Asian Review of Environmental and Earth Sciences
ISSN: 2313-8173
Vol. 2, No. 3, 42-53, 2015
http://www.asianonlinejournals.com/index.php/AREES

Environmental Impact Assessment and Sedimentology of the Carbonate Quarry Site for Al-Maroua'ah Cement Plant in Al-Hodeida District, NW Yemen

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Abstract

In this study, environmental impact assessment and sedimentology includes chemical analysis were carried out for the quarry site of the limestone raw material in Al-Maroua'ah cement plant in Tehama plane, Al-Hodeida district NW Yemen. The study includes the assessment of the limestone raw materials, the quality, chemical and mineralogical analysis and expected pollutions impact in the quarry site. The studied rock successions are belonging to the Amran Group, which is composed mainly of limestone rocks with few interbedded marl, shale and sandstone beds. The chemical analysis of the limestone rocks show CaO content is (50.31%), with very little MgO content (0.71%). The present shale marl and sandstone rock units are useful for the correction of the rocks to concise with the international specifications of the cement production. The site of the quarry of the main raw materials of limestone rocks was selected far From the villages and human populations to prevent the environmental pollutions according to the WHO and YEPA specifications. The emitted dust from the operations of the quarry machine makes impacts on the surrounding environments especially for the farms and the natural plants and animals, which are living in the region. For this, the site of quarry is selected in a mountain far from the vegetation, population and villages to avoid the expected environmental impact. Mitigation plan for prevent or decreases the pollution impact to the minimum, was discussed.

Keywords: Al-Maroua'ah, EIA, Limestone, Quarry, Chemical analysis, Dust pollution, Gases pollution, Management plan.

Contents

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1. Introduction

Al-Maroua'ah cement factory is significantly contributed in the development of the Yemeni economy after operating in early 2015. The plant management had adopted the commitment to improve the local economy of Al-Hodiedah Governorate, and the region where the plant exists, to provide jobs for the citizens of the Governorate and of the region in particular, in addition to the medical and educational services proposed to be provided in the plant region, as well as the erection of the integrated residential city for the staff and the labors of the plant. The cement production capacity in Al-Maroua'ah cement factory reaches up to 3,000,000 MT of cement.

This study had been produced to assess the environmental impacts of the operations held in the quarry of the raw materials and the resulting residuals of such operations followed the limitation of the EPA [1]. The plant management undertakes to apply the Yemeni environment management plans proposed in this study; including the measures of reducing the emissions; and the continuous environmental monitoring program. Moreover, this study deals with the assessment of the carbonate rocks as the main raw materials in cement production.

2. Methods and Materials

The evaluation of the quarry and the raw materials for cement production and its environmental impact includes field works and survey as well as chemical analysis.

The field works include the selection of the quarry site according to the international specification to prevent the environmental pollution as well as the systematic sampling of the limestone raw materials for quality evaluation.

It will exploit the Falafel Mountain to supply the factory for raw materials (limestone). The EI assessment was followed the parameters listed in the EPA [1] and National [2] Falafel Mountain was divided into three areas for exploit and the details of these areas and coordinates are listed in Figure 1.

Twenty five (25) rock samples were collected and later prepared and analyzed by XRF in the lab of AL-Watanyiah Cement plant in Lahg Governate followed the procedure listed in Tucker [3]. The results were interpreted and the rocks were evaluated for cement production.

3. Quarry Site and Characterization

The quarry site is lying in Jabal Falafel Mountain in Al-Maroua'ah region, 36 km east of Al-Hodiedah Governorate, and 4-5 km from the main road connect Al-Hodiedah with Sana'a City (Fig.1). Jabal Falafel Mountain lies near Dear Daood village, which is situated in Tehama Plane parallel to the coast of the Red Sea. Some of these areas are agricultural farms with abundant underground water in all seasons of the year. The land surface of the region is located at an elevation of about 120 meters above the sea level (Fig.1)

The primary raw materials used in the production of cement are usually provided from limestone quarries, which are generally located near the plant site to reduce transportation and production costs, whereby the limestone bedrocks are the most important imperative raw materials for cement industry. The limestone rocks are extracted by drilling and explosion before being transported by conveyor belts or heavy trucks. Later on, the extracted rocks are subjected to cracking and screening processes to specify the grain size, and finally stored [4].

