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IMPACT OF AIR POLLUTION WITH DUST IN THE OUENZA IRON MINE – NE ALGERIA

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Abstract: Dust generation and its dispersion has been the major concern in ambient air quality in mines. This paper focuses on generation and dispersion of particles during mining operations. Atmospheric pollution in mines areas of Ouenza has become a serious problem. The goal of this study is therefore to review the air pollutants of the approach by discussing studies applying mass conservation model methods. To support these theoretical calculations, field measurements will be performed to determine the air quality in the region concerned and to develop a program to prevent excessive air pollution that threatens human health and the environment. For the treatment of the results, we used regression analysis, assuming that the relationship between the pollutant concentration C_i and weight of various P_i sampling stations in the mine of Ouenza is a straight line following a linear tendency. Validation of the results from this study for urban air pollution would be highly beneficial.

Keywords: *particle deposition, emissions, modeling, concentration model, dispersion*

1. INTRODUCTION

The incursion of dust events in atmosphere, coupled with inputs from industrial emissions, could have negative implications regarding regional air quality. Opencast min-

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ing creates more air pollution problem in respect of dust and the fines. There is no well defined method for assessing the impacts on air quality due to mining projects. An investigation should be conducted to evaluate the impacts on air quality and the characteristics of the air-borne dust due to opencast mining [1, 15]. Air pollution is caused by emissions from point sources, area sources, mobile sources, and biogenic. Substantial evidence has accumulated that air pollution affects the health of human beings and animals, damages vegetations, soil and deteriorates materials, affects climate, reduce visibility and solar radiation, contributes to safety hazards, and generally interferes with the enjoyment of life [16].

Most industries utilize air pollution control equipment to abide with current regulatory requirements, these equipment ranges from bag filters, to scrubber systems to cyclones. The application of these equipments is mainly dependent on the type of pollutant that is predominant in the waste stream and the quantity and quality of the pollutants present in the waste stream. Pollutants that impose sever health implications will be prioritized as well. The final output, released through the stacks must fulfill regulatory requirements of the plant. These effects takes into account the amount of pollution that is released to increase the pollutant levels with the ambient air concentration, thus it ensures that the pollutants would not cause air pollution problems to the communities living downstream of the pollution sources.

In order to reduce the pollutants emissions in the atmosphere it is necessary to permanently monitor air quality. Therefore precise modeling of pollutants concentration distributions near surroundings is significantly important. Air quality modeling plays an important role in the management of our environment [1].

Attention of researchers has been attracted by dispersion of air pollutant in many ways. Atmospheric dispersion modeling is one of the tools that can be used to investigated emissions and dispersion. Atmospheric dispersion modeling is mathematical simulation of the dispersion of pollutants primarily in the boundary layer of the atmosphere. It is undertaken by making use of computer program that solve mathematical equations and algorithms which simulate the dispersion of pollutants [2].

There are various solution and approximation approaches that have been used in past to deal with air pollution dispersion [3, 4]. In last few years a new approach, Laplace Transform Techniques have been used for solving advection-diffusion equation [5–10]. Standard mathematical dispersion models used for industrial dispersion modeling include the industrial Source Complex (ISC) developed by the USEPA, Gaussian Models (Plume, Puff, and Fluctuating Models), EPA SCREEN model, Regression Models, Simple Diffusion Models (Box Model and Atmospheric Turbulence and Diffusion Laboratory, ATDL), Gradient Theory Models, Source-oriented and Receptor-oriented Models and Multiple Cell Model. More complex models may incorporate more realistic meteorological treatments, but generally require data which is more difficult and expensive to obtain [11, 12].

Mining operations from open cast mines generate a considerable quantity of dust through various activities such as blasting, unpaved road haulage, loading and stockpiling [13, 14]. The generated dust is an environmental hazard that can negatively impact on human health as well as the surrounding environment.

The determination of emission rates of various mining activities and prediction of pollutants concentration is necessary to assess the impacts of mining on air quality [15]. The study of the transport and dispersion of dust in the atmosphere is crucial for managing and improving the current controls. It also determines the occurrence and frequencies of worst scenarios of weather and in the end, it enables people to avoid or minimize emissions during these adverse conditions [16].

