ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Assessment of Environmental Health Impact of ores mining project in Nyaruguru District, RWANDA: A perspective for Sustainable Development

Gasana Seka-Heka Franck[1], Mugerwa Théophile[2], Ndikumana Jean de Dieu[3]

1. University of Rwanda, College of Medicine and Health Sciences, School of Public Health, Department of Environmental Health, Kigali, RN1, Rwanda
2. Rwanda Natural Resources Authority, KN 3 Rd, Kigali, Rwanda
3. RUGAMBA MINING COMPANY Ltd, KN 3 Rd, Kigali, Rwanda

Manuscript Info

Manuscript History:

Received: 15 October 2015
Final Accepted: 22 November 2015
Published Online: December 2015

Key words:

Environmental Health impact, water, air, mining, project, and open pit mining, Nyaruguru

Corresponding Author

Gasana Seka-Heka Franck

Abstract

In this study aiming at assessing the environmental health impacts of mining projects in Nyaruguru District, the direct observation and interview methods were used. The main ores and minerals under exploitation are Wolfram, Cassiterite, Coltan and Gold**.** The study revealed that the disruption of the relief, weathering and erosion will be occurred during prospecting stage of the project. Construction of access roads and holes were identified as the main cause of change of geomorphology of the area which tend to affect the environment of various logistical facilities if the site is localized ecologically in a zone appreciable, an archaeological site and a natural habitat of protected species. Among the probable impacts associated to the exploitation of a mine as it is an open pit mining are interruptions and unbalances that are susceptible to not only affect air, water, soil ecosystem, but also the human and sociocultural environment. The Acid Drain Mine (ADM) will change the water quality of the study area. Both groundwater and surface water will be disturbed and therefore the slope will be unstable. The exposure of sterile to wind and rainwater is the main source of air and surface water pollution and this affects notoriously the health of neighbouring population of mining site.
The mine water is produced when an aquifer piezometric level is higher than the one of underground works or higher than the bottom of an open pite mine. Once mining operations are completed, the management of these waters often stops and causes hydraulic load layouts in fractures and mining works (galleries, through benches, quarries). These waters are at the origin of the phenomena of oxidation and dissolution of minerals, but they aren especially the vector of contaminants to surface and ground waters. They also cause swelling of certain minerals (clays) and viscosity change which have obviously important consequences on the stability of the land.

INTRODUCTION

Environmental Health impact Assessment (EHIA) is defined as a procedure used to scrutinize the environmental consequences or impacts, both beneficial and adverse, of a proposed development project and to ensure that these effects are taken into consideration in design process of the project. The EHIA is therefore centered on predictions. These impacts can embrace all significant features of the natural, social, economic and human environment. In the EHIA, a multi-disciplinary approach should be involved and it is better to be carried out later at the possibility stage of a project. Simply, a project should be assessed for its environmental feasibility **(**Pacifica F et al., 2007).

Rio declaration (UN, 1992) principle 17 calls for use of EIA as a national decision making tools to be used in assessing if proposed activities are likely to have substantial adverse impact on the environment of the area. The mining activities have been long contributed to the development of the country but their environmental impacts should be taken into consideration for management and conservation of natural resources. The sustainable development should not be achieved without a careful attention to the environmental management. Based on Rwanda Organic Law n° 04/2005 of the 08/04//2005 in its articles 67 to 70, the study of environmental impacts is a must for execution of mining projects (Gazette of Republic of Rwanda, 2005).
Mining as it is the extraction of materials from the ground, it is the first step in the commercial exploitation of a mineral, mining is considered as the first stage and it is done to recuperate components of parts of mined minerals (Bernd G et al., 2007).

The main environmental problem associated with mining in parts of the world is uninhibited discharge of contaminated water from abandoned mines (Banks et al., 1997). The acid mine drainage (AMD), was accepted as phenomenon which is responsible for costly environmental and socio-economic impacts (Suzan Oelofse, 2008). The legacy of bad mining practices from 20th century has made potential environmental impacts from mining a delicate topic in Rwanda (Alina F. et al., 2008). The trace elements from the mining site even at small amount can cause a serious problem in the surrounding environment and may have direct risks for human health (Lar, Uriah Alexander, 2013).
At a mine area, mining goes together with some form of mineral processing or metallurgical extraction system. These allied procedures produce waste and have the potential to cause serious environmental effects on the surrounding. But waste alone from both these applies and mining itself isn't the only issue that may lead to harmful consequences for an ecosystem. Before, during and after mining operations there are many factors that play a contributing role in impacting the environment. Air, soil and water can all be affected and harmed in numerous ways, whether it be caused from the direct physical requirements needed to establish a new mine or become contaminated due to prolonged exposures to waste and pollution.

