Environmental and health effects of SONICHAR's coal mining activitiesin Tchirozérine (Niger)

ABSTRACT

The environmental challenge is relatively high in an ecologically fragile area like the Sahel, which has to deal with the phenomena of desertification and loss of biodiversity in which the rural, poor population depends on the natural environment for its survival.Indeed, Niger has a coal basin of Iullemneden;this mineral coal deposit has been exploited since 1978 for the production of electrical energy. This implies a challenge of preserving the environment and its natural resources. It is in this context that the present study aims to analyze the impacts of coal mining and its transformation by SONICHAR on the environment, the health of the populations living near Tchirozérine in order to propose preventive measures, reduction and mitigation. In order to achieve this objective, the methodology adopted for the study consisted of surveys, site visits and field observations. Also, samples of wastewater from the company were collected, transported and analyzed. Directive 019 of March 2011 from Quebec, served as a supporting document for the comparison between the activities carried out by the company and the mining standards. The analysis of the company's activities has shown that most of the company's activities do not comply with the mining standards explicitly mentioned in the Quebec Directive 019. All of the impacts on the physical components of the environment are major impacts, thus calling into question their integrity. The soils and the atmosphere are the units most affected by the activities of this plant. The physico-chemical analysis of the water sample taken showed that this water has concentrations of iron (1.9 mg/l) in fluoride (2.32 mg/l), its alkalinity (510 mg/l) and bicarbonate (612 mg/l). This shows that the concentration of these elements exceeds the standards. As for the population, the impact on the latter can be described as medium impact. The inhabitants have a remarkable awareness of the environmental and health risks they incur. With more than 46% claiming to have noticed the deterioration of their health. Even those who do not complain about the deterioration of their health, attribute the cause of certain observed diseases such as eye and lung diseases to the activities of the factory.

Keywords: Coal,Impact, Environment, Health, SONICHAR, Tchirozérine, Niger.

INTRODUCTION

Coal is the oldest fossil fuel used (Bessereau and Sanière, 2008). It is one of the main sources of energy, it produces almost 40% of the world's electricity (Word Coal Institute, 2005). More than three-quarters of the world's demand for coal comes from power stations and cement works where it is used as fuel (Bessereau and Sanière, 2008).

Niger has the Iullemneden coal basin which extends over 500,000 km ^{2} in its western part and of which two deposits are known (Martin, 2017). One of them is the mineral coal deposit of Anou-Araren (Agadez Region), exploited since 1978, for the production of electrical energy in the power station of the Société Nigérienne de Charbon d'Anou Araren (SONICHAR), located in Tchirozérine. This thermal power plant includes 2 sections of 18.8 MW (Sambo, 2014), which are used primarily to supply electricity to the SOMAÏR and COMINAK companies operating uranium deposits further north (85% of the electricity is purchased by these two companies) and secondly to supply electricity to the main cities of the Agadez Region (CRIIRAD, 2009).

This makes it possible to contribute to a significant development of the mining sector in West Africa, under the impetus on the one hand of attractive national mining policies and on the other hand of strong investment from the foreign private sector (Mballo, 2012) . With in Niger, SONICHAR, which has a production capacity of 200,000 tonnes of coal/year, extracts the ore in the open pit (ROTAB, 2018). It should be noted that the development of the mining sector raises many challenges, including that of the preservation of the environment and natural resources. This environmental challenge is relatively significant when one is in an ecologically fragile zone like the Sahel which has to deal with the phenomena of desertification and loss of biodiversity, and whose generally very poor rural population depends largely on the natural environment for its survival (Mballo, 2012).

Indeed, coal mines are not without problems, particularly through the production of large volumes of wastewater. Carbonization plants are also polluting, especially through their gaseous discharges (Agrifor Consult, 2006). However, the main environmental constraints related to coal are at the level of its use, it is a fossil, non-fossil, non-renewable resource, and atmospheric pollution is maximum with this form of energy (Agrifor Consult, 2006).

In addition , fears expressed by the population concerning the environmental and health impact of atmospheric and liquid discharges from the SONICHAR mine and factory have been notified by the Commission for Independent Research and Information on Radioactivityin 2009.

As a result, the concretization of the various national strategies for the fight against pollution and the safeguarding of natural environments become necessary. It is at this stage that the interest of a study on the environmental and social risks of certain human activities likely to cause problems appears.

The main objective of this study is to identify the risks due to the exploitation of coal mines as well as its transformation by SONICHAR on the environment and the health of the populations living near Tchirozérine.

I. Materials and Methods

1.1. Presentation of the study area

1.1.1. Geographic location

Tchirozérienne is a department of the region of Agadez, whose commune is about 70 km north-west of the capital of the region, with an area of 50,539 km² for a population of 119,252 inhabitants at the latest estimate. in 2016 (Saidou, 2016). It is in this locality that the site of Anou Araren is located, about 800 km as the crow flies north-east of Niamey, 45 km north-west of Agadez and 180 km south of Arlit. The SONICHAR complex is linked to the Tahoua-Arlit road by a 13 km asphalt road leading directly to the Anou-Araren power plant or 73 km from Agadez (figure 1).