The heavy trucks working in the quarry discharge the cargos in the funnel-shaped container (hopper), which is supported by series of sieves to separate pieces of large from the smaller rocks, thereby curtailing the load and effort of the initial crusher. The large rocks are broken down and the sizes are reduced (Size of product - 90% less than 25mm) before passing over conveyor belt which transfers the raw materials through Gamma automatic analyzer, and thereafter, they store in opened sheds yard [4, 5].

3.1. Sedimentology and Quality of the Limestone

The limestones is belonging to Amran Group and cropping out in Jabal Falafel Mountain, which is laying near the site Al-Maroua'ah cement plant. The carbonate rocks include successive and interbedded massive and bedded limestone and marls of about 500 m thick [6]. Thick massive sandstone bed of 25 m thick is interbedded with limestones. The limestones are composed of lime mudstone, packstone, grainstone and wackestone microfacies Flugel [7] and Scholl and Ulmer-Scholl [8]. It is mainly composed of calcite and micrite, with very rare dolomites, which represents very good quality for cement production [4, 5]. The sandstone is basically composed of silica grains and partial cemented with argillaceous matrix.

3.2. Chemical Analysis

The chemical analysis was carried out using XR-Fluorescence instrument type THRMO in the lab of Al-Watanyiah Cement factory and the data is listed in Table (1) which shows that is relatively pure with high to very high CaO% and low MgO%. The silica, aluminum, iron oxides and alkalis are very low. Thus, the raw materials require substantial correction with argillaceous, siliceous and ferruginous materials.