METHODOLOGY

The conception of a project requires an in-depth reflection on its various functions, on the organization of the space resulting on its consistency with an economic development strategy and on the mastery of its impacts on the environment, as well as the studies of technical and financial feasibility of his project. The contracting authority must wonder therefore about the impact of his project on the environment. The impact study must be the most possible upstream, embarked on a continuous, gradual, selective and iterative approach; from the methodological point of view, this study was conducted according to the following 4 methods:

1. The review and analysis of the existing documentation. The consulted documents are relative to the document of the project itself, the in force political, strategic and legislative frameworks and which provides guidance on the preservation of the environment.
2. The direct observation methodology: As it is a rural site and modified by humans, this method has been used for the identification of the various components of the biophysical environment and socioeconomic site.
3. The Interview method: This method has been used in the public consultation. This interview was conducted with the local authorities and various experts according to the foreseeable environmental issues. It has also been used at the time of the direct interview for the socioeconomic survey that allowed us to check if there would be households exposed to an involuntary relocation.

RESULTS AND DISCUSSION

The identification of the potential impacts (positive and negative) of this project of exploration, research and exploitation of minerals in the perimeter of Nyaruguru on the environment, the analysis of effects resulting on interactions between the place (human and biophysical) concerned and activities of the project (sources of impact) were done. These various surroundings will be able to be affected directly or indirectly, positively or negatively to the variable degrees. These impacts will be analysed in two times namely during the actual planning phase and after the phase of planning on the other hand.

Methodology of impact qualification: The methodology of impact qualification used in the setting of this survey refers to the following definitions that take account of the nature of the impact, of its extent (prompt, local or general) and of its length (temporary or permanent).
The criterion is the intensity of the impact (positive or negative) qualified of:

- Important when the element is harmed in its whole to the point where its quality is altered in an irreversible way;
- Average when the element is harmed, but not in its whole or irreversible way;
- Weak when the element is only harmed in a marginal way and on a short length.

Environmental Impacts associated with mining prospecting phase: The main harm to the environment caused by most operations of prospecting is the disruption of the relief owed to the construction of paths of accesses and holes of polls, and to the use of materials. Indeed, the routing of the material on the site of work, constituting generally of logistical equipment, can affect the environment if the site is located in an environmentally sensitive area, an archaeological site, a natural habitat of protected species, etc.
Environmental Impacts associated with the phase of exploitation: Among the foreseeable impacts associated to the exploitation of a mine, wether open pit or by quarry, include disruptions and unbalances that are likely to affect not only the air-water-soil ecosystem, but also the human and sociocultural environment.
Environmental impacts associated with the phase of closing and activities of rehabilitation of a mine: After activities of mining exploitation mines are abandoned often and the main nuisances to the near and far away environment are:

- ***The mine waters***: are produced when an aquifer piezometric level is higher than the one of underground works or higher than the bottom of an open pite mine. Once mining operations are completed, the management of these waters often stops and causes hydraulic load layouts in fractures and mining works (galleries, through benches, quarries). These waters are at the origin of the phenomena of oxidation and dissolution of minerals, but they aren especially the vector of contaminants to surface and ground waters. They also cause swelling of certain minerals (clays) and viscosity change which have obviously important consequences on the stability of the land.

- ***The sterile***: are exposed to wind and rain water and are the main source of pollution of the air and surface water. Once rehabilitated, there are always some unavoidable nuisances. During the activities of rehabilitation of the mine there is a big risk of air pollution by dusts from dismissals that serve closing of wells. In addition, there is the deposit of oils from machines and tractors which arrange deposits. When rain falls, these oils are infiltrated to groundwater and will load ground water in harmful chemical components to life. It is noted that it is the groundwater water which feeds rivers.

Impacts of the environment on the project: The environment of a mine can embarrass to its tour activities of minerals exploitation. Nevertheless, these impacts are not numerous, and are notably:

- Climatic change
- The season of rains or the dry season that negatively influence research and mining activities.
- A too abrupt topography that gene accessibility, site development (do not allow the appropriate mode of occurrence) and the transport of exploited minerals.