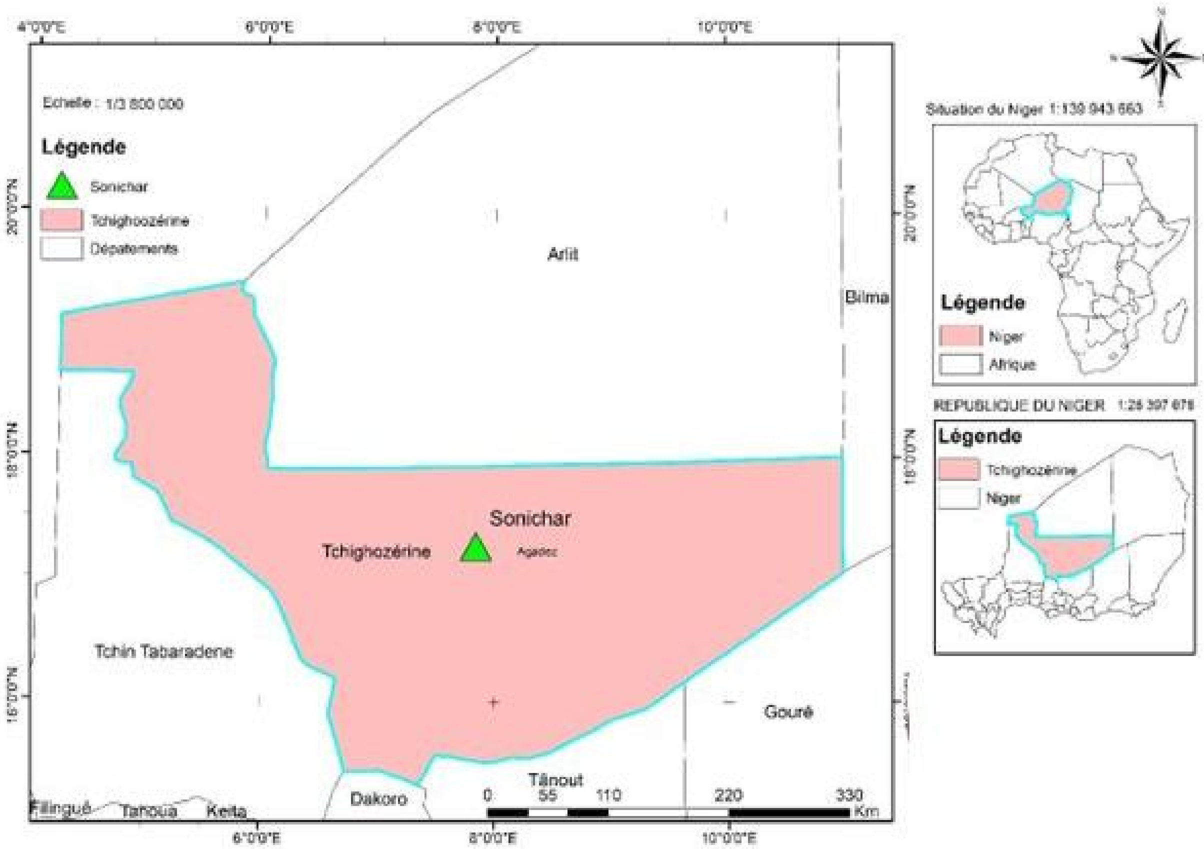


Figure 1: Geographical location of the department of Tchirozérine and the location of SONICHAR

The climate is sub-desert, with low annual rainfall around 150 mm, and an average duration of rainfall that does not exceed three months, during which rainfall can feed the koris and cause floods lasting several days in low areas. The study area is characterized by tall grass vegetation sparse with tufts of shrubs along the edge of the koris bed. Average annual temperatures are around 35°C with a large difference between day and night (Hamani, 2019).

The population mainly practices agriculture, livestock and handicrafts. The practice of market gardening is highly dependent on the flow of Koris. Almost the entire Anou Araren site is made up of a gently undulating plateau, where the bedrock is covered by a thin Quaternary terrace whose thickness is around a few meters (Siddo, 2012; Innoussa, 2013).

The subsoil of the department of Tchirozérienne is full of important mining resources including coal, tin and uranium, but only coal is exploited industrially. The Anou-Araren coal deposit is located in the sedimentary belt that borders the west of the Aïr crystalline and crystallophyllian massif. The Carboniferous in the region shows continental and laguno-Lacustrine characteristics. The bedrock is represented by fine-grained, finely bedded sandstone-quartzic metamorphic rocks. The type of coal mined in this region is lignite (Siddo, 2012).

Indeed, an open pit coal mine has been operated in the town since 1978 by the Société Nigérienne du Charbon d'Anou-Araren (SONICHAR), created in 1975 with a capital of nineteen billion seven hundred and thirty million CFA francs. (19,730,000,000). Its main mission is to supply electrical energy to the mining companies of Arlit as well as the cities of Agadez, Arlit, Akokan, and Tchirozérine and is placed under the supervision of the Ministry of Mines (Amadou, 2014) .

1.1.2. Presentation of the activities of the mine and the factory of SONICHAR

The production and sale of electrical energy to SONICHAR are mainly ensured by the two departments of the operations management, which are: the mine department (DM) and the central department (DC).

The main mission of the DM is to extract, store and supply the thermal power plant with coal with a grain size between 0-5 mm with an average ash content $\leq 51\%$, humidity $\leq 3\%$ and an average calorific value of 3800kcal/kg. This coal is extracted from the open pit mine (MCO), this mode of exploitation is chosen because the deposit is at a shallow distance (40 to 50 m) (Photo 1).

Photo 1:SONICHAR open pit mine.

The electrical energy production process is ensured by the DC, it consists in the production of energy from three raw materials which are: coal delivered by the DM with a grain size of 0 to 5mm; the water pumped at the Rharous pumping station and the natural air which is blown by a fan.