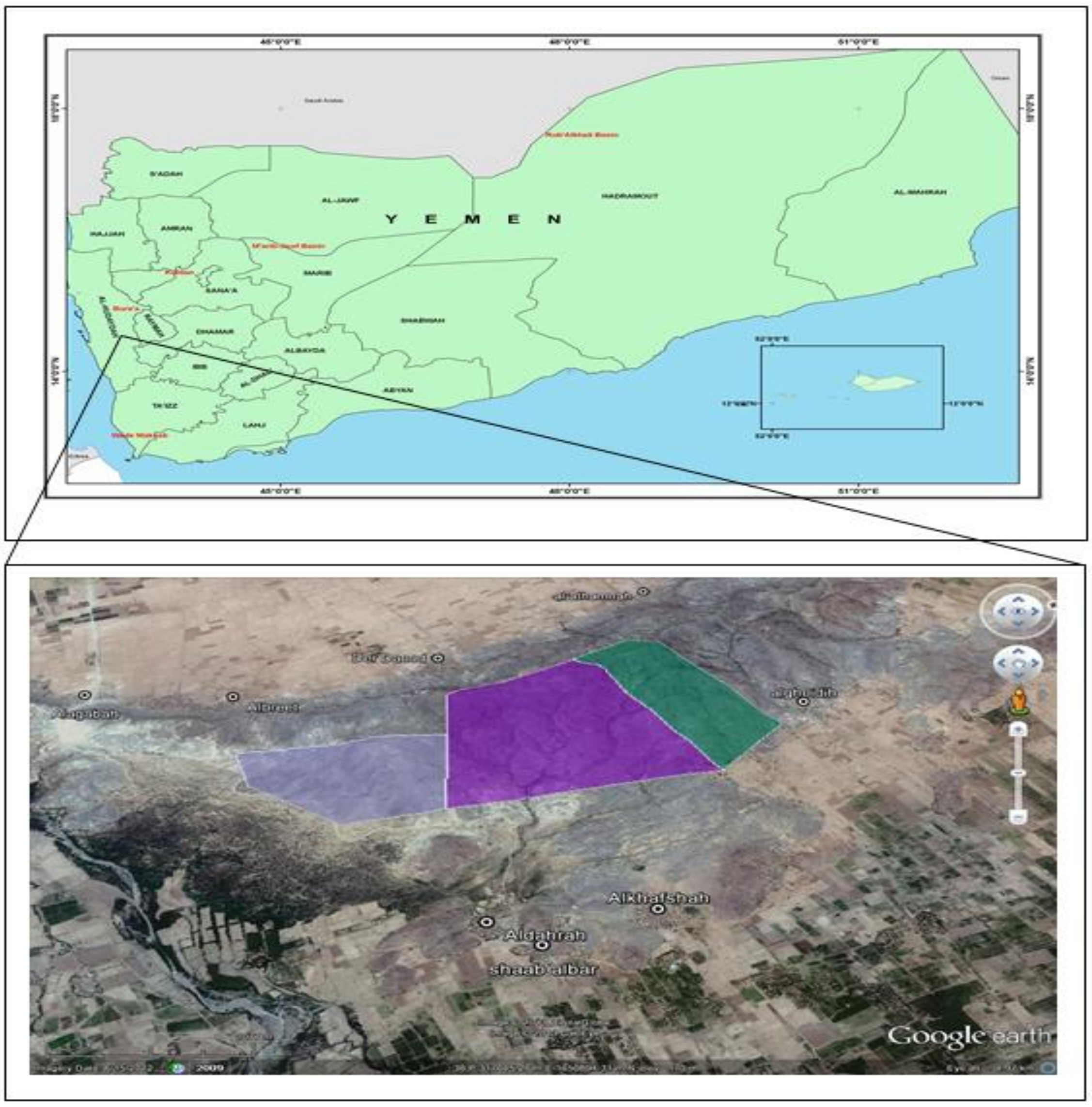


Fig-1. Location map of Yemen shows the site of Al-Maroua'ah cement plant and the quarry site (the colored blocks), at Jabal Falafel Mountain (Sat image-google earth).

Fig-2. Field photograph shows the extraction processes of limestone

Table-1, Shows the chemical analysis data of the limestone and other raw materials in the study area.

Sample no.	Type	Results %										
		SiO2	Al2O3	Fe2O3	CaO	MgO	SO3	Na2O	K2O	Cl	TiO2	LOI
LS-1	limestone	2.74	0.38	0.14	50.31	2.42	0.058	0.025	0.024	-	-	-
LS-2	limestone	2.72	0.400	0.180	51.69	1.84	0.210	0.040	0.110	0.001	-	-
LS-3	limestone	0.31	0.007	0.000	55.47	0.71	0.086	0.023	0.000	0.001	-	-
LS-4	limestone	1.47	0.176	0.033	50.82	2.78	0.079	0.021	0.036	-	-	-
LS-5	limestone	0.67	0.000	0.000	55.44	0.52	0.140	0.020	0.000	0.001	-	-
LS-6	limestone	0.74	0.240	0.280	54.46	0.7	0.226	0.026	0.064	0.001	-	-
LS-7	limestone	0.14	0.019	0.000	38.35	13.228	0.019	0.240	0.000	-	-	-
DK	Volcanic Rock	72.08	13.22	2.77	1.1	0.25	-	4.36	3.26	-	0.25	2.28
CLAY	Clay	58.89	11.98	6.36	8.15	2.83	-	2.45	1.81	-	1.37	-
MR 2		7.595	2.2	2.08	41.92	1.42	0.29	0.078	0.08	0.022	-	-
Sst.	Sandstone	96.57	1.66	1.47	0.06	0.03	-	0.006	0.18	-	-	-

4. Description of the Natural Environment

Topography of the site is located at height of about 120 m and the mountains altitudes around is reaching 400 m height a.s.l. and 300 m above land surface .The area is gradually sloping towards the west and expands in all directions as wide planes extends for hundreds of kilometers [9].

4.1. Climate and Water Metrology

The Tehama region is of arid climate, extremely hot during winter months (November to March) when temperatures range from 20C^0 to 30C^0. The mean monthly maximum temperatures are ranging from 32C^0 in January to 39C^0 in June. Annual precipitation is 100 mm in the costal line to 400 mm near the foothills and mountains, most of which occurs in April to October. The annual evapotranspiration is about 1864 mm/year. The region is characterized by high relative humidity with average of 71-76 %. The wind in Tehama Plane (includes Al-Maroua'ah area) is of southern general direction (Table.3).

