Environmental control made in fifty three opencast mines of the Basque country: attention to acoustic and water contamination.

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Abstract. In the Basque country fifty three opencast mines exists which partly impacts the environment in a high grade; the Department of Mining engineering, metallurgic and material´s science of the University of the Basque country signed a collaboration agreement with the autonomic government in order to control the exploitation and restoration works, and the possible damages to the environment. In this paper we expose the methodology and conclusions of the study of acoustic and water contamination, proposing also the properly reclamation actions.

Introduction

In the Basque country fifty three opencast mines exists, which causes negative environmental impacts that must be controlled and reduced in order to obtain an effective environmental managing system. The quarries of the Basque country exploit different raw materials, such as limestone, sandstone and subvolcanic rocks used as aggregates, and also ornamental rocks. The exploitation methods are differents; drilling and blasting method is the usual exploitation method in the quarries of aggregates, causing several negative impacts on the villages in the vicinity.

The project here exposed is the result of an agreement between the autonomic government of the Basque country and the department of mining engineering, metallurgic and material´s science of the University of the Basque Country.
The main objectives of the project are:

1. Measure and control of vibrations and air blast.
2. Measuring, control and minimization of atmospheric contamination.
3. Measuring, control and minimization of acoustic contamination.
4. Analysis and control of the impact caused over the surface water and groundwater.

5. Control of the exploitation and restoration works.

In this paper we have focused our attention in the exposition of the measurement, control and minimization of the acoustic and water contamination.

Measurement, control and minimization of acoustic contamination.

Noise, as a contaminant issue of every mining activity (independently from the air blast), is caused from two main sources: treatment plants for raw materials and movable equipments. To identify the main sound sources, all the processes associated to the mining cycle are analyzed: hole perforation, blasting, loading, transport, treatment and raw materials storing, which may cause high acoustic levels.

To typify and quantify the sound levels, digital sound devices are used: portable sound devices measuring the pressure sound, make the balance by the type A curve according to the norm UNE 20.493/92 and calculate the continuous equivalent sound level (Leq); they also register the peak instant values originated in a measurement.

Measurement proceedings

Different measurement points has been established to value the potential sound incidence on the villages. The main factor to select these points was the potential existence of inconveniences in the population; therefore the measurements have been made in the vicinity of the buildings nearer to the quarries, or where acoustic impacts may be higher. Also, it is selected to measure in the buildings exterior to minimize the inconveniences over the population and to reduce their awareness.

In reference to the measurement techniques and without specific sound laws in the Basque country the recommendations of the norm ISO 1996 are followed. Therefore the measurements are made in the exterior of the buildings with sound device placed at 1.5 m height and separated a minimum of 3.5 m from elements which can modify the signal. The microphone is placed at 1 m from the operator and orientated directly to the sound source.

In each measurement point all climatic informations (temperature, humidity, wind directions), sound sources, predominant sources, activity level of each source, and registered time are gathered.

We selected a temporary sampling due to the high number of sound sources and to their accidental nature; in this sampling the sound levels present during a certain period of time is measured (Leq and the peak-fast value as the norm ISO 1996 recommends), repeating these measurements in a systematic and punctual way over time.

Therefore in a statistical study following systematic and punctual measurements, the evolution of the sound level is analyzed, determining the most common value and his extreme values, approaching these in high proportion to the former, as much as high number of measurements is made.

The measurements of the Leq,60 (Leq during 1 minute) in each register point, is made every 5 minutes during a period of 20 minutes, so obtaining 5 measures; this actions is repeated every 2 hours covering from 7.00 h to 22.00 h. With this procedure and through an strict measure of the Leq,60 and peak-fast values, and the predominant sound sources and their characterization, we can model the uncertain function we are looking for: sound in function of time. An example of a register obtained in a measurement point can be seen in figure number 1.