1.2. Methodology

1.2.1. Investigations

These were carried out at three levels:

- **At the level of technical and administrative services:**

An interview at the level of the technical and administrative services made it possible to begin the investigation at the level of the commune of Tchirozérine. This interview was made with the officials of the Ministry of the Environment, Population and Health of the said locality. An interview guide allowed us to carry out this interview

To obtain authorization for the field approach, a visit was made to the town hall. We were received by the deputy mayor, he suggests the subdivision of the local into 4 parts (At the entrance of the locality, at the level of the market, at the city SONICHAR and behind the city) for an integral taking of the opinions of the each other depending on where they live.

These interviews at the level of technical and administrative services mainly aim to obtain the data they have on the environmental and health constraints of the company's activities in the municipality and to know the provisions or actions they are taking to reduce or alleviate these constraints.

- **At population level**

The surveys at the level of the local population were carried out using a pre-established survey sheet allowing the collection of all the information deemed useful for this data collection. The objective of these surveys was to understand the perceptions of the population on the exploitation of the mine. Also, it will make it possible to measure the real awareness by the population of the pollution of their environment following this exploitation as well as the effects on their health and the measures and actions that they undertake to control and reduce the potential impacts. A total of 80 people were interviewed in the randomly chosen locality. At this level, the respondents, chosen by chanceat the level of the four compartments of the locality (Table I). Respondents were selected regardless of their age, gender, length of residence, level of education, and occupation.

Table I: Distribution of the number of people interviewed according to the different compartments of the municipality

	Entrance to Tchirozériene	Market	City SONICHAR	behind quoted	Total
Number of persons	20	20	20	20	80

1.2.2. Mine and factory tour

At the mine level, the direct observation method is carried out in order to better understand how the activities at the mine and plant level are carried out. This visit made it possible to identify the extraction and production process, the methods and tools used, which will make it possible to verify whether they comply with environmental standards or not. Through this visit, the identification of impacts generated by mining was made. The equipment used during this phase is among others: a GPS: GARMIN-type GPS, used to take the coordinates of the sites; a camera: for taking pictures.

Estimating the impact involves identifying the sources of danger or sources of impact and the different mechanisms that govern the occurrence of the impacts. This step consisted in carrying out a meticulous examination of each phase of the mine in order to determine the activities that are potential sources of impact and/or the sources of danger, the dangerous situations and the nature of the impact that may result.

In the absence of a document defining the standards for carrying out the work of the mine in Niger, Directive 019 of March 2011 from Quebec served as a support document to make the comparison between the activities that are carried out and the standards of mining operation.

1.2.3. Collection of water samples

The waste water was taken approximately 200 m from the plant at a point with coordinates in latitude: 17.27857527 and longitude: 7.83155961, along their route which it follows permanently once released from the plant.The choice of this point dependsofease of access and sampling, and location in relation to the plant. This water is taken in a bottle of mineral water with a capacity of 1.5 l, at the time of the in-situ sampling, the bottle is rinsed 3 times in a row with the water to be taken in order to have the sample adopted. to the container as recommended by Rodier's technique (1996). The sampling is a collection of grouped samples, carried out manually, in a plastic container, filled to the brim**.** A GSP was used to record the geographical coordinates of this sampling point.

1.2.4. Physicochemical analyzes of water samples

1.2.4.1. Determination of physical parameters

The physical parameters analyzed are pH, electrical conductivity (EC), total dissolved charge (TDS) and temperature. The pH was measured using an ERMA-type pH meter, while the electrical conductivity and temperature were measured using a TDS-3 type conductivity meter and the turbidity using a WAGTECH type turbidimeter.

1.2.4.2. Analyzes of chemical elements

The elements analyzed, depending on the reagents available in the laboratory, are: copper, chlorine, iron, fluorine, ammonia, phosphate, zinc, calcium, magnesium, nitrate, nitrite and alkalinity. The equipment used during this phase is: the WAGTECH type spectrometer and the reagents which are specific to each element.

A volume of water of 20 ml was mixed in a cell with the appropriate reagent (capsule). The whole is stirred and then left to stand for a determined time to obtain the development of the expected coloration. The cell was then placed in the spectrophotometer at the measurement wavelength to directly determine the content of the parameter concerned. But before, a reagent blank was used to set the absorbance to zero thus eliminating the signal due to the reagent and the sample.

II. Results & Discussion

2.1. Identification of impacts generated by coal mining

During mining, each phase through which the process passes to lead to the extraction and processing of the ore is associated with different groups of environmental impacts. The atmosphere, water and soil are the main components of the environment most subject to the impacts associated with mining.

