Geology as the basis for quality of life. The sustainability of lithium in the village of Gonçalo (Guarda - Portugal)

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Introduction

The growth of the world population and the increasing demands for energy and raw materials by modern societies are facts of the last decades [1]. Nowadays, special attention is placed on the exploitation of an important and scarce geological resource in Europe, but abundant in Portugal, especially in the area of Gonçalo (Guarda) – the lithium. The concerns of the societies with environmental questions and sustainability are a priority issue to avoid that lithium exploitation is carried out without the environmental concerns. The goal of this work is to evaluate the potential environmental impacts of the C-57 lithium mine (Gonçalo) exploitation in water, soil and air quality.

The main water analyses done were: alkali and alkaline earth metals, transition and post-transition metals, anions and pH. In the same way, for the determination of the quality of the soil, samplings were made in the upstream and downstream areas of the mine exploration. The soil samples were pre-treated and the parameters analysed were the alkali and alkaline earth metals, transition and post-transition metals and pH. Finally, the analyses regarding the quality of the atmospheric air were made during and after the work stoppage of the mine exploitation. The main parameters analysed were PM10, NO_2, CO, SO_2 and O_3. As final result of this work it was made a evaluation of the potential impacts of lithium mine activity on the quality of water, soil and air.

Methods

The concentration of PM_{10} were determined by Beta radiation absorption method, in accordance with ISO 10473 (MP101 analyser). The determination of nitrogen dioxides concentration was made by chemiluminescence method (AC32M analyser), according to EN 14211. The Ozone concentration was determined by UV absorption photometric method (O342M analyser) according to EN 14625. The carbon monoxide concentration was made by infrared radiation method (CO12M analyser), and finally the sulphur dioxide concentration was determined by fluorescence method (AF22M analyser), all the equipment's from *Environnement* company. Soil samples were collected from upstream and downstream points of the mining operation. These were manually homogenized and oven-dried at a constant temperature (40 ^{0}C). The samples for chemical analysis were sieved using a 2 mm mesh sieve to remove plant matter and subsequently screened to pass through a 250 µm screen (ASTM E-11, USA Standard Testing Sieve). Soil pH was determined in water extract in accordance with ISO 10390 standard. Atomic absorption spectrophotometry (AAS, GBC 906) was used to determine the metals concentrations in the soils (ISO 11047 and ISO 11466). Ionic chromatography (Dionex DX-120) is used for the determination of the anions (ISO 10304).

Results and Discussion

Figure 1 shows the mean variation of the outdoor air quality, with and without mining work, for the CO, O_3, NO_2 and PM_{10} parameters, between 20-26 March and 16-23 April during the mining operation period (8:00 to 18:00). Although the external air quality monitoring period is still very small, it appears that the mining exploitation don't have influence in the outdoor air quality for the CO, O_3, NO_2 and SO_2 (information not show) parameters. On the other side, the results obtained for PM_{10} appears to be influenced by the mining work (specially between 20 and 23 of April). It should be noted, at this time, due to the winter rains, the emission of particles to the atmosphere it will be less, since there is still a large percentage of moisture in the soil.

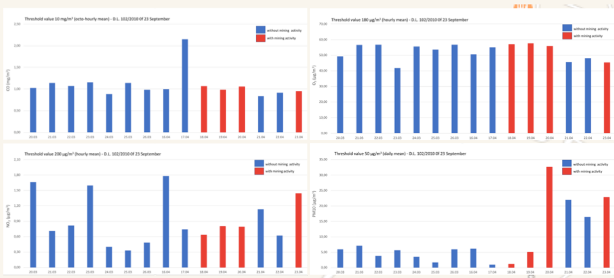
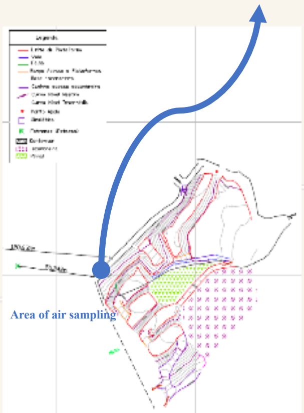


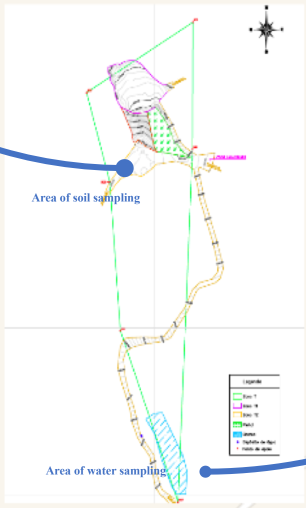
Figure 1. Variation of $[CO]_{mean}$ (A), $[O_3]_{mean}$ (B), $[NO_2]_{mean}$ (C) and $PM10_{mean}$ (D) between 20-26 March and 16-23 April for the working period (8:00-18:00).