The annual average values of sunshine in Al-Hodiedah Governorate range between 7 to 10 h/day, which correspond to 50 to 75 % of the theoretical maximum. The monthly Sunshine duration in Al-Hodiedah Governorates ranges from 7 h/day in July to 10 h/day in November.

4.2. Biology and Agriculture Farms

Many types of trees are considerably proliferating in the mountains surrounding the factory site. The agricultural fields are spreading down on the lands surrounding Falafel Mountain, which sometimes expands to distance more than 2 Km. Corn and vegetables cultivation as well as mango farms are widely spread throughout the valleys (PL/1, A, B, C).

4.3. Natural Environments

In Al- Maroua'ah area represents one of mountainous regions, which includes relatively high biodiversity and provides significant habitat for the birds and their migration to other regions. Most of native and semi-origin animals and plants exist in the study area, such as: *Hemitragus jayakari*, the Arabian Gazelle (*Gazella gazelle*), the Mountainous Caribou (*Capra ibex nubiana*), the Striped *Hyaena* (*Hyaena*), the Wild Cat (*Felis sylvestris*) and the Panther (*Panthera xanthopygos*).

The types of the birds exist in the region are Yellow-Incision Nightingale (*Pycnonotus xanthopygos*), Songbird (*Prinia gracilis*), Brown Songbird (*Phylloscopus umbrovirens*), Yemeni Apple Bird (Carduelis yemenensis), Dark Skin Flycatcher Bird (*Muscicapa gambagae*), Arab Partridge (*Alectoris melanocephalia*), and Black *Shuhite* Bird (*Milvus migrans*) [2, 10]. Falafel Mount is a barren area in which do not grow any plants, but there are some trees from Acacia type (PL/1, D).

4.4. Human Populations

In the Republic of Yemen had a high population growth ratio reaches 3.5% in the recent decades. This immense population expansion created certain risk to the scarce environmental system and threatened the great biodiversity and the bio-natural fortune in the country.

4.5 Water Resources

Come from rain-fed, which is inadequate in all districts of northern Tehama except for dry cropping where low rainfall is about 50% below evapotranspiration rate during the most days of the year. Consequently, groundwater is the main and supplementary source of irrigation . Impact of overexploitation of deep aquifers results in depletion of groundwater table from 1-7 m/year. Sources of irrigation in Al-Hodiedah Governorate are shown in (Table. 2). It is unexpected to note that groundwater in irrigated area was retreated in 2004 to 2008 despite the lack of control measurement for the resource [2, 11, 12].

Table-2. Shows cropped area by sources of irrigation, Al-Hodiedah area.

Cropped Area (Ha)		Cropped Area by Source of Irrigation (Ha)						Irrigated Area	
Year	(Ha)	Rains	Wells	Floods	Streams	Dams	Tanks	Area (Ha)	% Total
2004	325,330	146,398	97,599	69,873	450	10,898	112	178,932	55
2008	299,881	152,040	91,584	29,808	5,938	17,482	2,848	147,841	49

Source: [11-13].

Table-3. Meteorological data of Al-Hodiedah district from 1995 to 2008.

Metrological Variables	Observation Periods		Geog. location of the Stations			Metrological Averages		
	1995	2008	Latitude	Longitude	Elevation	Min.	Max.	Ave.
Monthly Temperature (D.C.)	1995	2008	1454	4295	10	19.3	38.5	29
Yearly Temperature (D.C.)	1995	2008	1454	4295	10	25	33	29
Monthly R. Humidity (%.)	1995	2008	1454	4295	10	71	76	73.5
Yearly R. Humidity (%.)	1995	2008	1454	4295	10	73	75	74
Monthly Wind Speed (m/s.)	1995	2008	1454	4295	10	2.8	4.2	3.5
Yearly Wind Speed (m/s.)	1995	2008	1454	4295	10	2.8	4.8	3.5
Monthly Sunshine (hrs/day)	1995	2008	1454	4295	10	6.9	9.8	8.4
Yearly Sunshine (hrs/day)	1995	2008	1454	4295	10	6.9	9.8	8.4
Monthly Evapotrans. (mm)	1995	2008	1454	4295	10	120.7	189.9	77
Yearly Evapotrans.(mm)	1995	2008	1454	4295	10	121	190	1864
Monthly Rainfall (mm)	1963	2007	1454	4295	10	1.8	24	7.3
Yearly Rainfall (mm)	1963	2007	1454	4295	10	2.5	398	93

