GÖBEKLİTEPE
International Journal Of Health Sciences

e-ISSN: 2757-6221

Arrival Date : 16.04.2022
Published Date : 25.06.2022
2022, Vol:5, Issue:8 pp: 1-10
DOI: http://dx.doi.org/10.55433/gsbd.226

CASE STUDY ON DUST FORMATION IN MINING OPERATIONS AND ITS EFFECT ON HUMAN HEALTH; CALCULATING A QUARRY DUST EMISSION AMOUNT

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ABSTRACT

In the face of developing technology and raw material need, there is a continuous mineral production in the world. Increasing mining activities cause many environmental problems, especially dust emission. Dusts generated in mining operations are of two types, generally explosive (particularly coal dust) and harmful to health (stone and coal dust). Dusts released during production activities in open pits are classified as harmful to health. These dusts pose a great risk for both the environment and employees. In order to reduce these risks, dust formation steps and dust removal methods should be determined carefully.

In this study, made in the quarry producing concrete aggregate; The amount of dust emission that will occur after stone crushing, screening and storage processes has been calculated. A pie chart distribution of the amount of dust given to the environment was made and statistically the maximum dust formation step was examined. The effects and risk values of the generated dust amounts in terms of human health were determined. Measures that can be taken to reduce dust emissions are presented under headings.

Keywords: Human health, Pneumoconiosis, Quarries, Dust emission,

MADENCİLİK İŞLEMLERİNDE TOZ OLUŞUMU VE İNSAN SAĞLIĞINA ETKİSİ ÜZERİNE ÖRNEK ÇALIŞMA; BİR TAŞ OCAĞI TOZ EMİSYONU MİKTARI HESAPLANMASI ÖRNEĞİ*

Özet

Gelişmekte olan teknoloji ve ham madde ihtiyacı karşısında dünya üzerinde sürekli bir maden üretimi mevcuttur. Artan madencilik faaliyetleri başta toz emisyonu olmak üzere birçok çevresel soruna neden olmaktadır. Madencilik işlemlerinde oluşan tozlar, genel olarak patlayıcı (özellikle kömür tozu) ve sağlığa zararlı (taş ve kömür tozu) tozlar olmak üzere 2 çeşittir. Açık ocaklarda yapılan üretim faaliyetleri sırasında açığa çıkan tozlar, sağlığa zararlı tozlar sınıfına girmektedir. Bu tozlar hem çevresel hem de çalışanlar açısından büyük risk oluşturmaktadır. Bu risklerin düşürülmesi için toz oluşum basamaklarını ve toz giderme yöntemleri dikkatlice ortaya konulmalıdır.

Bu çalışmada beton agregası üreten taş ocağında yapılan; taş kırma, eleme ve depolama işlemleri sonrasında ortaya çıkacak toz emisyon miktarı hesaplanmıştır. Ortama verilen toz miktarının pasta grafik dağılımı yapılmış ve istatiksel olarak en fazla toz oluşum basamağı incelenmiştir. Oluşan toz miktarlarının insan sağlığı açısından etkisi ve risk değeri belirlenmiştir. Toz emisyonunun düşürülmesi için de alınabilecek önlemler başlıklar halinde sunulmuştur.

Anahtar Kelimeler: İnsan sağlığı, pnömokonyoz, Taş Ocakları, Toz emisyonu.

*A part of this study was presented at the EurAsia Waste Management Symposium held in Istanbul in 2018.

1. INTRODUCTION

The construction sector, which has developed rapidly in the world and in our country, increases the need for stone quarries. Many problems arise because the need for stone quarries increases and the quarries remain inside the settlements. Besides being efficient, fast and economical, production to be made in quarries must be compatible with the environment. Many environmental problems such as dust and noise arise during the works carried out in the quarries. A lot of researches have been done to overcome these problems (1,2,3,4).

Dusts generated during mining operations can be divided into two as explosive and health-hazardous (stone and coal dust) dusts. Stone dust, which is one of the dusts formed during mining activities such as the extraction, processing (drilling, blasting, transport, etc.) and evaluation of rocks in quarries, can have a disease-causing effect. Fine quartz dust (SiO_2), one of the stone dusts, is a dangerous crystalline dust that is inhaled (5). Silica particles are the dust most commonly encountered by those working in mines and quarries (6). The risk potential of dust generated during various activities in mines depends on their specific properties (organic or inorganic compositions), particle sizes (<5µm) and inhaled dust concentration (7,8).

