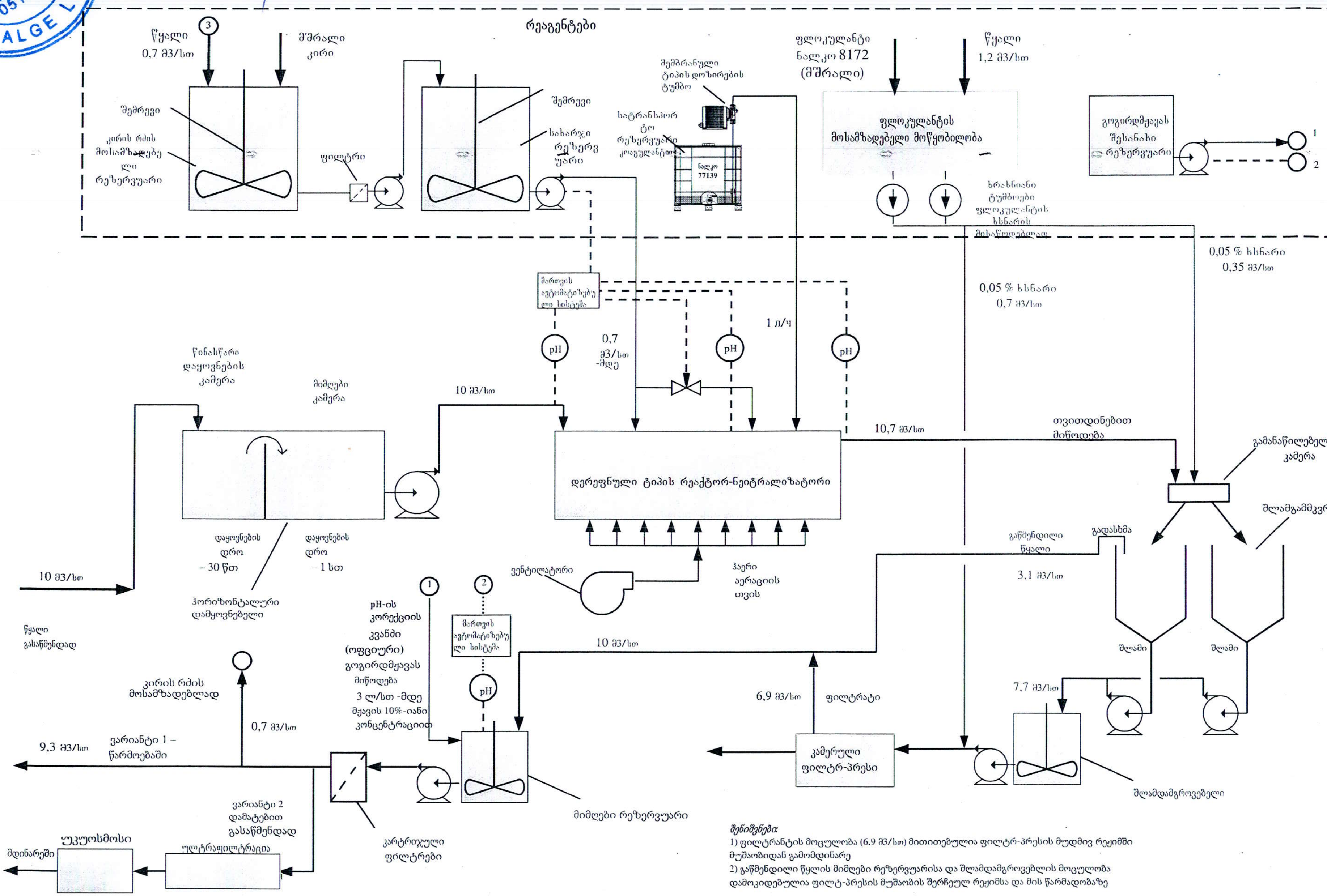
To manage the whole wastewater treatment system it is necessary to launch automated control systems.

The report is attached with the process flow of stream cleansing indicating the cleansing stages, streams and consumptions, in kind of the Annex.

Conclusion:

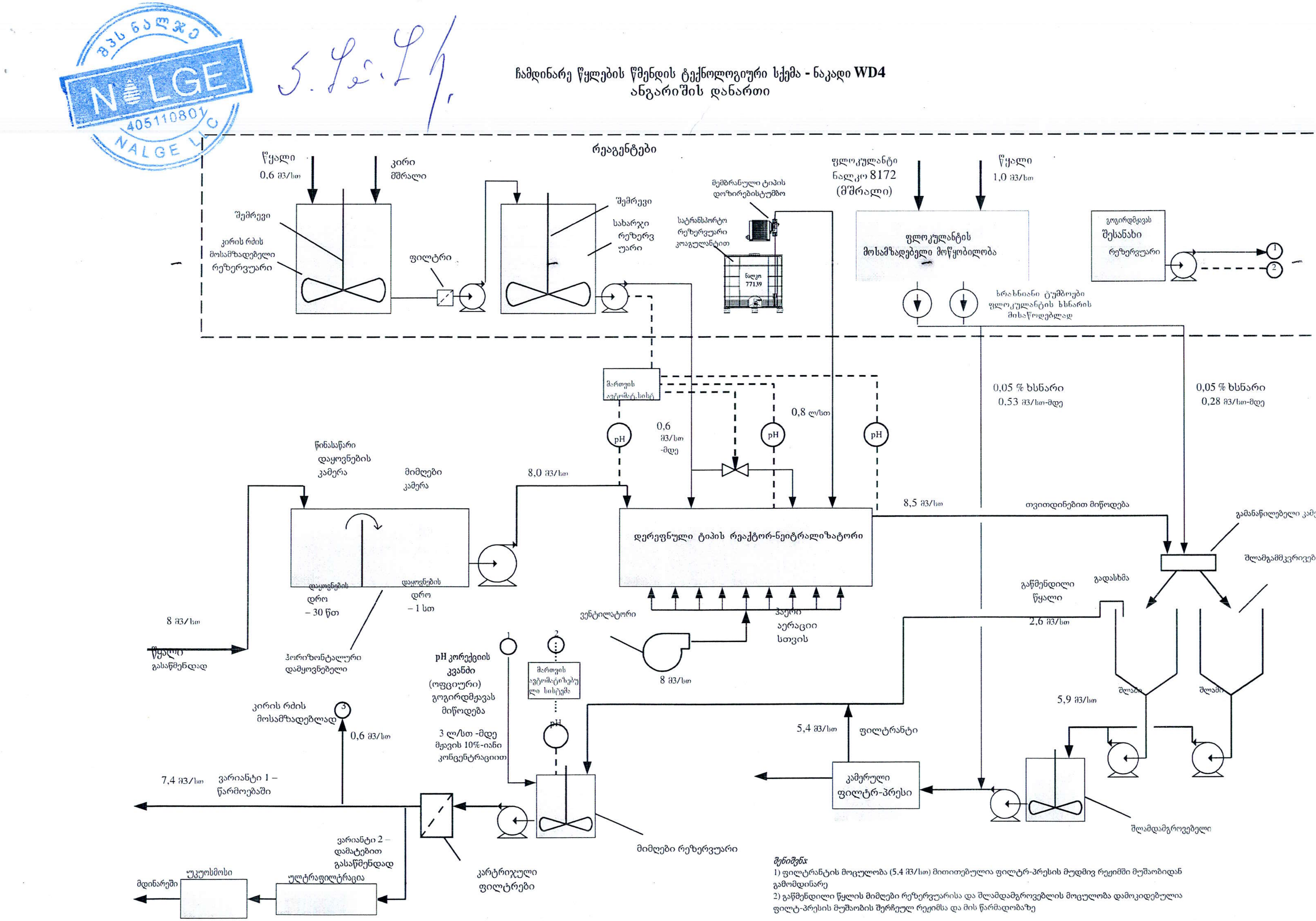
- Due to the small concentration (less than 250 mg/l) recovery of the metals from the streams is not economically feasible. It is also impossible to use streams for any kind of agricultural needs due to the content of heavy metals in them.
- The report provides results of laboratory studies of cleansing WD3 and WD4 streams from heavy metals, to achieve the maximum permissible norms of discharge of wastewater in the surface waters.
- The process flow of stream cleansing is developed, which is attached to the report.
- Recommendations regarding the equipment used are provided.
- By the method treatment with lime the maximum allowable norms of all parameters have been achieved, except for the content of sulfates. The purification quality exceeds 99% for each metal.
- To reduce sulfates concentration, the additional stream purification system is required using membrane technologies.
- The next stage is designing. At this stage, the issues are to be solved solved such as selection of specific units, options for their placement, laying communications, etc.

ჩამდინარე წყლების წმენდის ტექნოლოგიური სქემა - ნაკადი WD3
ანგარიშის დანართი



შენიშვნება
1) ფილტრანტის მოცულობა (6.9 მ3/სთ) მითითებულია ფილტრ-პრესის მუდმივ რეჟიმში მუშაობიდან გამომდინარე
2) გაწმენდილი წყლის მიმღები რეზერვუარისა და შლამდამგროვებლის მოცულობა დამოკიდებულია ფილტ-პრესის მუშაობის შერჩეულ რეჟიმსა და მის წარმადობაზე

ჩამდინარე წყლების წმენდის ტექნოლოგიური სქემა - ნაკადი WD4
ანგარიშის დანართი



შენიშვნა

1) ფილტრანტის მოცულობა (5.4 მ3/სთ) მითითებულია ფილტრ-პრესის მუდმივ რეჟიმში მუშაობიდან გამომდინარე

2) გაწმენდილი წყლის მიმღები რეზერვუარისა და შლამდამგროვებლის მოცულობა დამოკიდებულია ფილტ-პრესის მუშაობის შერჩეულ რეჟიმსა და მის წარმადობაზე