Source: FAO [14]

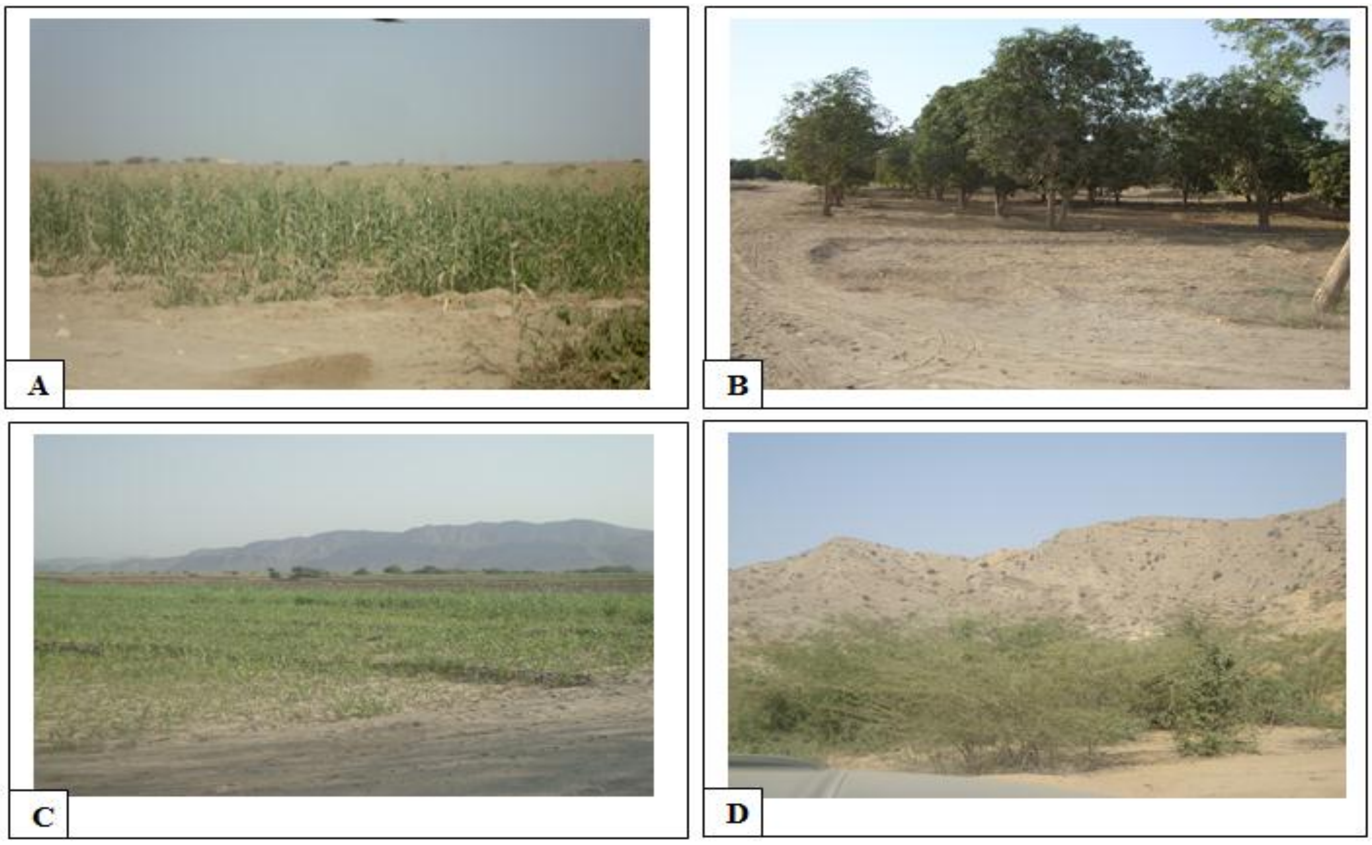


Plate-1. Field photographs show the plant diversity in the agriculture farms and natural trees in Jabal Falafel Mountain.