The human respiratory tract consists of the extrathoracic region (nose-pharynx-larynx) and the upper respiratory tract (tracheobronchial region) consisting of the trachea, and the bronchi (lung region) formed by the division of the trachea into two. Dusts larger than 5 µm are kept in the extrathoracic region, while dusts smaller than 5 µm enter the alveoli, the thinnest recesses of the lung, causing various health problems (9,10).

The negative change caused by dust in the lungs in the human body is defined as "pneumoconiosis" and this disease is an important cause of disability and death among workers working in a dusty environment. It is known that half of the workers are exposed to coal dust, silica and asbestos (11,12,13). Although pneumoconiosis is a general dust disease definition, various names are made according to the nature of the dust (14). In the table below (Table 1), the diseases that may occur according to the elements in the dust are given in detail.

Table 1. Minerals Affecting Human Health and Diseases They Cause (15)

Name of Mineral		***Diseases Caused***
Trace Elements	Iron, copper, lead, magnesium, zinc, manganese, cobalt, chromium, selenium, molybdenum, iodine	All Processes in Metabolism
Asbestos group	Chrysotile, crocidolite, tremolite, amasite, anthophyllite, actinolite	Lung, pleura, peritoneum, ovary, stomach, pancreas, kidney, upper digestive tract and respiratory tract cancers, hyalanized calcified pleural plaques, pulmonary fibrosis.
Quartz Group	Amethyst, tridymite, cristobalite, keratite, coesite, stishovite, chalcedony, silex	pneumoconiosis
Coal Group	Hard coal, peat, lignite, anthracite	pneumoconiosis
Silicate Group	Phenacite, olivine, alumino silicates, greene, epidote	pulmonary fibrosis, hyalanized calcified pleural plaques
Zeolite Group	Analcime, leucite, natrolite, chabazite, heulandite, stilbite	pleural and peritoneal cancers, pleural thickening, calcified pleural plaques
Radioactive Group Calcite, Aragonite, Vaterite	Uraninite, Tyuyamunit, thorininit, autunit	bone, bone marrow, skin and lung cancers gallbladder stones
Talc, Mica, Kaolin		pulmonary fibrosis

The effects of the processes carried out in stone quarries, where dust formation is very high, are very high on human health. In this study, the amount of dust generated during the aggregate production processes in a sample quarry was investigated. The amount of dust formed was compared with the limit values that may affect human health.

1.1. The Impacts of Quarries on the Environment

Along with rapidly growing construction sector and other aggregate usage areas, quarries have approached the central settlements and environmental problems have increased. Quarries create negative effects such as dust, noise and vibration on the settlements in the surrounding areas during work and also the randomly opened quarries bring with them the visual negativity which is quite contrary to the city view. The environmental impacts of quarries can be summarized in 3 main categories (16,17,18). These are;

1. Vibration, Noise, Stone Leaping: occur as a result of the blast during the production in quarry.

2. Dust: It occurs as a result of explosion, disintegration, loading, transport (round trip total distance), unloading, crushing screening operations.

3. Visual pollution: It is the pollution created by the field where the mine tallow is discharged, removal of vegetation cover on ore and by the voids and high slopes that occur during mining operations.

1.2. Environmental Problems Caused by Dust

The particles with a diameter of less than 1 mm are called dust. Depending on their size and structure, dust particles can be hanging in the air or precipitate in a very short time. Generally, the dustiness of an airspace is described as the weight of dust as mg in 1 m^3 air (gravimetric method) or the number of dust in 1 cm^3 air (piece number). Dusts are divided into 3 classes according to grain sizes (19);

Normal Dust : They are dusts with diameter greater than 10 microns. In still weather, they move towards the ground at an increasing speed.

Fine dust : They are dusts with diameters between 0.1 and 10 microns. In still weather, they move towards the ground at a constant speed.

Very fine dust : They are dusts with a diameter of 0.1 micron and smaller. Their movements in the air are similar to the movement of gas molecules. They are always moving and they do not settle on the ground.

It is an inevitable phenomenon that is unwanted and tried to be prevented in mining because it is harmful to health and in underground operations, especially in coal mines, it causes dust explosion.

