

## Guidelines for catchment management and mining impacts in arid and semi-arid regions of South America (CAMINAR Project)

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**Abstract** In arid and semiarid climates where water is a scarce resource, mining activity supposes for interested agents in the basin where the mines are located a new resource's user and a potential pollution source. The sustainable mining concept involves the maintenance of the good state of water quality in the basin where the mine is located; these water resources must be compatible with other activities developed in the area such as agriculture and cattle, furthermore than human consumption. Current mining defined as sustainable counts on the public participation as a vector to avoid conflicts derived from change of soil activity. This is very important in arid and semiarid regions of South America where the social component is very established and it can check a mining operation. CAMINAR (Catchment management and MINing impact in ARid and semiarid South America) project, granted by European Union VI Framework Programme, is focused on mine water management in arid and semiarid climates of South America and it considers the importance of the participation of interested agents in order to obtain a sustainable management of water resources and potential mining impacts on the water environment. A main objective of the project is the elaboration of water management guidelines, which allow improving the availability of water resources and the optimization of their use. This paper presents a summary of these guidelines, providing a participative approach of main agents involved in water management and use.

**Key Words** Water management, mining impacts, guidelines

### Introduction

Arid, semi-arid and hyperarid areas cover 35 percent of the world's land surface. These regions are inhabited by almost two billion people, many of whom live in developing nations, and who are directly dependent on the land's natural resources (Graztfeld, 2003). While the exploration and extraction of minerals or hydrocarbons offer the potential for much-needed economic and social development, these activities can sometimes have environmental and social consequences. If they are not well managed, these effects may persist after the exploration and extraction processes have concluded.

A significant part of the mining industry is located on these arid areas. It is therefore an important consumer of water that competes with other water uses in the area, particularly with agriculture. And it makes necessary to implement a proper management of the watershed affected for all parties concerned, such as mining, agriculture, society and public administration (Loredo et al 2008).

Currently, more than 65% of the world's water is used for agricultural purposes. The population increase suggests a rise in cultivated areas to meet future demand for food (Prinz and Malik 2003). Moreover, in areas with mining, agriculture is reduced by changing land use and the lack of water that is used primarily to mining activities and the decrease of piezometric level caused by water pumping of mines that can affect several kilometres depending on the size of the labours. It is clear therefore that water is a limiting factor for economic and social development of arid and semiarid regions. The presence of mining as a new actor on stage implies a new pressure for the environment.

Nowadays, mining activities have sufficient technologies to prevent and adapt most of the possible impacts, especially those which affect surface water and groundwater; The negative image that some sectors of society are trying to show of mining industry come in many mining liability cases before the enactment of environmental laws. Only a very small portion of the min-

ing operations do not comply with environmental legislation, and in most cases are small and artisanal mining operations in developing countries (Loredo et al 2008).

The use of this virtual outrageous image avoids carrying out mining operations in some areas, especially in arid and semiarid regions, arguing the potential impacts that mining could create on water resources. It is intended to avoid the entrance of a new consumer of water.

But a civil coexistence is possible in mining and agriculture through a resource management; consistent catchment managements plans developed in a participatory manner that considers all stakeholders are the first step towards sustainable water management, especially in times of drastic climate changes.

### **Mining, Water and Sustainability**

Currently the mining industry provides more than a hundred raw materials necessary for the development of technology that we usually use, and most of these raw materials are located in arid and semiarid areas. The general perspective on sustainability is changing as a function of development of regions or countries. In the states of the so-called first world, the environmental measures applicable to the opening of a new mine are very strict, and the pressure from environmental groups and the community to avoid it's rising. In developing countries "sustainable" means to have access to water, which is a right of every human being, as well as food is. Mining industry in these countries can secure water supplies and food to the population in developing an industrial structure that creates wealth and prosperity.

Other type of mining displayed in some of these countries is damaging the image of mining sector. These are operations informally developed by artisan or cooperatives. This is small scale and artisanal mining, so rooted in South America, Africa and parts of Asia, where there is no environmental control or previous studies. What care about is the quick access to the resource to go somewhere else to run out the same, leaving the area around the mine in an unsustainable way, and generating a great environmental impact. This impact is very serious with regard to water, since the acid drainage generated by mine wastes, can be important. Other problem is the reagents used to obtain the metal, which can suppose uncontrolled discharges to the river or soil contaminating both the surface water and the groundwater (Loredo et al 2009).