All environmental and social consequences either positive or negative are managed by the mining operator all along three phases of the life of the project. The range of impacts varies in the space and in the time. The intensity of impacts (positive or negative) is classified according to the following criteria:

. Effects on the health of a biota,
. Reduction of the species diversity,
. Impacts on the human health,
. Effects on the present use of land and resources,
. Abandoning the use or future production of resources

Criteria of classification of impacts as being important, middle and weak were classified according to:

- Magnitude,
- Time and Frequency,
- Irreversibility,
- Intensity, importance, evolution and interrelations

These systemic methods permit to determine relations between the action and components of the environment and generally to model them.

The direct and indirect effects: Direct effects are the immediate consequences of the project in space and in time. Among the direct effects one can distinguish:

- The structural effects due to changes in the topography of the ground during the operation of the mining, disappearance of plant or animal species with landscape, disturbances to the living environment of residents, effects of cuts of natural amd human environments.
- The functional effects related to the exploitation of minerals and laundries, maintenance of equipment (water pollution, air by dust, solid and liquid waste, and production of various chemical wastes).
- Indirect effects result from a cause and effect relationship from a direct effect. These may affect the project's remote territories or appear in a period longer or shorter but their consequences can be as important as direct effects.

These include:

- The effects induced by the project, including socio-economic and living environment (modification of basic activities of the local population such as trade and work on mine sites that replace agriculture).
- The temporary effects are limited in time effects, or they disappear immediately after cessation of the cause, or their intensity diminishes gradually to disappear. Note, for example the air pollution during excavation of the mine, the prostitution that goes along with the income of local workers.

The impact study identifies and analyzes the cumulative effects resulting from the interaction of many direct and indirect effects caused by one or more projects. The analysis should lead to reduce temporary and permanent effects induced by the mining activities.

Table 1: The principal environmental components susceptible to be affected

Environment category	**Environmental element**
Physical environment	Soil quality
	Change of soil profile
	Erosion et sedimentation
	Quality of the surface water
	Runoff and infiltration rate
	Ground water quality
	Air quality
Biologic environment	Existing flora
	Existing fauna
Human environment	Infrastructures (adduction of water, electricity, road).
	Local business (equipment and consumer products).
	Quality of life / job creation from the operational phase

Table2: Equipment and aspects that must be taken into account for the closure of Nyaruguru mines.

Equipments	**Aspects that need to be took in account**
Underground mines	Filling wells, inclined planes and ventilation shafts; effects of water from polluted beach nourishment, drainage of mine water.
Open pit mine	Slope stability; management of groundwater and surface water; security and prohibition of access; effects of drainage from and towards the well; removal of evacuation routes.
Treatment facilities	Removal of buildings and foundations; removal of fixed and mobile infrastructures; cleaning workshops, storage areas of fuel and reagents; waste disposal; reprofiling

	and revegetation of the site.
Tailing heaps and Land recovery	Strengthening of slope; leaching effects on runoff; dust; visual impact.
Management of tailings ponds	Stability of embankments; chemical modifications of mining waste; percolation effects through dikes and bottom of the basins; water management surface and effluent; generation of dust from the edges; access and security.
Hydraulic equipment	Stability of dams, reservoirs, settling tanks, pipelines, canals, spillways; disposal of sludge treatment facilities; surface drainage and removal of drainage effluents.
Dumps	Containment of hazardous waste; removal of sewage treatment plants; prevention of pollution of the water table; prevention of abusive landfills.
Infrastructure	Dismantling of supply installations for electricity and water; remodelling of the access and evacuation routes; reuse supplies deposits and loading platforms.
Prospection surface	Rehabilitation of drill areas and access roads.

Table 3: Sources of likely direct negative environmental impacts

Phases of project	**Sources of impacts or project activities**
Mining exploration	Construction of access roads, digging wells: • Disruption relief due to small construction • survey paths platforms, • Air pollution by dust
Research and mining explorations	Excavation: biophysical disruption following the management of excavated material, deforestation and removal of humus and airy surface soil (habitat for soil fauna).
	Deposits solid mine waste (tailings): Sterile exposed to wind and rain water; are the main source of air pollution and surface water (erosion residue deposits by wind and water, sedimentation in rivers).
	The presence of a labor on the construction site every day: Health risks: Air pollution by dust, environmental pollution due to a large number of people and lack of hygiene on the site (household waste, lavatories).
	Excavation of opencast mines: loss of agricultural land, habitat reduction, fauna and flora disappearance: the increase of the concentration of CO2 in the atmosphere and thus to climate change. (Damage to the ecological integrity of the region).
	The wastewater in ore washing places: dissolution and deposition of toxic chemicals into waterways and groundwater.
	Damaged relief; risks of accidents
Mining exploitation	Underground mining: -instability of the ground, risk of landslides and dangerous landslides life of workers -The Mine water that will pollute groundwater
Phase of closure and project rehabilitation	-Air pollution by dust from the waste that serve the mine closure. -Pollution of gear oils used in the closure of the mine.