A. The Corn farms near AL-MAROUA'AH site of the cement plant.
B. The Mango trees near AL-MAROUA'AH site of the cement plant.
C. The wide extended agriculture farms in the vicinity of Al-MAROUA'AH Plant Site.
D. The acacia natural trees in the vicinity of Al-MAROUA'AH Plant Site.

5. Ambient Air Quality and Levels of Noisiness

Most regions in the Republic of Yemen do not possess scientific data about the air quality and levels of noise. In this Study, efforts were exerted to collect database upon air quality and levels of noise in the region of Al-Maroua'ah cement plant. It is worth mentioning that this region is situated 5 km from the main road connect Sana'a and Al-Hodiedah Cities and far from villages, noisiness and crowded people and markets.

Al-Maroua'ah area is characterized by proliferation of agricultural lands on both sides of the mountain, where the people is working in agricultural and the fields of cattle breeds and sheep herding. No air pollutant was found, while the vehicles traffic is few, quiet life atmosphere is prevailing and population density is low (Table 4).

The data of the air quality and dust concentrations in Al-Maroua'ah area is lying within the limits of the standards of EU [15] AAEP [16] EPA [1] and (Table.5). Air pollution comes from operating of the quarry machines (shovels, trucks and crushers), which produced dust, carbon dioxide and associated gases. Production of 3000 tons/day cement creates pollution of dust and CO2 gas emitted to the surrounding environments e.g. natural and agriculture plants as well as animals and people. The pollution is coming from; (1) explosions of dynamite in the quarry, (2) Shovels transport the raw materials to the main crusher, (3) Viechels and trucks transport the raw materials. Three types of crushers are operating to crush the limestone raw materials to smaller size and produce two essential types of impact; dust and gases in the air, and noises.

Table-4. Collected data of dust concentrations in the air of certain localities in Al-Maroua'ah cement plant site in the morning (in field work).

Time	location	PM 1 µg/m³	PM 2.5 µg/m³	PM 4 µg/m³	PM 10 µg/m³	PM 10 µg/m³	TSP µg/m³	Ambient Temp. c°	Relative Humidity %
08:30	South limit of Al-Maroua;ah beside the main road	1.6	13.7	40.7	71.2	91.1	116	35	48
08:36	North limit of Al-Maroua;ah beside the main road	1.9	16.4	54.3	100.7	125.9	143.4	34	52
08:48	Al-Qute'a area beside the main road	1.7	13.9	42	78.7	103.6	136.9	35	49
08:50	Al-Qute'a area 30m from the main road	1.6	13.1	38.4	73.1	103.7	135.5	34	52
08:52	Al-Qute'a area 30m from the main road	1.9	13.3	36.6	58.5	68.8	79.2	34	49
09:26	Wade Siham	1.7	14.1	42.1	75.9	95.4	109.5	35	49
09:27	Wade Siham	1.7	13.8	41.1	75.7	97.2	119	36	44
10:03	Bur'a natural protectorate	2.0	17.4	54.1	100.9	131.8	159.2	36	49

Table-5. Proposed Standards in view of Air Quality [1, 15, 16];

Pollutant	Pollution Ratio (µg/m³)	Average Duration of Measurement	Competent Authorities
Fine Dust (PM-10)	50 100	Annual Daily	Yemen
	50 150	Annual Daily	American Authority for Environment Protection
Dust / Suspended Particulates	60 - 90 150 - 230	Annual Daily	World Health Organization
	150 300	Annual Daily	European Union

6. Potential Environmental Impact

The potential environmental impacts are resulted from different stages of operation of AL-MARAOUA'AH Cement factory. The important pollutions include air, surface and ground waters, soil, biodiversity, methods of utilizing of the natural resources, health and safety factors, impact on the landscapes, social and economic indices in the region.