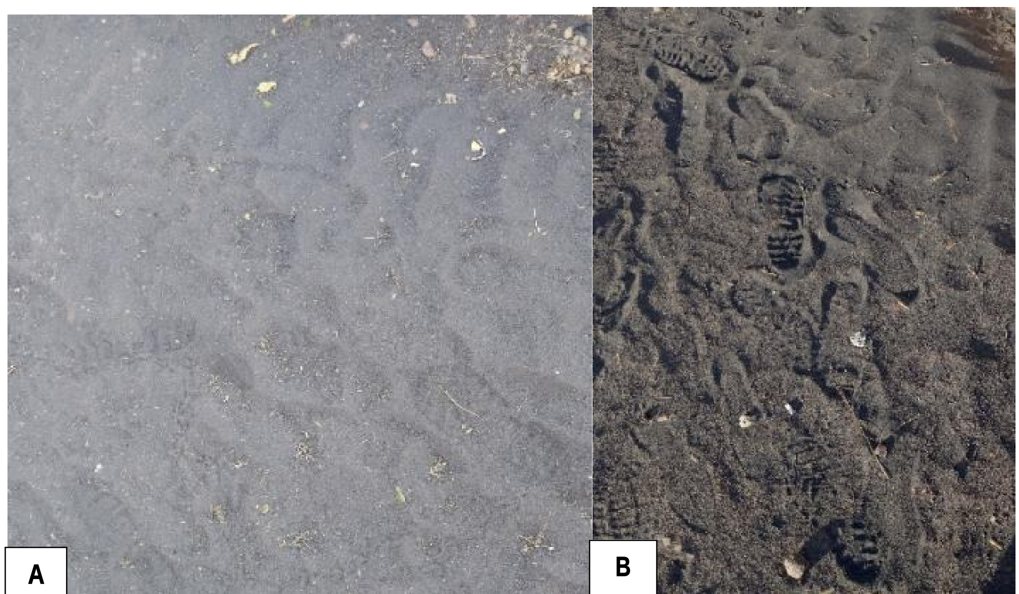
Identifying actual impacts shows the mine and mill activities that cause effects on components of the environment. The interactions causing these impacts are marked by a cross in each intersection cell of the source of the impacts and the receiver of the impacts (Table II). Identification reveals that the mechanical crushing of coal at the mine and itstransformation into energy at the plant level are the activities that affect the two receiving environments (biophysical and human).

Table II: activities sources of impacts and the environment receiving impacts.

	Impact receiving environments								
	Biophysical environment						human environment		
Factory activities	Countryside	Flora	Wildlife	Waters	Floor	Air	Health	Economy	Social
Activities at the mine									
Stripping	X	X	X	X	X	X	X		
Drilling	X	X	X	X	X	X	X		
Mining-shooting	X	X	X	X	X	X	X		
Loading-transport	X	X	X	X	X	X	X		
Mechanical crushing	X	X	X	X	X	X	X	X	X
Factory activities									
Water pumping				X				X	X
Transformation into energy	X	X	X	X	X	X	X	X	X

➢ **Floor**

Soil contamination by mining activity is characterized by the presence on the ground of mining heaps, acid mine drainage, waste treatment water, waste oil, fuels, lubricants, products containing heavy metals (Iron, Cu, Nickel, etc.), waste water discharge. The most visible impact on the ground is that of the coal dust which covered its superficial part a little around the mine (Photo 2).



<u>Photo 2:</u> Ground covered with coal dust (A and B) resulting from mechanical coal treatment by SONICHAR.

The soil represents the matrix most visibly affected by pollution thanks to the activities of the mine. Dangerous situations for soil pollution correspond to contamination due to atmospheric fallout, the storage of coal directly on the ground, mining waste stored on the surface, in particular bottom ash, acid mine drainage, waste treatment water and accidental spillage of polluting products (hydrocarbons, lubricants, products containing heavy metals, etc.). This leads, among other things, to the appearance of bare soils, the change in the mechanical behavior of the soil due to the flow of traffic from machinery, the modification of the soil cover as well as its physico-chemical properties.

Similar results were found by Goix (2012) in a study on the origin and impact of pollution related to mining activities on the environment and health, case of Oruro (Bolivia). Indeed, this study showed that the ore storage contaminates the surface on which it is stored as well as the close surroundings due to the resuspension of the particles, also the acid mine drainages contaminate the surface waters of which they are the tributaries. as well as the soils on which they circulate through the direct infiltration of contaminated water or reprecipitation of mineral phases by supersaturation.

The risk of soil contamination by various contaminants (heavy metals, organic components, etc.) is not to be neglected due to the storage of coal on the ground, but also that of bottom ash and the use of various explosives. Bottom ash, especially in terms of its composition, which, according to Guilbault (2013) is mainly composed of silica oxide (SiO_2), followed by aluminum oxide (Al_2O3) and ferric oxide (Fe_2O_3). In addition, organic compounds are also present polycyclic aromatic hydrocarbons (PAHs). This presents great risks of metal leaching and has negative impacts on health and the environment.

- **Soil contamination by wastewater**

Wastewater from coal processing is discharged directly to reach the koris. This act is not without consequences from the moment when during our visit, the cultivated soils, like many gardens located near this place of passage, are flooded and no longer productive, and abandoned by the owners (Photo 3).

<u>Photo 3:</u> Passageway for SONICHAR wastewater.

- **Physicochemical analyzes of wastewater**

The results of the physicochemical parameters determined in the waste water from the SONICHAR are presented in Tables III and IV.

Table I: Physical parameters determined in the waste water from the SONICHAR.

Settings	pH	temperature	THIS	T	VS	G	O	D	TDS	Alkalinity
Results	8.9	29.6	1029	374	Trouble	n/a	n/a	-	559	510
Units	-	Degree C	Us/cm	NTU	-	-	-		mg /l	mg /l
Standards	8.5	25	-	5	-	-	-	-	7680	500

Legend: T°: Temperature; EC: Electrical conductivity; T: Turbidity; C: Color; G: Taste; O: Odor; D: Hardness; TDS: Total Dissolved Solids.

Table IV: Chemical parameters determined in the waste water from the SONICHAR.

