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DECREASING THE OUTFLOW FROM THE TAILINGS STORING FACILITY EMBANKMENT

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A tailings storing facility operating by the upstream method in RA area is investigated. Sampling has been made from the area adjacent to the tailings storing facility dam. The sampling and monitoring results are studied. The graphical comparison of the piezometer monitoring results and the amount of the monthly precipitation values in the given area is implemented. The sampling has revealed the main detrimental effect of the tailings storing facility on the environment. Due to the study of the sampling and monitoring data, the main direction of the outflow from the tailings storing facility has been found out. The method for reducing/preventing the outflow from the tailings storing facility is proposed.

Keywords: tailings storing facility (TSF), acid waters, metal migration, upstream, downstream, geomembrane.

Introduction. The tailings storing facility or the construction for keeping and storing the wastes (tailings) produced during mining works is one of the main sources of the environment pollution. In the case if the tailings storing facility operates in the circulating water-flow regime, the pollution damage to the environment can be considerably decreased. The existing longitudinal and cross cracks are the main directions of the acidic water and metal migration from the tailings storing facility. Longitudinal cracks generally arise as a result of raising the embankment and increasing the amount of the tailings contents. Although there is a water-insulating clay layer in the internal structure of the embankment, and a drainage system is always mounted to eject water, the outflow of the water with heavy metals into underground waters is unavoidable as a consequence of the pressure of the existing tailings in the tailings storing facility and the water saturation of the clay layer. We have studied the tailings storing facility maintained by an upstream method operating in Republic of Armenia to reveal the outflow from the tailings storing facility of the embankment [1]. The monitoring results of the piezometers installed in the northern and southern parts of the tailings storing facility were investigated and sampling was carried out to find out the ecological risks caused by the water outflow from the tailings storing facility

of the embankment. Our monitoring has been carried out parallel with the maintenance since 2010. The piezometers were noted as N_1, N_2, N_3, N_4.

Sampling results. The gradual decrease of the water volume in the monitoring sites speaks about the fact that parallel to maintaining the tailings storing facility, the amounts of the outflow from the embankment increases. The increase in the pressure directed towards the internal surface of the tailings storing facility of the embankment brings about a decrease in the degree of the embankment strength. The monthly total values of precipitation from 2010 to 2014 are also introduced in Table 1. According to the fluctuations of the observation values and the precipitation amount introduced in Table 1, it can be asserted that the water amount in the piezometers is mainly a result of an outflow from the embankment.

Table 1

Monitoring data of piezometers and precipitation

Monitoring date	PN *(mm)*	N1 *(m)*	N2 *(m)*	N3 *(m)*	N4 *(m)*
1	*2*	*3*	*4*	*5*	*6*
10.01.2010	41	7.37	8.315	26.876	29.055
10.02.2010	54	6.795	7.783	26.85	29.073
10.03.2010	62	7.075	8.042	26.865	29.072
10.04.2010	71.8	7.395	8.36	26.088	29.085
10.05.2010	85	7.805	8.745	26.885	29.095
10.06.2010	70	8.117	7.05	26.885	29.115
10.07.2010	22	8.716	7.63	26.8	29.04
10.08.2010	18	7.89	7.035	26.782	28.93
10.09.2010	28	7.745	8.665	26.8	27.69
10.10.2010	49	7.962	8.845	19.052	26.825
10.11.2010	42	8.085	8.98	26.835	28.972
10.12.2010	21	8.14	9.04	26.835	28.715
10.01.2011	39	7.795	8.73	25.1	26.68
10.02.2011	93.2	6.78	7.765	24.432	26.115
10.03.2011	24.5	7.125	8.29	24.045	26.287
10.04.2011	72.9	6.683	7.665	24.51	26.49
10.05.2011	96.8	7.005	7.975	24.043	26.595
10.06.2011	43.8	7.89	8.81	23.96	26.593
10.07.2011	12	7.23	8.082	23.983	26.445
10.08.2011	107	8.06	8	23.996	26.465
10.09.2011	33.5	7.9	8.82	23.91	26.27
10.10.2011	15	7.5	8.45	23.94	26.22
10.11.2011	36.2	7.43	8.38	23.84	26.25
10.12.2011	7	7.36	8.3	23.98	26.35
10.01.2012	34.6	7.18	8.15	23.88	26.3
10.02.2012	38	7.09	8.02	23.89	26.32