Table 4: The equipment that will need to be monitored

Equipment	**Expected results at the closure**
Underground mine	The closures of underground tunnels are safe; the water

	quality in the adjacent aquifers filling is acceptable; the quality of mine water is acceptable
Open pit mine	No deformation of the surrounding area and slopes; water management system operating effectively; verified security installations
Installation of mineral treatment	Success of earthmoving operations and vegetation planting
Rubbles rocheux/dumps	No erosion or deformation gradients; acceptable quality and quantity of drainage water; acceptable quality of surrounding ground water; success of the vegetation cover
Facilities of management of mine garbage of Nyaruguru	No deformation or erosion of the dams; acceptable geochemistry of waste; surface water management system is operational; safety systems are working properly
Facilities of water management	Successful rehabilitation and replanting operations of the plant cover; Proper drainage of surface water Site
Discharges and dumps	No contamination of the water table; reliable coverage; successful revegetation
Buildings and facilities	Remodelling and restoration of the plant cover
Infrastructures	Remodelling and restoration of the plant cover
Prospection zone	Rehabilitation of drill areas and access roads

CONCLUSION

Environmental Health Impact Assessment indeed has a vital role to play in addressing environmental concerns surrounding project development and particularly ores mining projects. The present study revealed various environmental problems likely to occur if all EHIA procedures and protocols are not followed. The changes of landscape, water quality, groundwater level, air quality, slope instability were identified.

Rwandan Government and the whole population are comitted in the protective program of the environmental health which permits to sit a healthy and sustainable environment of which the socioeconomic development with active involvement of all the community will allow to make the Country leave the famous cycle of poverty. The mining society will have the first responsibility in all possible complementary arrangements of numerous measures of attenuation proposed in order to preserve the environmental health.

Considering the present situation, the promoter of the project must continue the exploitation indeed, but rationally while putting a particular accent on environmental heath surveillance for the best protection of the environment and the detection of unforeseen environmental health risks during the mining exploitation. The governmental institutions as the University of Rwanda, the Natural Resource Ministry, the Rwanda Environmental Management Authority, the Rwanda Natural Resources Authority (RNRA), and the Rwanda Development Board must accompany in this noble mission.

Recommendations on measures of environmental health impacts attenuations recommended will be followed strictly. The Mining Society should also work directly with the environmental health experts and the Governmental Institutions having the protection of the environment in their attributions (UR, REMA, RNRA, RDB, etc.). It is in its responsibility to maintain the conformity of its activities with national environmental health and mining legislation.

ACKNOWLEDGEMENT

The authors are grateful to University of Rwanda, School of Public Health and Department of Environmental Health Sciences; we acknowledge the support of the Environmental and Geologist Experts of RNRA, REMA and RDB for their acceptance to use their data records for this study. Anonymous reviewers are also acknowledged for the careful reviewing of the text.

REFERENCES

1. Pacifica F. Achieng Ogola: Environmental Impact Assessment General procedures, Kenya Electricity Generating Company Ltd, 2007

2. The Rio declaration on environment and development, The United Nations Conference on Environment and Development, 1992

3. Official Gazette of Republic of Rwanda of, Year 44 n°s 18 15th September, 2005

4. Bernd G. Lottermoser: Mine Wastes Characterization, Treatment, Environmental Impacts, ISBN10-3-540-48629-' Springer Berlin Heidelberg New York , James Cook University, 2007

5. Banks, D., Younger, P.L., Arnesen, R-T., Iversen, E.R., & Banks, S.B. Mine-water chemistry: the good, the bad and the ugly. Environmental Geology 32 (3), 157-174, 1997

6. Suzan Oelofse , Emerging Issues Paper: Mine Water Pollution, CSIR, Natural Resources and the Environment, 2008

7. Alina F. et al, Environmental monitoring of small-scale mining areas in Rwanda, 2011

8. Lar, Uriah Alexander. Trace Elements and Health: An Environmental Risk in Nigeria. *Earth Science.* Vol. 2, No. 3, pp. 66-72 doi: 10.11648/j.earth.20130203.11, 2013