Assessment of impacts is determine using quantitative uses of the analytical equipment's and computing methods, while other pollution can be identified in term of the qualitative comparison and description in accordance with the previous observations [17, 18]. Consequently, assessment of the environmental pollution impacts is directly linked to the definition of those locations, which may be exposed to pollution, including local areas, hospitals, residential areas, schools, offices, factories, commercial shops, mosques, sports stadiums and recreation places.

It is worth emphasizing that the site of the project is located in rural agricultural area, where villages and agricultural farms are distributed in the region, with absence of cities, public governmental or private facilities. The locations which are exposed to pollution and close to the plant site are the surrounding villages, the residential units which shall be erected for the plant labors and staff, and the agricultural fields (Fig. 3; Table.6).

7. Type of Air Pollution

This study focus on the assessment of the anticipated environmental impacts in terms of kinds of the air pollution, which may appear during the quarry processes and mainly resulting from the smelting operations of raw and grinded materials to produce 3,000,000 t/y of Clinker in AL-MARAOUA'AH Cement Plant.

It is well known that the quarry process of the raw materials is characterized by emission of immense quantities of dust and gases; which are generated due to the explosion of dynamites and the primary and secondary crushing and grinding of the limestone raw materials near the quarry. Moreover, the operations of the shovels, Viechels and machines are emitted real quantities of carbon dioxide and associated gases, which are pollute surrounding areas. The grinding of limestones to finer size, leads to inevitably significant emissions of dust. The size and composition of the emitted dust particles mainly depend upon the characteristics of the primary raw materials. (Table 6)

Table-6. Types of the emitted dust and the reasons of the formation during different processes [19].

Type of Dust	Methods of Formation during Manufacturing Processes
Dust resulting from Raw Materials	Drilling, bombing, crushing, cracking and transfer of raw materials
Dust resulting due to feeding of materials	Feeding, milling, storage, mixing and transfer of materials during the manufacturing process
Dust resulting from Kiln (Bypass)	Feeding and treatment of materials relevant to counter-clockwise rotation of hot gases in the Kiln
Clinker Dust	Cooling of Clinker by means of air exposure, and storage
Cement Dust	Feeding, milling, transport, packing and loading of cement

8. Weather and Topography

Data of weather conditions and terrain are forming important input indices of impact of the dispersion of dust and gases emissions from the quarry source in open spaces. Changes in weather conditions and topography may lead to change in the levels of concentrations at the exposure sites. Hence, it is required to obtain hourly data on weather conditions during the year.

The inserted data in the program is collected from the city of Al-Hodiedah, which enjoys weather conditions similar to those of Al-Maroua'ah area, where the air monitoring stations do not exist in the study area.

Al-Maroua'ah area comprises simple topography, which lies in flat plane with scattered medium height mountains. The altitudes of the topography were calculated in the field survey and Google Earth utility through the International Information Network (Internet) and using program GIS and DEM 90m for Earth (NASA.USA). This survey indicates that the height of the ground surface of the site is 120 m and the mountains are 365 m and 400 m.

There is important to classify the utilization of lands in the vicinity of AL-MARAOUA'AH Cement site, considering that the average dispersion is variable between the rural environment and the urban environment follow the general outlines of the USEPA [15, 18]. EPA is relevant to the air quality simulation programs depending on the factors of population density and land utilization methods as standards of classification. It is advised to apply the dispersion indices belonging to the rural environment. The site of the cement Plant is located in agricultural region and occupies an area of 5 km^2, where any kinds of industrial facilities do not exist. Hence, the rural environment indices were selected to apply, considering that the vicinity surrounding the site has low population density and agricultural vicinity.

9. Dispersion Modeling System

GIS modeling using potential data is applying for annual pollution, which is plotted on topographic map of the area include villages and the cement plant site fig.6.5, 6.6.