1	*2*	*3*	*4*	*5*	*6*
10.03.2012	80.8	6.83	7.79	23.88	26.21
10.04.2012	25.7	6.57	7.54	23.97	26.36
10.05.2012	150.9	6.3	7.3	23.93	26.29
10.06.2012	107.5	6.18	7.2	23.83	25.88
10.07.2012	125.7	6.32	7.3	23.86	25.82
10.08.2012	32.3	6.88	6.89	23.87	26.02
10.09.2012	68.5	6.18	7.2	23.63	26.32
10.10.2012	5.6	6.62	7.59	23.69	25.79
10.11.2012	32	6.91	6.91	23.87	26.19
10.12.2012	29	6.43	6.48	23.45	26.19
10.01.2013	59.5	6.96	6.94	23.18	25.96
10.02.2013	50	6.27	6.16	23.89	26.32
10.03.2013	41.8	7.52	6.37	23.85	26.13
10.04.2013	55.1	7.43	6.42	23.87	26.26
10.05.2013	146.2	7.45	6.41	23.07	26.22
10.06.2013	76.5	7.68	6.64	23.86	26.25
10.07.2013	11	7.04	6.96	23.87	26.23
10.08.2013	7	7.06	6.01	23.86	26.27
10.09.2013	16.6	7.26	6.21	23.87	26.19
10.10.2013	106	7.78	6.48	24.05	26.21
10.11.2013	73	7.55	6.42	23.86	25.84
10.12.2013	52	7.78	6.62	23.88	26.31
10.01.2014	3	6.79	6.76	23.94	26.25
10.02.2014	21	6.72	6.7	23.94	26.33
10.03.2014	17	6.89	6.89	23.87	26.32
10.04.2014	0	6.82	6.39	23.96	26.33
10.05.2014	125	0	6.43	23.99	26.3
10.06.2014	20	0	6.53	23.87	26.38
10.07.2014	0	0	6.71	23.93	26.38
10.08.2014	0	0	6.86	23.88	26.33
10.09.2014	8	0	6.05	23.99	26.04

The value characterizing the amount of precipitation is presented by PN.

It has been considered optimal to carry out measurements once a month. The depth of the observation sites is presented in Table 2.