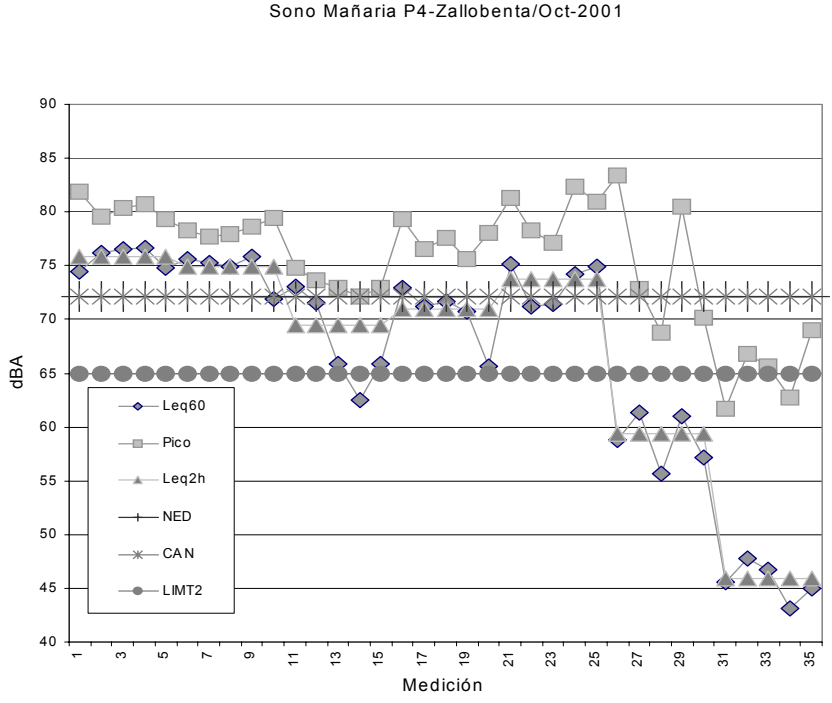

Fig. 1. Register obtained in a measurement point.

However, medium values are needed to allow a quick interpretation of the results, to compare the calculated value with the prevention criterion. Nowadays the most used criterion is NED or diurnal equivalent level. (Diurnal Leq media measured between 7.00 h to 22.00 h.)

Along the day it has been confirmed that the quarries inactivity periods are between 13.00 h. to 14.00 h. and between 19.00 h. to 8.00 h.; during this periods the activity of noise sources not caused by the quarries are constant, so it can be obtained the value of medium Leq without the quarries activity and using the theory of the addition of sound sources we can estimate the noise originated by the quarries.

Prevention criterion of damages

As a prevention criterion of damages and due to the fact that measures are made in the exterior of the buildings, we adopt the values proposed by the Public works and Urban Development Ministry, in 1993. (table 1)

It has been considered that the receivers are type II and NED values are applicated, so there's no activity in the quarries between 22.00 to 7.00 h.

Table 1. NED: Diurnal equivalent level (Diurnal Leq media measured between 7.00 h. and 22.00 h.). NEN: Nocturnal equivalent level (Nocturnal Leq media measured between 22.00 h. and 7.00 h.)

RECEIVER TYPE		ALLOWED INMISION LEVELS in dB A	
		NED	NEN
I	Sanitary, academic and cultural areas; natural reserves.	60	50
II	Housing, hotels and sports areas.	65	55
III	Offices, public services and commercial centers.	70	60
IV	Industries and traveling stations.	75	75

Sound level estimation.

Previously to obtain NED, according to the theory of the composition of sound levels, as is recommended by the ISO 1996/1 norm and from the measurements of Leq60, we must estimate Leq2h by the following equation:

$$Leq_{2h} = 10\log\left[\frac{1}{T}\sum_{i=1}^{N} t_i 10^{\frac{Leq60i}{10}}\right] \quad \textbf{(1)}$$

The quantity of NED is obtained from the Leq2h values, applying the theory of the composition of sound levels, by the equation number 2:

$$NED = 10\log\left[\frac{1}{7}\sum_{i=1}^{N} 10^{\frac{Leq2hi}{10}}\right] \quad \textbf{(2)}$$

Expressing NED for no uniforms lapses of times, we obtain the equation number 3 which defines NED in a more general way.

$$NED = 10\log\left[\frac{1}{15}\sum_{i=1}^{N} t_i 10^{\frac{Leqti}{10}}\right] \quad \textbf{(3)}$$

In this equation ti is the hours interval where is valid the value of Leqti (Usually 2 hours) and Leqti is the valid value for an interval of ti in hours. Usually ti=2hours obtained from 5 measures of Leq60 each 5 minutes in the programmed ti interval.

Equation number 2 is deduced from the equation number 3, supposing seven periods of 2 hours and underestimating the latest hour from 21.00 h. to 22.00 h. where we have confirmed a low activity level of all the sound sources. It has been confirmed that NED value and also CAN value from equation number 2, is 0.5 dB (A) higher than NED value obtained from the equation number 3 and, therefore, more restrictive.