Settings	Results	Units	Standards
Phosphate (PO3)	12	mg /l	20
Bicarbonate (HCO3)	612	mg /l	5183
Copper (Cu-) free	1.16	mg /l	2
total chlorine	0.74	mg /l	250
Fluorides (F-)	2.32	mg /l	1.5
Nitrates (NO3-)	46.64	mg /l	45
Sodium	-	mg /l	500
Total iron	1.9	mg /l	1
Manganese (Mn^{2}++)	0.002	mg /l	5
Calcium (CA^{2}+)	8	mg /l	75
Zinc (Zn^{2}+)	0.46	mg /l	5
total copper	1.28	mg /l	1.5

Analysis of Tables III and IV reveals two findings:

- Most of the values of the parameters studied (conductivity, taste, odor, free copper, phosphate, total chlorine, potassium, manganese, calcium, sodium, zinc) have values that comply with WHO standards for wastewater;

- Despite this majority, some values of the parameters measured exceed the standards such as pH (8.9), temperature (29.6°), turbidity which gives rise to very cloudy water (374 NTU), alkalinity (510 mg /l), iron (1.9 mg/l), fluoride (2.32 mg/l), nitrite (46.64), and bicarbonate (612 mg/l) contents.

Given these overruns of the standard values, the water from the SONICHAR should be treated before any reuse or discharge into nature. However, animals graze on these places, which can in the long term cause problems for livestock, hence the risk of contamination of consumers and therefore can affect the health status of humans. Also, the study conducted by Goix (2012) found similar results, indeed the analysis of the waters of the DMA continuum (acid mine drainage) - Lake Uru-Uru shows very high concentrations of Metallic Trace Elements. When the DMAs flow into Lake Uru-Uru, they still greatly exceed surface water quality standards for Cd (5335 ± 389mg/l against 0.25mg/l surface water standard) and Pb (43101 ±10372 mg/l against 2.5mg/l standard for surface water), which contaminates the water, hence the health risks for animals and humans.

With an alkalinity (510mg/l instead of less than 500mg/l) and a bicarbonate content (612mg/l instead of 400mg/l), higher than WHO standards, this result may partly explain the presence of a whitish superficial layer on the ground (Photo 4), serving as a passageway for this water due to high levels of alkalinity.

Photo 4: Soil contamination due to the permanent passage of SONICHAR wastewater.

This layer indicates the presence of sodium in the environment, which has serious repercussions on the soil by increasing its level of alkalinity. According to the FAO (2003), an increase in soil alkalinity reduces its permeability, particularly on the surface, despite possible leaching. Similar results were obtained in a study conducted in Morocco by Derwich *et al.* (2008) on wastewater used for crop irrigation. With a high sodium content (> 0.069 mg/l) determined for all of their samples, which is likely to lead to an increase in soil alkalinity, which may partly explain the non-production of abandoned gardens around the factory.

It should also be noted that, due to the current nature of this withdrawn water, the characteristics of the waste water discharge are likely to vary in time but also in space.

- ❖ **Water**
- **Water use**

In terms of water supply, the company uses only one source of water which is the water pumping station located in Rharous 32 km from the industrial site,current withdrawals are on average equal to 250 m3/hour (2,200,000 m3/year). Note that in 2006 a quantity of 1,295,873 m3 of water was used for a production of 167,503 MWh (CRIIRAD, 2009) . Thus the reduction of underground resources is indeed possible, in view of of the daily withdrawal made. Added to this is the consumption of the populations living along the pipeline, whose withdrawals are still unknown but very high, but the latter are already complaining about the insufficiency of the resource. This already shows that this uncontrolled use has consequences for the aquifer that has been exploited for more than a decade.

As stated in Directive 019, the company should seek to maximize the use of mine wastewater produced at the mine site and minimize its liquid discharges, the use of fresh water should be minimal. Also according to the method established by the Bureau of Geological and Mining Research, Hamani (2019) points out that the exploitable resources in the Rharous field are of the order of 350 m3/hour for a period of 25 years, beyond which it would be appropriate therefore to look for a new well field. This duration has been largely exceeded, hence the need to search for a new well field to allow the aquifer to recharge.

- **Water pollution**

Water pollution results from all the activities that contribute to the extraction of ore. Also, due to soil contamination, ground and surface waters are threatened by contamination. Indeed, the dangerous situations for groundwater pollution correspond to the storage of coal on the ground, which can lead to the leaching of certain elements into the groundwater, the leaching of mining waste stored on the surface, the leaching of land contaminated by atmospheric fallout, leaks and/or ruptures in tailings ponds, leaching from mining works and accidental spillage of polluting products (hydrocarbons, lubricants, etc.). Physico-chemical analyzes carried out by CRIIRAD (2009) of the water from the SONICHAR mine discharged into the valley showed that this water is contaminated by certain metals. Compared to the maximum admissible concentrations (MAC) recommended in Europe for drinking water, they are loaded with Sulphates (326 milligrams per liter / MAC of 250 mg/l), Aluminum (714 micrograms per liter / MAC of 200 µg/l), Iron (2,280 micrograms per liter / CMA of 200 µg/l) and Manganese (2,700 micrograms per liter / CMA of 50 µg/l). This shows the contamination of groundwater and the health risks it presents to the population who consume well water in this area.

- **Air**

Atmospheric emissions are generally the result of exhaust gases and fumes emitted due to the circulation of machinery, but also the emanation of mineral dust from the extraction / transport / ore processing phases. The most observed emissions are due to the mechanical treatment of the coal which raises enormous dust (Photo 5) pollutes and degrades the quality of the air in the locality.