The amount of the damage that dust causes in the mines varies depending on the type and duration of exposure All dust entering the body is harmful but the dust, collected in the lungs, between 1 and 9 grams containing 20% silica cause silicosis disease and 15 grams of silica causes severe silicosis (20,21,22). If the dust containing 50 grams and 175 grams of 1% -2% silica is accumulated in the lungs, it causes Pneumoconiosis from the most common occupational diseases.

Figure. 1. The Main Parameters of The Dust Formed in The Quarries (Production, transportation) (pictures are anonymous)

2. METHOD

2.1. Calculation of Dust Emission

In the stone quarry studied in the Black Sea region, 200,000 tons of production are carried out annually by excavation method. During production, it works 10 months a year, 26 days a month and 8 hours a day an accordingly it is known that the production of 20,000 tons per month, 769,2 tons per day, and 96,1 tons per hour are carried out. The pollutant emissions caused by the basalt quarry and crushing-screening plant during the operation phase have been evaluated within the scope of this study.

Dust emission formation in stone quarry will occur during scraping operations, removing, loading, storage, evacuation, breaking, sifting and relocation of the materials. These factors are considered separately and the amounts of pollution are calculated below. The emission factors used in the calculations are given in Table 2.

Table 2. Dust emission factors during quarry production (22)

Dust Sources	*Emission Factors (kg/t)*	
	Uncontrolled	Controlled
Dust Emission as a result of Blasting	0.080	-
Dust emissions from excavation	0.025	0.0125
Dust emissions from loading	0.010	0.005
Product cast	0.010	0.005
Transportation	0.7	0.35
Open storage of material	5.8	2.9
Primary crusher	0.243	0.0243
Secondary crusher	0.582	0.0582

2.1.1.The amount of dust to be formed in stripping operations

The area where the basalt deposit is located is 100000 m2 (10 hectares). In this area, the valuable part to be taken is close to the surface and the thickness of the cover layer that needs to be scraped is an average of 0.25 m.

100000 m^2/ 10 years=10000 m^2/year × 0,25 m =2500 m^3/ year

The operating life has been determined at 10 years. Scraping operation will be done in parallel to production and will be completed by working one shift every 11 days per year. The daily amount of material to be scraped is 360 tons. The dust emission during the removal of 25 cm surface soil is calculated as follows. The amount of cover excavation to be done per hour in the quarry(m^3/h)

Calculated according to the formula

$M_{ös}$ = K/(G x V_s x h)…………………………………………………… [1].

$M_{ös}$ = The amount of cover excavation to be done per hour(m3/h), K = Cover excavation capacity (2500 m^3), V_s =Number of shifts [1], h =Working time in the shift (8 hours), G =Number of days to work (11 days), $M_{ös}$ = 28.4 m^3 / h.

28.4 m^3 / h x 2.6 tons/m^3 = 73.86 tons Hourly excavation is about 74 tons.

Dust emissions from excavation: 74 tons/8 h*0.025 kg/ton= 0.231 kg/h

Dust emissions from loading: 74 tons/8 h*0.01 kg/ton= 0.092 kg/h

Dust emission of product casting : 74 tons/8 h*0.01 kg/ton= 0.092 kg/h

Dust emission from transportation 3 times by 1 truck of 15 tons(the longest road distance from the quarry to the vegetable soil casting area is 0.250 km) : 3 times/8 h*0.7 kg/km-vehicle x0.250 km x 2= 0.131 kg/h

Dust emission generated from vegetative soil storage: Scraping operation will continue in parallel to production. The removed material will be stored and kept to be used for filling voids formed in parallel to the production and for afforestation operations.

The vegetable soil storage area is 0.16 hectare and selected within the production area.

5,8 kg dust/ha.day x 0, 16 ha ÷24 h/day=0,038 kg/h

The operation of scraping of cover soil, vegetable soil on the basalt will be done before moving on to the quarry works. The resulting dust emissions are kept separate from the dust emissions generated during production operations.

According to this; the total amount of emissions to be generated during scraping, loading, transport, storage and unloading of the cover soil;

0.231 kg/h +0.092 kg/h + 0.092 kg/h + 0.131 kg/h + 0,038 kg/h = 0,584 kg/h (Fig.2).