The main objective of this paper is to present a mass conservation model method easy to use for evaluating the presence of air pollutants in OUENZA mine, and the potential exposure of frequents to that risk. These studies were is to compute air pollution concentration in this mine using the general material balance equation. The goal of this paper is therefore to review the air pollutants of the approach by discussing studies applying mass conservation model methods.

2. METHODOLOGY

2.1. STUDY AREA

The massive of Ouenza (1288 m) is located in the old town Morsott Joint, 160 km from the port of Annaba and of 20 km from the Algero-Tunisian border. The mine was connected to the port of shipment by normal electrified railway of 190 km.

The iron-bearing deposit of Ouenza rests on the north side of a mountain range, which rises to 1288 mat the peak, it is about 12 km long by a 5 km wide. The primary extraction of iron ore hub in Algeria is the deposit of Ouenza. This field produces about 2 million tons per year of which 70% are higher grade than 55% and 30% variable content 45–50%. As for poor ore grade of 45% so they are temporarily stored on the floor of the mine. Iron ore is hematite grading 54% iron, plus 2% manganese (Cretaceous Aptian). These open-air reserves present a potential danger for the population of the Ouenza. The mine has suffered a decline in production as a result of the quality mismanagement of the exploited raw materials. For this purpose, the rest of the extracted quantity represents low-grade ores of different iron contents, which are mainly hematite, goethite, limestone and sandstone. These poor ores are currently stored near the mine and the town of Ouenza [36].

The iron ore deposit of Ouenza is divided into four neighborhoods; Chagoura south and north, Conglomerat; Saint-barbe and Hallatif. All these neighborhoods are exploited in the open pit mine [6, 15].

2.2. DUST DISPERSION MODELS

Dispersion modeling uses mathematical equations describing the atmosphere, dispersion, chemical and physical processes influencing a pollutant released from sources of a given geometry to calculate concentrations at various receptors as a result of the release [16].

Dispersion models require two types of data inputs: information on the source or sources including pollutant emission rates, and meteorological data [17]. In addition, they also need information on the topography of the study area (Fig. 1). Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determines the diluting effect of the atmosphere [18]. The models then use this information to simulate mathematically the pollutant's transport and dispersion. The output is air pollutant concentrations, for a particular time period, usually at specific receptor locations. The MATLAB SIMULINK, 7.7. software is used for the numerical processing [20]. The models also serve to assist in the design of effective control strategies to reduce emissions of harmful air pollutants [19]. A dispersion model is a computer simulation that uses mathematical equations to predict air pollution concentrations based on weather, topography, and emissions data.

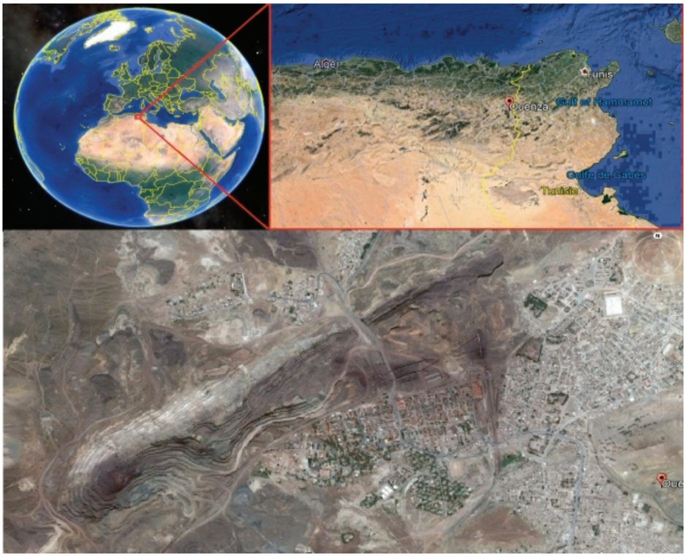

Fig. 1. Location of Study Area of Ouenza (Google Earth image)

Any model depends on the following inputs (Fig. 2):

- Emission parameter: Type of source, emission rate, location, height, temperature, etc.
- Topography: Rural or Urban area, terrain elevation, height and width of any obstruction, receptor location (height, distance from source), etc.

- Meteorological Condition: Wind speed and direction, Atmospheric temperature, Atmospheric stability, Cloud cover, solar radiation, etc.

The pollution transport and deposition modeling system is briefly described here.