Picture 5: Release of coal dust during mechanical processing activities.

The negative impact on air quality is its reduction near mining sites, causing nuisance for the population and affecting their quality of life. These atmospheric emissions occur at each stage of the mine cycle, the operation of the SONICHAR mine being of the open pit type, air pollution is mainly manifested by the emission of dust and gas but also by the emission of coal dust during its mechanical treatment. Similar results were obtained in a study conducted by Goix (2012) which cites the main sources of atmospheric emissions in mining operations as emissions from foundries, re-suspensions from heaps and re-suspensions during transport of the ore from mine to smelter.

2.1.2.1. Impacts on the population

2.1.2.1.1. Sanitary risks

All of the respondents, regardless of their age category and length of residence, believe that there are environmental and health risks. Consequently, the entire population senses and sees these risks that exist in their living environments, hence this percentage (100%) which highlights the link that populations establish between environment and health.

- Report on the state of health

Aware of the presence of risks, the population is led to estimate their health status (Figure 2), 41% of those questioned say they have noticed the deterioration of their health against 59% claiming to have a stable condition.

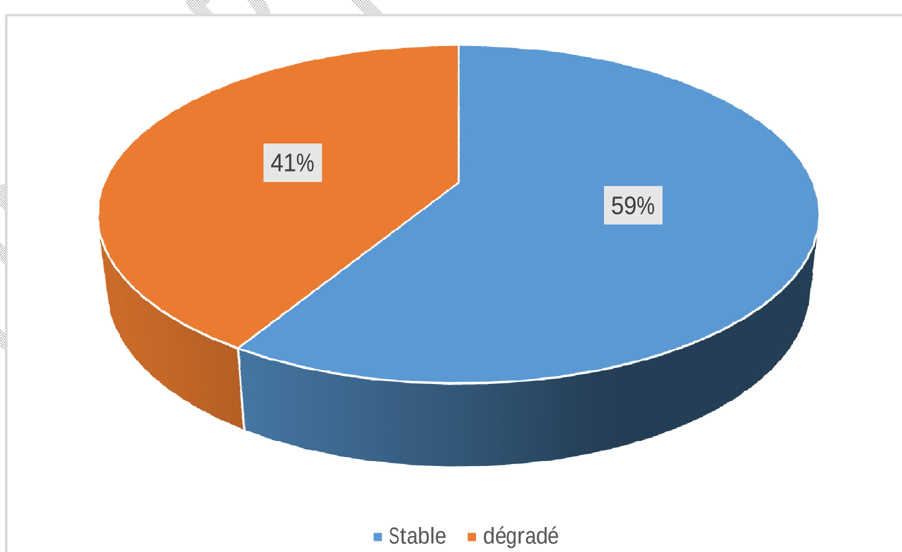


Figure 2: Assessment of the state of health of the population in relation to SONICHAR's activities.

However, this health degradation is a function of age but also of the lifespan in the environment. Thus, as for the observation that the population makes on their state of health, according to the age categories ([20-40 [young people and [40-50[elderly people), the number of people who affirm that their health is degraded by causes mining and industrial activities stands at 46% against 54% who state that their condition is stable (figure 3).

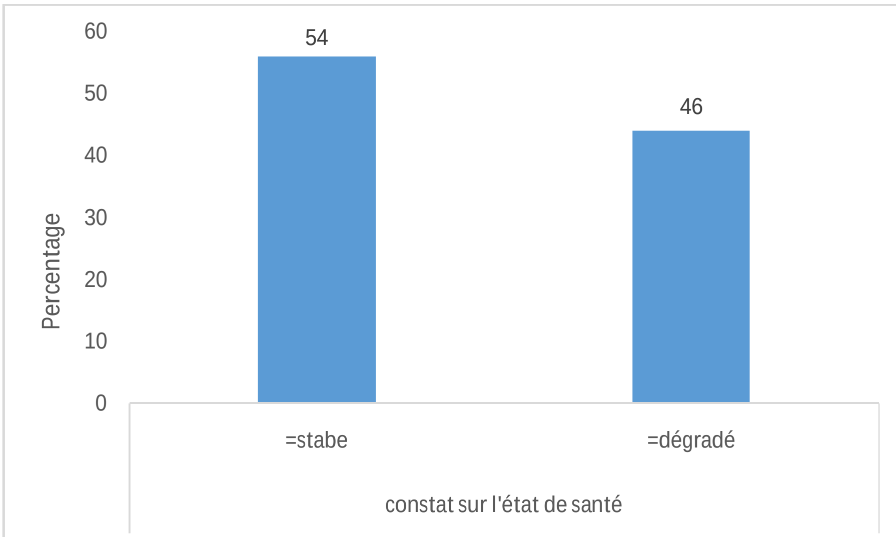


Figure 3: State of health deterioration according to the population in connection with the mining and industrial activities of SONICHAR.

46% of people affirm that since they live in this environment their health is degraded, these people are in majority of the old people while 54% of inquired affirm that their state is stable. This can be explained by the fragility of the health of these people compared to young people, since this group of (elderly) people is more sensitive to environmental pollution, at the same dose of exposure, their body defends itself less well than a person in the prime of life. The exposure time can be the cause of sensitivity to environmental pollution, the length of stay in the environment of these populations which differs also explains the vulnerability of certain people.

Among the people claiming that their state of health is degraded, 91% have a lifespan of more than 5 years, while only 3% of these people who have a lifespan that does not exceed 2 years say that their state of health is degraded. since they have been living in the municipality (figure 4).