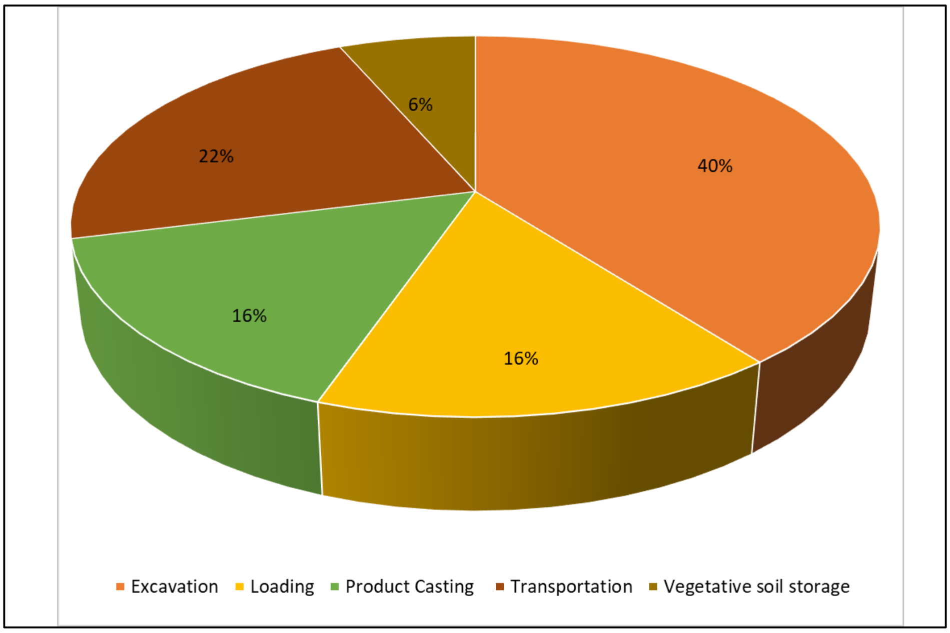

Fig 1. The Amount of dust to be formed in stripping operations

2.1.2. Emission of Dust Caused During the Excavation of Basalt and its Delivery to the Facility

Emission calculations of basalt, separated from main mass loosened by blasting, which occur during loading to truck, transporting, unloading to the crushing-screening plant, its breakage, elimination and transportation, are coming. The material excavated from the quarry will be loaded on the trucks and shipped to the crushing-screening plant. An average of 500 meters will be traveled by trucks from the quarry to the facility. Therefore, dust emission will occur at a distance of 1000 m. due to shipping as the round-trip to the crushing-screening plant from quarry. According to this;

Removing the material:

Dust emission during removal of material obtained by blasting;

Removal of materials dust emission = 96,1 tons/hx0,025 kg/ton= 2,4025 kg/h

Dust emission during loading = 96,1 tons/h x 0,01 kg/ton = 0,961 kg/h= 1,00 kg/h

Transportation of material transportation to crushing-screening plant: Dust emissions from transporting by 20-ton truck (distance from the stone crushing facility 1000 m)

Total number of transportation = 96,1 tons/hour / 20 tons/vehicle ≈ 5 vehicle/hour.

At the quarry, approximately 96,1 tons / hour of production and about 5 times of transport in an hour will be carried out.

5 times*0.7 kg/km-vehicle x 1000 km = 3.5 kg/h

Total dust emission: 6,8635kg/hour (fig. 3).