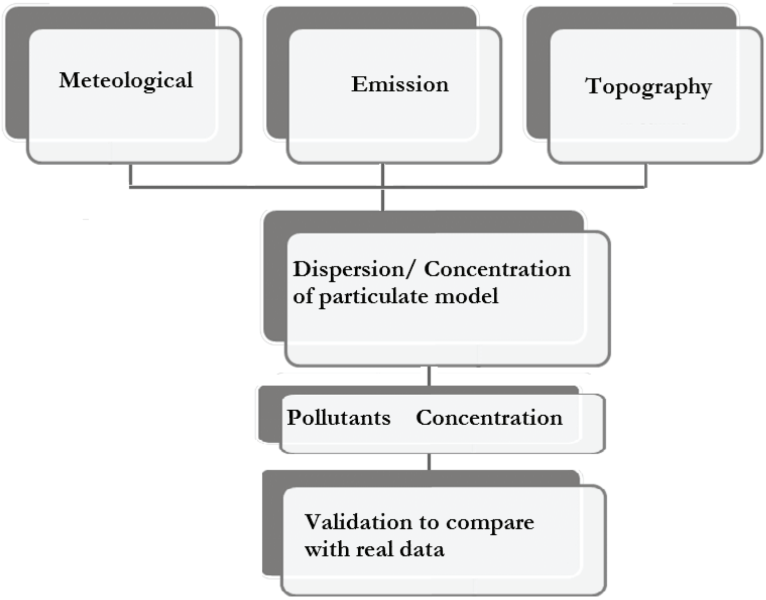

Fig. 2. Components of the Dispersion Model

There are several basic mathematical algorithms some of which include: Gauss model (plume, puff) [17, 18] Lagrange and Euler model [19], regression models, box models, multiple cell models and other new approaches, e.g., [20]. These models differ in the type of pollutant accommodated, pollutant source type and whether they use plume or puff approach.

For the purpose of the present study, the modeling of dispersion of air pollutants from an industrial source can be broken down into the followings

2.3. MASS CONSERVATION MODEL

The calculation of the transport and dispersion of pollutants is based on the basic principle of continuity-conservation (1). This principle describes a physical reality quite understandable.

The well-known atmospheric transport and dispersion equation is given as:

$$\frac{\partial C}{\partial t} = -D\frac{\partial^2 C}{\partial X^2} + U\frac{\partial C}{\partial X} - Sinks \cdot terms + Source \cdot term \qquad (1)$$

By replacing S in KS terms and source terms, we find the following equation

$$\frac{\partial C}{\partial t} = -D\frac{\partial^2 C}{\partial X^2} + U\frac{\partial C}{\partial X} - \alpha K + S_{sr} \tag{2}$$

where: C is the pollutant concentration in air, the source term represents input emissions and the sink terms include dry and wet deposition processes, $\frac{\partial C}{\partial t}$ is the variation of the concentration versus time, $\frac{\partial C}{\partial X}$ is the variation of the pollutant concentration in function of the distance (X), U is wind speed in the region, D is dispersion index of pollutants is the calculation with the following formula (3):

$$D = \frac{\sum (X - \overline{X})^2}{n-1} \tag{3}$$

where: X is concentration taken, $\overline{X}$ is the average of the concentrations.

If we consider the unit (Ouenza); outside of the unit contour is no polluting sources approximate, is that: we don't find the approximate pollutant sources.