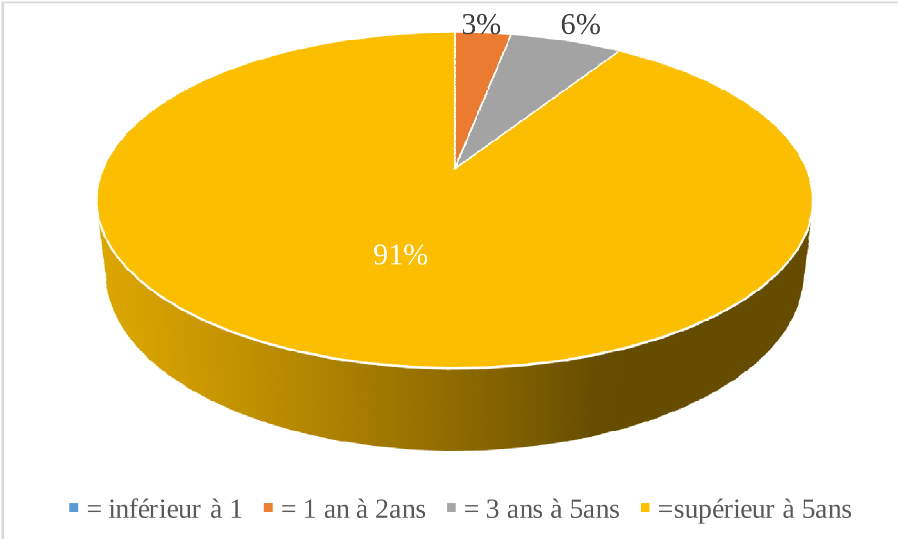


Figure 4: Percentage of people having noticed the deterioration of their health according to the time of residence in the commune of Tchirozérienne.

This dependence on the length of stay in the environment can be explained by the fact that the health effects of certain pollutants often only appear after many years and therefore have a long latency time (up to 20 years or more). Hence the high rate among people with more than 5 years in the middle compared to those who have a short duration.

Respondents believe that the physical characteristics of the air they breathe, such as dust, smoke, can be the cause of illnesses such as coughs, colds and especially eye diseases. The latter also complain about the degradation of their food by this dust which covers food and drink. Thus the population recognizes well, that the environment is a triggering factor of many diseases by the various physical aggressions of this one (pollution, unhealthy food, urban gigantism, destruction of green spaces) as affirmed by Legendre (2003) in his article about the environment and health.

Use of the terms dust by the population surveyedshows that the populations feel a certain degradation of the atmosphere in their living space as well as the awareness of the risk it runs for the degradation of their health. This awareness of the presence of the risk by the population is due to the perception of the physical elements and the effects that can be felt by inhaling air. This same awareness was notified in a study conducted by Daniel *et al* (2018) who cite the same reasons for this awareness in their study conducted in Yaoundé (Cameroon) on the perception of air pollution by inhabitants. Also the study conducted by Ouédraogo (2012) showed that over two years of study a high prevalence of pathologies such as malaria, gastroenteritis and respiratory diseases. These last two according to this study alone cover about 50% of the cases of affections. These results allow us to confirm our results of investigations making case of respiratory diseases due to mining activities.

2.1.2.2. Positive impacts

On the social and economic level, in a way, the positive impacts, the benefits that the population derives from mining and industrial exploitation are, among other things, the production of energy, commercial development, job creation, access at the health center and infrastructure development for education (Figure 5).

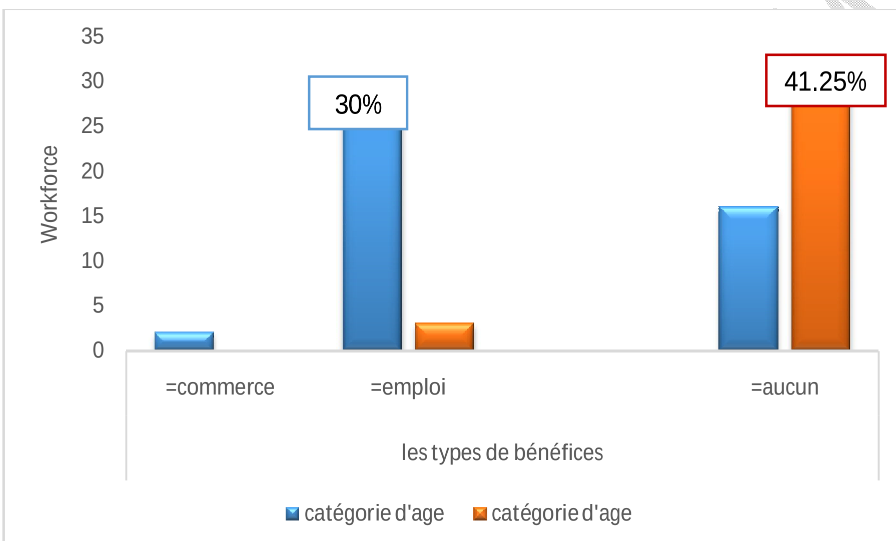


Figure 5:Socio-economic benefit following the presence and activities of SONICHAR in the commune of Tchirozérine.