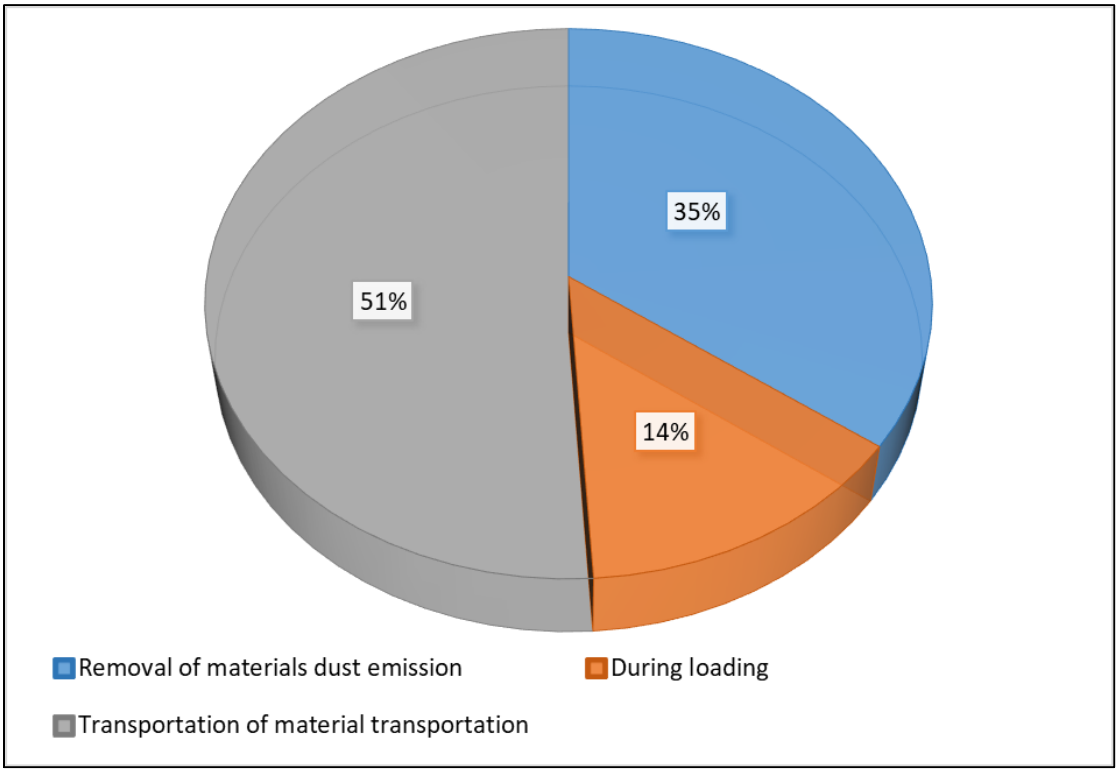

Fig 2. Dust caused during the excavation and its delivery to the facility

2.1.3. Dust Emission as a result of Blasting

The amount of production to be broken off in an explosion is about 8385 tons and 43 holes will be opened. Delay capsule will be used during blasting; a delay interval will take 30 seconds and each hole will be blasted sequentially. The generated dusting is instantaneous and loses its effect within 10-15 seconds. Therefore, during the time elapsed in the second delay interval, the dusting of blasting that occurs in the first delay interval will fade away. For this reason, the calculations have been made considering the amount of material to be excavated from a hole (195 tons).

Amount of Material = 195 tons / hole (the amount of material to be broken off at a stroke)

Blast emission factor = 0.08 kg/ton

Total emission in blasting = 195 x 0,08 = 15.6 kg/blast.

2.1.4. Emission to Occur During the Operation of Crushing-Screening Plant;

Within 10 hectares of the registration area basalt Quarry will be opened to obtain raw materials and the removed material will be transferred to Crushing-Screening Facility within the registration area and will be processed.

The entire basalt to be produced in the quarry will be processed daily in the crushing-screening plant. It is planned that 200.000 tons of material will be excavate per year and all of this is will be processed in the basalt crushing-screening plant. A stabilized road of approximately 80 m length will be used for transportation from crushing-screening plant to asphalt road. The distance to asphalt road from the facility is 2 x 80 m = 160 m including round trip.

Total time of transport= 96.1 tons/hour / 20 tons/vehicle = 5 vehicle/hour.

In the facility, approximately 96.1 tons/hour of production and about 5 times of transport in an hour will be carried out.

Removing Material: Produce amount: the resulting emission rate when the emission factor for removal of 167 tons/hour material from the quarry is taken as 0.025 kg/ton;

167 tons/hour x 0,025 kg/ton = 4.175 kg/hour

Loading of Material: When the emission factor of loading material into trucks is taken as 0.01 kg / ton, the resulting emission flowrate; 167 tons / hour x 0.01 kg / ton = 1.67 kg / hour

Transportation of material (crushing-screening plant): In the case of a truck carrying 20 tons-times of material, the number of hourly trucks;167 ton/hour/20 ton-time = 8.35 times/hour, 0.7 x 0.1 x 8.35 times/hour = 0.5845x2 = 1.169 kg/hour

Unloading Material: When the emission factor for the discharge of material is taken as 0.01 kg / ton, the resulting emission flowrate;167 tons / hour x 0.01 kg / ton = 1.67 kg / hour,

Crushing Material: Since the crushing operation will carried out in a controlled manner, the resulting emission flowrate that will be generated when the emission factor for crushing the material is taken as 0.0585 kg/ton;167 tons/hour x 0.0585 kg/ton = 9.77 kg/hour