Table 1. Metals (alkali, alkaline earth, transition and post-transition) content and pH of soil samples ($mgkg^{-1}$ dry weight)

Metals/pH	Samples					Range		Mean	Median	Soil Quality Guidelines a)		
	S1	S2	S3	S4	S5	minor	major			Residential	Agricultural	Industrial
Al	36208	58661	57890	59626	36753	36208	59626	49828	57890			
Au	24.4	22.7	24.0	21.5	21.5	21.5	24.4	22.8	22.7			
Ca	8.1	17.9	24.0	6.6	26.5	6.6	26.5	16.6	17.9			
Cd	0.7	0.8	0.5	0.3	0.5	0.3	0.8	0.6	0.5	10	1.4	22
Cr	60.3	276	165	170	116	60.3	276	182	168	64	64	87
Cu	21.2	21.1	25.6	9.9	16.5	9.9	25.6	18.9	21.1	63	63	91
Fe	21777	29521	22043	16987	20515	16987	29521	22169	21777			
K	4777	4224	4604	2875	3902	2875	4777	4076	4224			
Li	391	223	232	83	187	83	391	223	223			
Mg	782	721	1214	794	1108	721	1214	924	794			
Mn	47.3	17.9	6.4	3.3	8.3	3.3	47.3	16.6	8.3			
Na	121	122	99	114	91	91	122	109	114			
Ni	11.4	13.0	17.6	8.3	9.9	8.3	17.6	12.0	11.4	45	45	89
Pb	50.5	47.1	28.9	34.7	31.4	28.9	50.5	38.5	34.7	140	70	600
Sn	1418	1251	1395	941	943	941	1418	1189	1251	50	5	300
Zn	48.9	58.5	62.5	61.1	61.2	48.9	62.5	58.4	61.1	200	200	360
pH	5.8	5.0	5.1	5.2	5.5	5.0	5.8	5.3	5.2	6 to 8	6 to 8	6 to 8

[a] Canadian environmental quality guidelines (The Canadian council of ministers of the environment) - http://ceqg-rcqe.ccme.ca/en/index.html) accessed 29 April 2018





In Table 2 are the results of the soil analysis. The results reveal an acidic soil, where the tin (941 to 1418 mg / kg), the lithium (83 to 391 mg / kg) and the gold (21.5 to 24.4 mg / kg) are present in high concentrations, due to the existence of an aplite-pegmatite field, with veins of tin and also some gold. Particularly important is the chromium element, because it is present in high concentrations in all soil (upstream and downstream of the mining operation) which seems to indicated that it is not a contaminating effect due to the mine activity but rather an intrinsic characteristic of the soil itself. Concentrations are even higher than the guidelines of soil quality for residential, agricultural and industrial of the Canadian council of the environment. The other chemical elements analysed in this study show concentrations similar to those found for this type of soils and reproduced in different scientific literature [2,3].

In Table 2 are the results of the water analysis. The water samples were collected in a downstream area from the mine. Sample W2 is a groundwater with flow to a surface water body (W1 and W3). The W1 sample was collected in late summer of 2017 and the W3 after the winter rains in 2018. The analytical results do not show the presence of any influence of the upstream mining operation. However, the concentration of Cr in the water samples is high, which is in agreement with the results obtained for the soils.

Table 2. Cations and anions concentration (μgL^{-1}) and pH of water samples.

Ions/pH	Samples			Range		Mean	Median	Water Quality Guidelines a)		Surface Water
	W1	W2	W3	minor	major			short term	long term	Quality Guidelines b)
Al	0.9	1.1	0.6	0.6	1.1	0.9	0.9			
Ca	641	772	778	641	778	730	772			
Cd	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.0	0.09	
Cl	6067	6725	6495	6067	6725	6429	6495			
Cr	22.4	8.8	25.7	8.8	27.7	19.0	22.4		9.9	50
Cu	4.7	2.8	3.2	2.8	4.7	3.6	3.2			100
Fe	741	635		635	741	688	688		300	
K	1330	801	1078	801	1330	1070	1078			
Li	19.8	6.9	8.7	6.9	19.8	11.8	8.7			
Mg	641	578	507	507	641	575	578			
Mn	250	204		204	250	227	227			
Na	7223	7909	7593	7223	7909	7575	7593			
Ni	12.2	9.9	13.8	9.9	13.8	12.0	12.2			
NO_3	1489	786	1138	786	1489	1138	1138	550000	13000	
Pb	0.5	0.7	0.6	0.5	0.7	0.6	0.6			
PO_4		1717		1717	1717	1717	1717			
SO_4	554	516	818	516	818	629	554			
Zn	8.3	3.4	0.5	0.5	8.3	4.1	3.4		30	500
pH	6.3	5.6	5.7	5.6	6.3	5.9	5.7		6.5-9.0	

a) Canadian environmental quality guidelines (The Canadian council of ministers of the environment - http://ceqg-rcqe.ccme.ca/en/index.html) accessed 29 April 2018

b) Critérios para a classificação do estado das massas de água superficiais, Instituto da Água I.P. (https://www.apambiente.pt/dqa/assets/critérios-classificação-rios-e-albufeiras.pdf) accessed 29 April 2018

Conclusions

With the results obtained until now, we can conclude that there is no evidence of negative effects produced by the lithium extraction on the quality of water and soil. For the air quality, there is an evidence of a negative influence of the mine exploitation on the PM_{10} concentration, yet below the legal limit of 50 μgm^{-3} (daily mean).

References

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