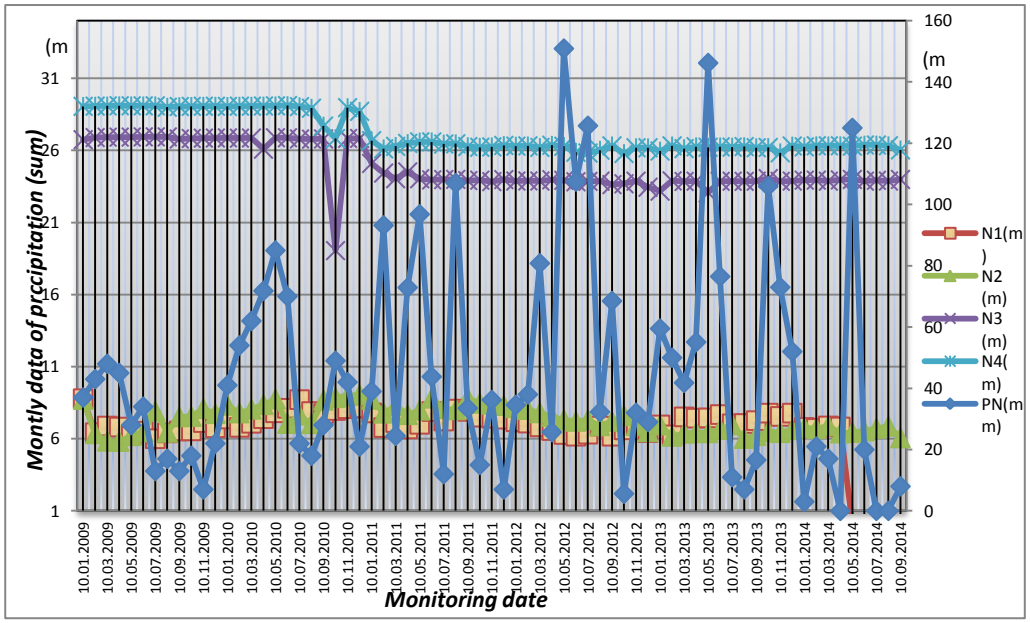

Fig. The monthly values of the piezometer observations and the precipitation

According to the curves introduced in the figure, it becomes clear that parallel to the tailings storing facility maintenance, the outflow amount from the embankment increases. To reveal the migration of acidic waters and metals, as well as the damage caused to the environment, an investigation has been realized. The investigation includes taking samples from the underground waters and determining some physicochemical parameters of the waters. This will allow finding out the possible impact of the water absorbed from the tailings storing facility on the environment.

The holes have been installed in the northern and southern parts of the tailings storing facility (Table 2) and served as sampling sites. These holes have been drilled up to the parent rocks and regarded as functioning piezometers. To make the difference in the water quality noticeable, a sampling form the small lake 40 meters off the embankment which is not subjected to the tailings storing facility impact has been carried out. Generally, sampling has been accomplished in five spots including the checking sampling from the lake situated at a distance of 40 m from the southern part of the embankment.

The sampling spots are conventionally named NP_1, NP_2, NP_3, NP_4, and the lake water – N_L. The spots NP_1, NP_2 are in the northern, while NP_3, NP_4, and N_L - in the southern part of the tailings storing facility.

The content of the elements and compounds in the water in the piezometers installed on the southern and northern parts of the embankment of the tailings storing facility is shown in Table 2.

Table 2

Sampling results

N	Determined component	NP_1 Borehole h=30 *m* *mg/ml*	NP_2 Borehole h=30 *m* *mg/ml*	NP_3 Borehole h=10 *m* *mg/ml*	NP_4 Borehole h=10 *m* *mg/ml*	N_L *mg/ml*
1	NH_4^+	4,9	2,9	13,7	0,30	0,20
2	Na^+	73,03	82,40	113,39	58,55	8,9
3	K^+	36,03	21,03	16,23	0,67	0,95
4	Ca^{2+}	500,9	553,44	396,43	392,50	33,09
5	Mg^{2+}	340,15	251,62	25,92	71,22	9,24
6	Cl^-	11,01	12,01	16,8	13,38	1,75
7	SO_4^{2-}	2611,84	2406,15	1250,66	1104.01	16,16
8	HCO_3^-	271,20	170,50	121,7	274.2	152,20
9	NO_3^-	Not determined	Not determined	Not determined	0,20	0,9
10	Total mineralization	3895,16	3517,15	1966,93	1927,43	221,79
11	pH	6,65	6,56	6,95	6,61	8,36

The sampling results have shown that an intensive outflow takes place from the northern and southern embankments of the tailings storing facility. The outflow of the water with such chemical composition can bring about a great ecological damage particularly influencing the biodiversity of flora and fauna.

The study of the chemical composition in sample N_L, has revealed that water is almost not influenced by the tailings storing facility, and its chemical composition corresponds to the boundary permissible concentration set for surface waters.

Internal and external erosion of the embankment of the tailings is another ecological problem during maintaining the tailings storing facility and a mine utilizing [2]. The external bacteriological background is creating good conditions for erosion. Since barren rocks are used as the main construction material in the embankment structure, the waters ejected from the tailings storing facility and absorbed from the external surface of the embankment favor the water saturation of barren rocks a serious danger for erosion arises under the conditions of such water saturation and high external temperature. The erosion process proceeds more intensively in the layers close to the external surface of the tailings storing facility embankment. Although the external surface of the embankment is earthed, the flow of the surface waters towards its internal structure is unavoidable. The erosion of the external surface of the tailings storing facility embankment mainly depends on three factors:

- the water saturation degree of the rocks with a potential of developing an acidic medium,
- the external temperature,
- the earth cover of the external surface of embankment.