It is also necessary to consider that the ecosystems forming the arid areas of the planer are particularly sensitive to any change in the environment. New uses of water in these areas, largely due to pressure from humans on the environment are causing a loss of biota typical from these areas, endemic in some cases, thereby facilitating the process of desertification (Hooke 2006). It is a process difficult to stop, especially in the endorheic basins, because if we add the overexploitation of water for human use (irrigation, livestock, drinking water) with little rainfall and high evaporation we will have a saline environment that prevents the normal growth of vegetation.

There are examples of coexistence between agriculture and mining, and even in many cases which the mine is a "waste" to landfill, such as water pumping, becomes a resource for agriculture. Potential use of mine water, either directly if the water is not affected by acidification or other contaminants, or after treating them to bring their quality to that required for the region crops, it could lead to an increasing part of the arable land since it increases the availability of water as in the gold mine Betz Post in Nevada (USA) and operated by Gold Barrik in Carlin Trend (Nevada), where water is extracted through daily pumping 3,670 liters / second, of which 10% is used to irrigate 2,000 hectares of crop and, on the other hand, this water could serve as an alternative source for use in times of drought or low precipitation in summer, a period in which agriculture is intensively developed.

### **CAMINAR Guideline**

Catchment Management and mining impacts in arid and semiarid regions of South America Guideline is one of the most important CAMINAR project products. The elaboration of the guides has required a process of evaluation of best available techniques and analysis of the state of art in several arid or semi-arid basins of the planet with strong mining presence. From our analysis we obtained a series of conclusions that were very important in the development of the guide.

On the other side, the partners from the three basins under study, through the local and national meetings and dialogue have provided vital information by the knowledge of the needs demanded by the water users in the basin. Consequently, it has been developed a previous structure

of the guide as a base for the elaboration of a product accepted by all the stakeholders of the basins. The draft of the guides has been object of discussion on the three countries (Peru, Bolivia and Chili) in order to know the impressions and comments of the involved stakeholders.

The guideline has been published by UNESCO within the IPH-Lac with number 17, it suggests a common basis for water resources planning and management in mining operations in semi-arid and holding stakeholders and catchment as management context, and it was written to indicate the foundations of a new culture of water management in these areas focused on an efficient and equitable use of water.

It is written from a very technical approach, and therefore it provides different techniques, trying to translate the best practices for managing water resources in arid and semiarid regions. This is a guide which concisely sets out the most important aspects of water management in arid basins with mining presence.

This guideline offers a plan for action or general guidelines without an extended research on the subject, since there are specific publications for each of the items developed in the document. Three main objectives have been pursued: to promote preservation and equitable use of water resources in arid and semiarid areas, to encourage proactive management of projects both at the level of watershed protection quality and efficient water use in mining operations.

Following and introction to water sources in arid and semi-arid areas, the guideline has been divided into four sections. The first section (chapter 2) is devoted to water source planning in mining operations within the context of a catchment. The second section (chapter 3) is focused on water management in medium-sized and large scale mining operations. The third section (chapter 4) is focused on water management in artisanal and small scale mining as well as on an assessment of their impacts on the hydrological environment. Finally, the fourth section (chapter 5) has been devoted to the management of mining liabilities and passive treatment technics for acid mine waters and soil remediation.

Within each chapter discusses the best management practice for each topic, as well as practices that are now under study and are considered emerging and have potential to become best management practices in the coming years, with special attention on prevention of impacts on water bodies.

## Conclusions

The guideline has tried to look for a place on the group of publications on water management in arid and semiarid regions with mining. It has been made through a basin approach, participative and without exclusions, in order to legitimate the document and make it a base document for the treatment of problems on water resources between the mining industry and the involved stakeholders. This participative approach has obtained the acceptance of the guide and a compromise to use it in the pilot study basins.

Main problems and lacks have been identified in arid and semiarid areas with mining by revision of the international experience in water management; for example, the non-existence of a methodological guide for water management in arid and semiarid areas with mining has been made evident. A great effort has been made for the elaboration of a management guides that could help to improve the water management at a catchment scale, reinforcing the good practices in the management of mining impacts and the water resources of the catchment. The guides have been structured into three sections including the complete life cycle of the mining project (exploration, exploitation and closure), and the concept of integral water management of the catchment.

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