Sifting of the Material: When the emission factor of the material during the screening process is taken as 0.01 kg/ton, the resulting emission flowrate; 167 tons/hour x 0.01 kg/ton = 1.67 kg/hour

Open Storage of Material: The removed basalt will be temporarily stored in a suitable area within the work area, 5.8 kg dust/ha.day x 0.1 ha / 24sa/day=0.024 kg/hour

Transportation of material (crushing-screening plant): In the case of a truck carrying 20 tons-times of material, the number of hourly trucks; 167 ton/hour 20 ton-times = 8.35 times/hour, 0.7 x 0.1 x 8.35 times/hour = 0.5845x 2 = 1.169 kg/hour (Fig.4).

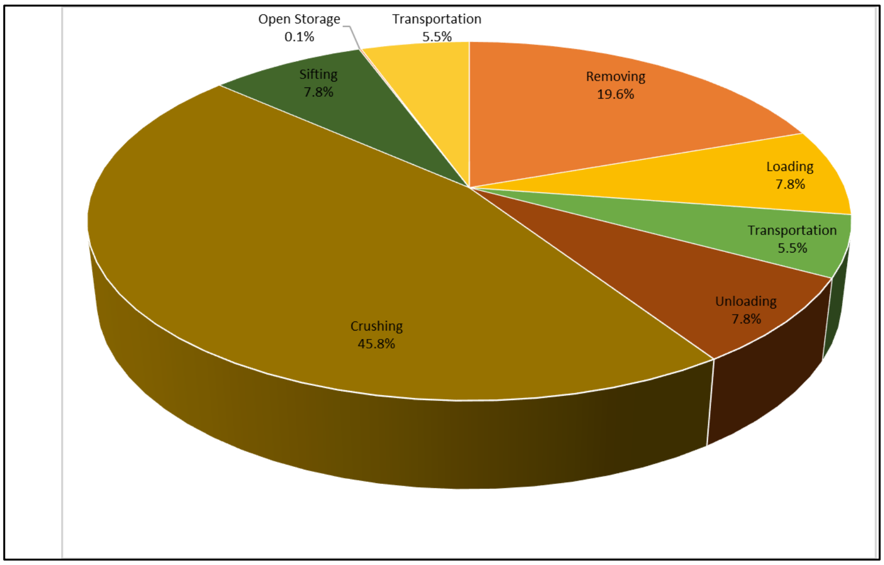

Fig 3. Emission to Occur During the Operation of Crushing-Screening Plant

According to this; the total amount of emissions to be generated during the removing, loading, transporting, unloading and open storage of the excavated material is as follows; 4.175 kg / h + 1.67 kg / h + 1.169 kg / h + 1.67 kg / h + 9.77 kg / h + 1.67 kg / h + 0.024 kg / h + 0.169 kg / h = 21.317 kg / hour (Fig. 4).

3. RESULTS

In this study, the amount of dust generated during production in a sample quarry was calculated. The findings obtained as a result of the studies carried out are given below.

As a results of the study, it has been found that the total amount of emissions to be generated during scraping of the cover soil, loading, transport, storage and unload is; 0.584 kg/h.

It has been found that the total amount of emission to be formed during removal, loading, transport, unloading and open storage of the excavated material is; 21,317 kg/hour.

The total emission values found are below the 1 kg/hour limit of the "Industrial Air Pollution Control Regulation" which entered into force by being published in the Official Gazette dated 30.03.2010 and numbered 27537. For this reason, the subject of the study will not be the negative impact of the emission, which is generated during pickling production and crushing elimination operations in the basalt quarry, on the environment.

After the production, irrigation will be done in the quarry in order to avoid the pollution due to the transportation of the removed material by the trucks caused by the roads and works. During the transportation, the top of the material sent will be covered with nylon canvas. The transportation way will be irrigated; no spattering will be done during loading unloading; in arid and windy weather stock material will be covered with canvas and nylon over it.

By making the propagation modeling of dust emission to occur at blasting, the area to be affected by the dust to be generated at the time of blasting should be determined. With modeling studies, how dust emissions, which are pollutants originating from the operation within the working area, will spread under existing meteorological conditions and as a result of this spread possible ground level depositions caused by the relevant pollutants must be determined.

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