According to the results of monitoring presented in Tables 1, 2 and the figure, it becomes obvious that the tailings storing facility has a great impact on the environment. In this case, the main directions of pollution are the northern and southern embankments of the tailings storing facility. The sampling results show that the water insulating layer existing in the internal structure of the embankment and the drainage system operate inefficiently.

Minimizing of impact. To decrease and minimize the impact of the tailings storing facility on the environment, the method of the downstream maintenance of the embankment, and the geomembrane version [3, 4] of raising the embankment can be applied. The method of downstream maintenance does not suppose a change in the embankment structure but proposes incrustation of the embankment with a geomembrane layer. The incrustation of the embankment's external and internal surfaces will lead to the decrease in both the erosion of the external surface of the embankment and the outflow from the embankment. The geomembrane with its physicochemical strength hinders the migration of acidic waters and heavy metals from passing into the basin of underground waters, as well as prevents the penetration of the surface waters from the external slope of the embankment into the medium saturated with barren rocks existing in the embankment's internal structure. Moreover, the downstream maintenance method makes the incrustation process by geomembrane in the embankment structure easier.

The cost of the embankment incrustation with a geomembrane is rather high, but considering the importance of environment protection as a priority, the changes proposed can be regarded as admissible. The method of downstream maintenance with its properties is considered to be safer [5], particularly in the case of medium-sized and large tailings storing facilities.

Conclusion. The method of downstream maintenance allows to re-shape the tailings storing facility on the geomembrane layer in the back part of the embankment in case if it is possible to substantiate the technical and economic expedience of maintaining the tailings as a technogene mine. In an area insulated by a geomembrane it is possible to carry out a bacteriological extraction of intermediate sulphidic outcome extracted from tailings [6].

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ՊՈՉԱՄԲԱՐԻ ՊԱՏՆԵՇԻՑ ՏԵՂԻ ՈՒՆԵՑՈՂ ԱՐՏԱՀՈՍՔԻ ՆՎԱԶԵՑՈՒՄԸ

Տ.Ս. Նավասարդյան, Գ.Գ. Սևոյան

Ուսումնասիրվել է Հայաստանի Հանրապետության տարածքում հոսանքն ի վեր մեթոդով շահագործվող պոչամբար: Իրականացվել է նմուշարկում պոչամբարի հյուսիսային և հարավային պատնեշների հարակից տարածքից: Կատարվել է նմուշարկման և մշտադիտարկման արդյունքների ուսումնասիրություն: Իրականացվել է պիեզոմետրերի մշտադիտարկման արդյունքների և տվյալ տարածքում տեղումների ամսական գումարային արժեքների գրաֆիկական համադրում: Բացահայտվել է մշտադիտարկման արդյունքների և մթնոլորտային տեղումների կապը: Նմուշարկման միջոցով պարզվել է պոչամբարի հիմնական վնասակար ազդեցությունը շրջակա միջավայրի վրա: Նմուշարկման և մշտադիտարկման տվյալների ուսումնասիրության արդյունքում պարզվել է պոչամբարից տեղի ունեցող արտահոսքի հիմնական ուղղությունը: Առաջարկվել է պոչամբարից տեղի ունեցող արտահոսքի նվազեցման/կանխման մեթոդ:

Առանցքային բառեր. պոչամբար, թթվային ջրեր, մետաղների միգրացիա, հոսանքն ի վեր, հոսանքն ի վար, գեոմեմբրան:

УМЕНЬШЕНИЕ ОТТОКА ИЗ ПЛОТИНЫ ХВОСТОХРАНИЛИЩА

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Исследовано хвостохранилище на территории Республики Армения, работающее методом верхнего течения. Осуществлено опробование с ближайшей территории плотины хвостохранилища. Исследованы результаты опробования и мониторинга. Выявлена связь между результатами мониторинга и атмосферными осадками. Проведено графическое сопоставление суммарных месячных значений осадков данной местности и мониторинга пьезометров. С помощью опробования выявлено основное отрицательное воздействие хвостохранилища на окружающую среду. На основе данных опробования и мониторинга установлено основное направление утечки из хвостохранилища. Предложен метод предотвращения/уменьшения утечки из хвостохранилища.

Ключевые слова: хвостохранилище, кислотные воды, миграция металлов, вверх по течению, вниз по течению, геомембрана.