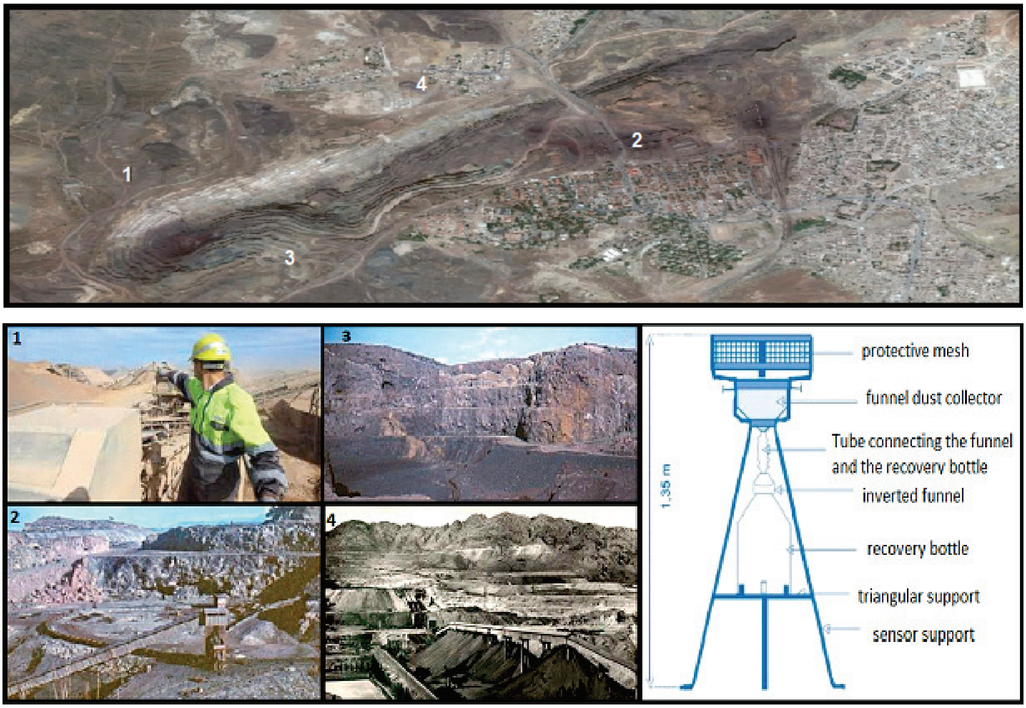

Fig. 3. Sources over the entire contour Equivalent source

***S*_*sr*_: is the number of pollutant sources outside considered the production unit. As well we suppose of source that the different sources into the unit can be simulated by a single equivalent source (Fig. 3).

αK: expresses the well or device (technical) pollutant absorber. In the case of the absence of this last we can be written that: $\alpha K = 0$.

D: is the dispersion coefficient that varies according to the normal distance from the source. We consider that this coefficient is the same as that found inside the units.

Finally, our conservation mechanism equation of mass can be written as follows:

$$-D\frac{\partial^2 C}{\partial X^2}+U\frac{\partial C}{\partial X}=0 \tag{4}$$

It has the following form:

$$\phi(k)=k-pk+q=0 \tag{5}$$

It is obvious from the equation written above thank it is a second order differential equation with constant coefficient p and q without second member can be put in the following form:

$$Y(X)=C_1\exp(k_1x)+C_2\exp(k_2x) \tag{6}$$

$$k_1 = V/D \text{ and } k_2 = 0$$

There k_1 and k_2 are real where $k_1 = k_2$.

Then we find that the general solution of our equation is as follows:

$$C(X)=C_1\exp(v/dX)+C_2 \tag{7}$$

3. EXPERIMENTAL RESULTS AND DISCUSSIONS

The research was done to mass concentration model dispersion in the Ouenza mine (Fig. 1). On the map, there are marked four places on the Ouenza mine.

The study of the determination of the concentration of the pollutant allowed establishing the degree of concentration and the impact on personal health status directly or indirectly exposed to dusty substances .We have indicated the sensitive places considered sources of dust in the production areas.

3.1. MATERIEL OF MEASUREMENT

For the analysis and measurement of pollutants, we have to use the type of measuring device that currently exists in the mine (Type CPM3). This device is intended to measure the weigh to respire in the atmosphere work sites or workshops to monitor in accordance with the latest medical data.

After retrieval work stations with the device mentioned above, the filter is retrieved from the device and brought into the lab and industrial hygiene in chemistry lab to determine the concentration of dust Fig. 4 and composition chemical there of Table 3.

Table 1. Instrument for measurement of dispersion of particulate

Type of device	Characteristics			
	weight	airflow	autonomous	charging time
CPM3 French sensor	3 kg	3 m^3/h	10 h	14 h

The relevant meteorological data that include wind speed, humidity are collected by an anemometer and hygrometer respectively. Dilution and dispersion of particle in a surface mine is a function of design of mine working and local meteorological condition.

3.2. MEASUREMENT TECHNIQUES AND ANALYSIS OF RESULTS

A. Case 1: measuring dust

Knowledge of influencing factors (concentration, chemical composition, etc.) of pollutants on the body reflects very important to locate certain specific risks such as the risk of silicosis, pneumoconiosis and others.

The values in Table 2, we report measurements of average concentrations of dust in jobs the mine (mg/m^3) and a threat of danger dust in its scope the entire working population.