A first estimation of the sound level originated by the quarries (which has been named CAN), is obtained applying the theory of the addition of sound sources and using the values of Leq corresponding to inactivity periods, resulting in the following equation:

$$CAN = 10\log\left[10^{\frac{NED}{10}} - 10^{\frac{Leq}{10}}\right] \quad \textbf{(4)}$$

It must be said that the great variation of sources, as well as the diversity of generated noise types (continuous, fluctuating, transitories and impacts) and their uncertain character, make it very difficult to characterize the emission sound levels.

Proposed actions to minimize the acoustic impacts

From the beginning of the project it has been confirmed that in certain moments of the acoustic sampling of some quarries, the levels established in the prevention criterion of damages has been repeatedly exceeded. In these cases it has been designed recommendations to minimize the acoustic impacts.

The usual methods to minimize the acoustic impact are: reduce the causes, isolate the sources, and absorb or attenuate the noise between source and receiver.

Reduce the causes means that all the equipment of the quarries, fixed and movable must be adequate to the new standards to reduce noise; in Spain this standard is regulated by The Royal Order 1215/1997 and The Royal Order 1389/1997 but in most of the quarries the equipment, due to be previous to this orders, are not completely adequate to them. It must be remembered that the mining equipment causes high costs, and the quarries are industrial activities of limited economic resources, so the purchase cannot be done immediately.

Therefore, the used methods to reduce noise are isolating the sources and absorb the noise. In this way the use of acoustic barriers made with the materials of

the quarries (waste dump and stock piles) is, in some cases, an economic and efficient solution. Another proposed action includes the covering of the treatment installations with isolating materials. The use of films of rubber to reduce the noise caused by the impact of the materials over metallic surfaces is also an appropriate solution.

Also it has been confirmed very interesting and convenient, to propose new methods of discharging materials in order to reduce the discharge height. Of course, is always necessary to carry out the adequate maintenance in the mobile and fixed equipment to avoid vibrations, looseness and frictions. Also with a correct maintenance, the tonal noise can be reduced resulting in a less annoying noise.

Analysis and control of the impact on surface and underground water

All the processes involved in these quarries potentially affects the water management; the landscape of the Basque country is very rough with high mountains and deep valleys and the quarries are located in areas of high inclination, which affects the natural process of sedimentation and erosion. Furthermore, long time periods occur between the exploitation of an area and the re-vegetation operations, thus erosion is likely to happen and surface runoff is affected.

The raw materials of the quarries are limestones and sandstones with a high permeability. The quarries of limestone are frequently affected by karst processes, with exokarstic forms. One of the limestone quarries also has the peculiarity of being exploited and located in an area which suffered in the past underground mining activity, so there exists a series of abandoned galleries through which underground water seeps and circulates, creating a complex underground circulation.

Due to the fact that the quarries are located near the villages and exploits permeable levels, there are a lot of wells for drinking water in the proximity, so special care was needed to maintain the quality of these waters. One of the opencast mines has tailing dams and water storages which also needs a specific water quality monitoring plan.

In order to carry out the follow-up of the water quality and to control the possible influence of flows from the exploitations, two sampling points in each quarry have been defined, far enough from each other to contrast the obtained results. The first point is placed in an area of the stream not affected by the works, and the second point is located in a place where the water comes from the area affected by the quarry.

It must be said that the treatment of the raw materials does not need the addition of any chemical product, so no chemical contamination was expected. The parameters investigated are the level of suspended solids and hydrocarbons, both parameters usually affected by the activity of the quarries. Suspended solids come from the possible flow from the water runoff and from the eventual flow of fine materials from the sediment dams; the hydrocarbons stem from the possible incorrect maintenance of the mine equipments.

An effective system has been developed for sampling, which warrants that the final results from the analysis have optimum liability and representative value.

As prevention criteria the *Spanish Law for Water* in its annex to the Hydraulic Public Dominion as it appears in table 2 was established.

Table 2. Limit values of suspended solids and hydrocarbons in water, according to the Spanish Law for Water.

LIMIT VALUES (mg/l)			
Parameter	Table 1	Table 2	Table 3
Suspended solids	300	150	80
Hydrocarbons	40	25	20

The periodicity of this water control is every two months. Only in few occasions and related with extreme meteorological conditions the limit values have been exceeded.

In order to complete the evaluation of a potential water contamination, we begin this year to control also the pH and have introduced biotic controls from which we expect to obtain additional results to evaluate and contrast the previous analysis.

Finally, for a better environmental water management of the quarries, a global water management plan, which includes all the mining companies, is needed to work with the water management in a congruent and responsible way.