The analysis of these results shows that the impacts of the activities on the human environment are, among other things, of a social and economic nature, thus, the population focuses only on the economic level, namely trade and employment where 30% of the young people claim to benefit from temporary employment while the elderly (41.25%) claim to have no benefit from its activities, all categories combined, if it is only to suffer the harmful effects of the activities of this factory. However, the population has access to drinking water for their consumption but also for irrigation, thus improving agricultural productivity. The temporary employment offered to the population also allows the increase of source of income, and the infrastructure is developed through the construction of a school, health center, a housing estate for employees and a restaurant. The category (20 to 40 years old) is the most profitable in terms of employment thanks to the work force and its performance that its employers aim for, hence the choice of this one.

However, the socio-economic impacts are not only positive, in fact the passage of waste water around certain gardens leads to their abandonment because they are flooded and non-productive, which is a severe blow to the economic and social plan for the owners.

2.2. Mitigation measures

The mitigation measures for these various impacts generated following the operation of SONICHAR are first and foremost the implementation of the environmental policy which has been adopted by the managers of this structure since July 2010. Consideration of the environment as they stated in their policy is necessary for the future of their business but also for the health and food security of the inhabitants of this area.

Atmospheric emissions being the most mentioned by local residents, and the most visible for kilometers from the city, in this area, one of the measures that is commonly used on the site is watering, these measures are effective since they minimize the raising dust, but often lead to other issues for the management of contaminated drainage water and the potential for contamination of surface water off-site.

One of the effective alternatives for the reduction of dust lifting from mining sites is the use of trees as a physical barrier to modify the wind speed profile. As proven by a study conducted by Hamel (2017) study aimed at controlling and reducing atmospheric emissions from mining sites by vegetation. This study demonstrated that the use of trees as a physical barrier to modify the wind speed profile is effective in reducing dust lift from tailings piles and soil erosion, but only the green wall windbreak is well located and know the sensitive receptor points. This measure is effective for human health and the health of ecosystems, although it does not reduce the presence of particles in the atmosphere. The company conducts studies for the selection of windbreak species but also to know the conditions of the site, this will make it possible to undertake the reduction of atmospheric pollution caused by it.

Since soil and water are inseparable, measures to protect soil will undoubtedly protect water resources. Thus, the use of mining waste to create covers makes it possible to store and neutralize water, then releases it through evaporation. This “cover that stores and releases water” prevents rainwater from oxidizing mine tailings and releasing acids that contaminate soil and groundwater. This is the result of a study conducted byHakkou and Benzaazoua (2016) after several trials confirming the effectiveness of this method. This method fits well with our environment, which is West Africa.

The recycling of non-acid mining waste is an alternative, indeed the research team Hakkou and Benzaazoua (2016) tested the development of a light ceramic by mixing coal residues with local clay to compete with commercial products. These researchers made mortar, concrete, artificial stones and bricks with the fly ash and coal residues recovered. Thus, innovation in mining waste recycling could provide good jobs to marginalized communities, while addressing the environmental and health impacts of mining debris, especially in this locality where the population complains a lot about these residues.

Adequate measures must be taken for the storage of coal in order to ensure the adequate protection of surface water or underground water but also of the soil, in particular by the collection and treatment of leaching water such as, for example, the place blankets before storage. They must also put in place adequate measures to protect the ore storage areas against wind erosion by creating fences to minimize the transport of coal dust.

For positive impacts, such as job creation, the employer must give the same chances of hiring the entire population. This will allow the population to feel less aggrieved.

Conclusion

This work focused on identifying the environmental and health risks of coal mining at SONICHAR in Tchirozérine. The surveys carried out among the population and within the company have shown that the activities of the mine and the plant have real impacts on the population but also and above all on the biophysical environment.The impacts generated during the activities of the mine and the plant on the environment are impacts having major to medium extents. Most of the activities call into question the integrity of the elements of the environment and completely modify their dynamics whether it is water, air, soil, fauna and flora. In addition, the company's activities are not in compliance with Directive 019 on the mining industry of March 2012, which accentuates the various negative impacts on the environmental matrices**.** The soils and the atmosphere are the units most affected by the plant's activities. The soils are affected by the atmospheric fallout of coal dust, which is continuously emitted in the locality. Thus, polluting both the air, modifying its quality and covers the soils of the area, thus modifying their physico-chemical composition and continues to have health repercussions on the population.The soils of the area are also confronted by the passage of water coming from the plant. The physico-chemical analysis of the sample of this water showed that this water has high concentrations exceeding the standards, in iron, fluoride and bicarbonate. Also the alkalinity of this water exceeds the standards, thus leaving a whitish layer on the soil, a major sign of their salinization, which can be the main cause of the non-productivity of the gardens which are near the area as well as their abandonment by the owners. .

At the level of the population, the impact on the latter can be qualified as medium impact, since these activities modify the way of life of the population without completely modifying their dynamics.These inhabitants have a remarkable awareness of the environmental and health risks they incur with more than 100% of the people questioned claiming to be aware of the presence of the risks and more than 30% claiming to have noticed the deterioration of their health even those who do not complain. no degradation of their health, attributes the cause of certain diseases (eye and lung diseases) of which they are victims to the activities of the factory. These statements are dependent on the length of life in the environment and the age of the people questioned, hence the variation in the answers.

The study made it possible to better integrate the concept of environmental protection at the level of the study area but also in the country in general, and to identify the environmental and social problems due to mining. Therefore, mitigation measures to reduce its risks have been proposed. These include, among other things, the use of vegetation as a windbreak, the storage and neutralization of water, techniques for protecting storage areas and, finally, the recycling of non-acid mining waste. This will minimize the damage caused to the environment but also create more jobs for the local population and at the same time reduce the impact on their health.

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