Table 2. Dust concentration in different work stations mine of Ouenza

Shooting prelevment	Work station	Date	P_1 [mg]	P_2 [mg]	$P_2 - P_1$ [mg]	t_1 [h, min]	t_2 [h, min]	t	V [m^3]	C [mg/m^3]	SiO_2 [%]
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1. Crusher	system monitoring	08/07/13	1538	7858	6320	07 h 22 min	09 h 22 min	2 h	6	1053	13.60
		08/07/13	1813	8091	6278	13 h 15 min	15 h 15 min	2 h	6	1046	
		02/10/14	2000	7838	5838	07 h 40 min	09 h 40 min	2 h	6	973	
		07/10/14	1929	8839	6910	08 h 00 min	11 h 00 min	3 h	6	767	
	operator of crusher	10/07/13	1820	3941	3621	08 h 30 min	09 h 30 min	1 h	3	1207	08.80
		10/07/13	1702	5395	3693	13 h 00 min	14 h 00 min	1 h	3	1231	
		21/10/14	1912	7990	6078	08 h 30 min	10 h 30 min	2 h	6	1013	
		21/10/14	1823	7841	6018	13 h 00 min	15 h 00 min	2 h	6	1003	

1	2	3	4	5	6	7	8	9	10	11	12
2. Shuttle (band)	shuttle driver	21/07/13	2805	5070	2265	10 h 15 min	11 h 15 min	1 h	3	755	08.80
		10/11/13	1815	6045	4230	07 h 45 min	09 h 45 min	2 h	6	690	
		21/07/14	2210	4603	2393	13 h 30 min	14 h 30 min	1 h	3	731	
3. Quarter May 6	sounder	14/07/13	1513	4957	3444	08 h 45 min	10 h 45 min	2 h	6	574	08.80
		14/07/13	1528	5578	4050	13 h 15 min	15 h 15 min	2 h	6	690	
		22/10/14	2338	6845	4506	08 h 25 min	10 h 25 min	2 h	6	760	
		24/10/14	2317	7157	4440	09 h 00 min	11 h 00 min	2 h	6	740	
4. Load on the train	Handling station	15/07/13	2117	5120	3003	09 h 00 min	10 h 00 min	1 h	3	1010	08.80
		09/11/14	1853	8466	6612	09 h 00 min	11 h 00 min	2 h	6	1102	
		20/11/14	1915	8347	6432	08 h 25 min	10 h 25 min	2 h	6	1072	

B. Case2: Dust chemical analysis

Table 3. The chemical analysis of iron ore dust

Substances	Fe	CaO	SiO_2	Al_2O_3
[% weight] [mg /m^3]	52.52	4.25	8.8 to 13.6	2.34

Samples have determined that the average concentration of SiO_2 is between 8.8 and 13.60 (mg/m^3) , this clearly shows that this value is greater than the health standard 4.40mg/m^3 causing occupational diseases (silicosis, siderosis, etc.).measured pollution levels used to assess the potential harmfulness of the atmosphere, monitor pollution and determine the impact of consolidation measures.

C. Processing and analysis of results

For the treatment of the results, we used regression analysis, assuming that the relationship between the pollutant concentration C_i and weight of various P_i sampling stations in the mine of Ouenza is a straight line whose function is followed:

$$C_i = b + \varsigma \cdot P_i \tag{8}$$

or b and ς are the unknowns of the equation to be determined by experiments.

The results of Fig. 4 experience allows us to point out that the relationship between dust concentration and weight of the dust particles is straight line in the pitch of weight variation p = 20 to 32 mg and sample locations/crusher the band's career, and the loading on the train, the increase in weight P improves concentration dust.

Figure 7 shows the experimental results of pollutant dispersion by applying the model of mass conservation. Using the Matlab-Simulink [27], one can determine the concentration of the dust according to the different distances from an initial distance X_0 to the distance of 8 km.

This model is introduced the sis with all data into a computer program and gave the following figure (Fig. 5).

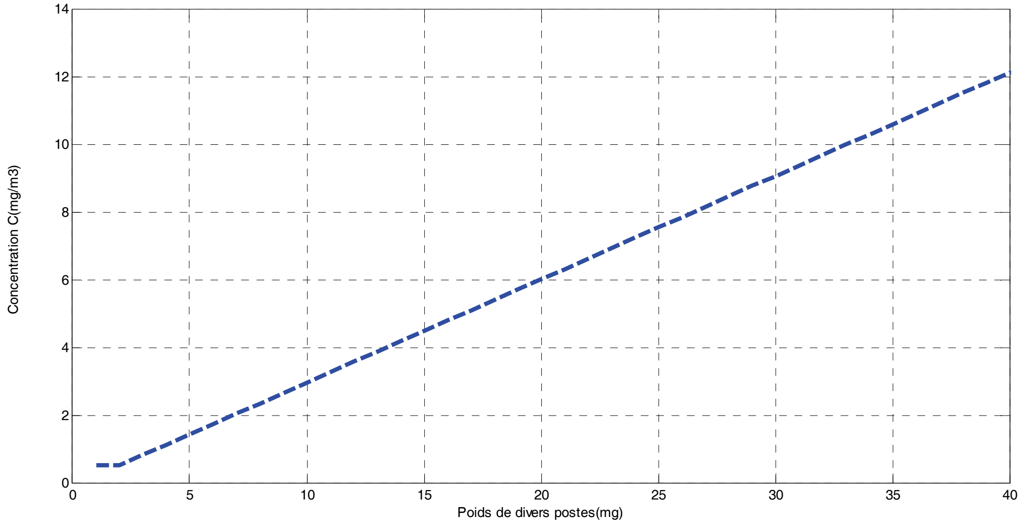

Fig. 4. Concentration versus particle weight

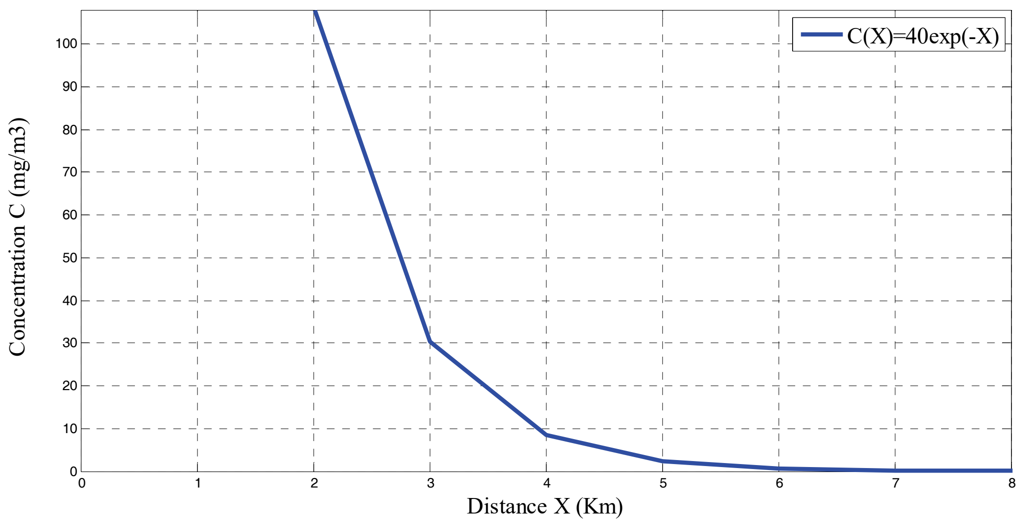

Fig. 5. Model of the conservation of mass

4. CONCLUSION

The health of the people might damage significantly because of the continuous exposure to these pollutant concentration for such a long duration. Our study of air pollution by dust in various positions in the mining business (mine of Ouenza) resulted in outcome measures that allowed reporting anomalies in certain production facilities.

In this paper, atmospheric dispersion model, continuity-conservation model, is used to predict the dispersion and ground level concentration at an opencast mine, with specific reference to Ouenza Mine as a case study.

The above discussed model is useful to know the pollutants concentration, and the chemical analysis of the pollutants collected in the area through proper sampling is necessary to know the chemical characteristics. Indeed, the comparison of experimental results with standards shows that the rate of dustiness far beyond the limits, putting the health of workers to the risks arising pollutants (Danger to humans, danger for the machine, danger to environment). We recommend taking all preventive measures to identify pollution and ensure good reliability of the production tool.

In the future, plume Gaussian air dispersion model of the performance can be analyzed and tested against measurements at ground level concentration of SO_2 daily average obtained at locations in industrial zone of Skikda city.

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