BREEZE ISC GIS Pro version 4.1.3model was used with more accurate data, which is developed according to the model of USEPA United States Environmental Protection Agency [20] to assess the environmental impact of the dust and gases emissions.

9.1. Dispersion of Dust

The adopted interpretative of illustrate the levels of concentrations are shown in Table 5.10. In the absence of the control the pollution of potential emissions in the cement plant, wide area is exposed to emission levels exceed the health standards that permits by the EPA [1] in terms of dust concentration.

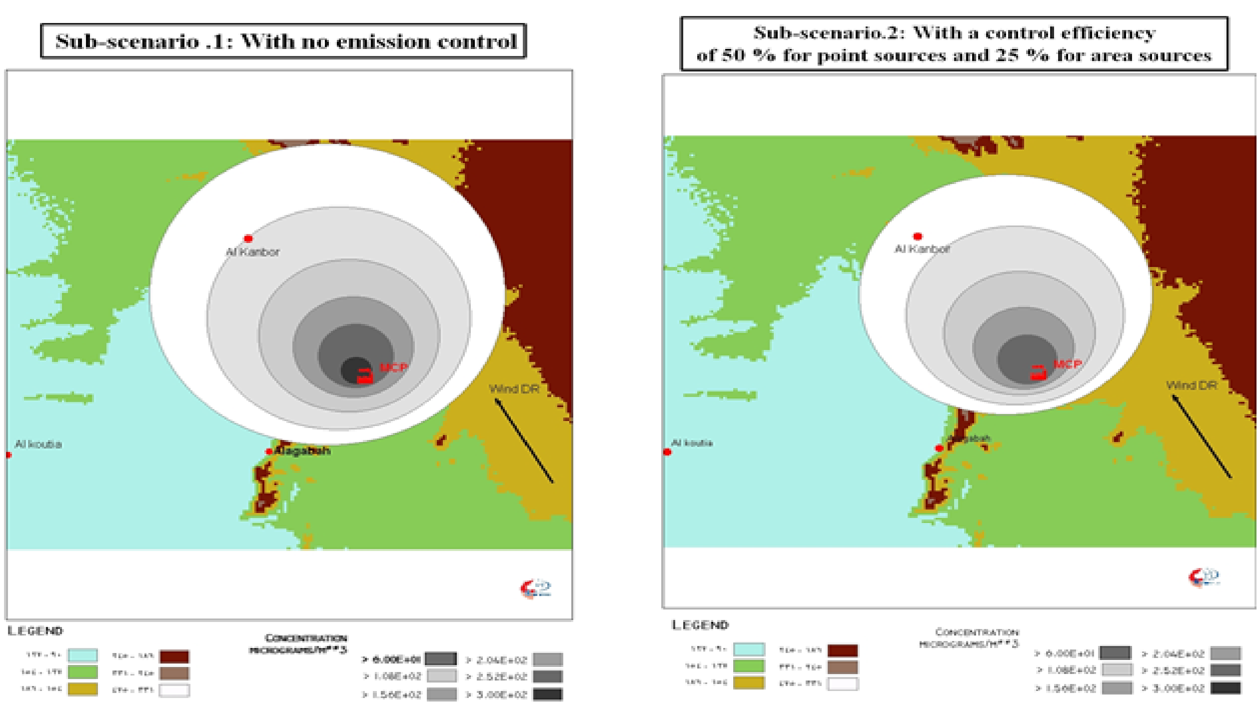
Fig-3. Shows the dust emission from the sources of the open spaces in the quarry site.

Table-6.6. Proposed emission data produces from the sources of the open spaces in the cement plants.

Source of Emissions	Area (m^3)	Level of Emissions (*mg/sec×m³*)			
		Without Control Systems	Effectiveness of Controlling Methods		
			25 %	*50 %*	*80 %*
The proposed current Quarry	40,000	0.33	0.25	0.17	0.07
AL-MARAOUA'AH Proposed Cement Plant	263,000	0.30	0.22	0.15	0.06

Table-6.9. Shows the approval probabilities in specify dispersion of emissions.

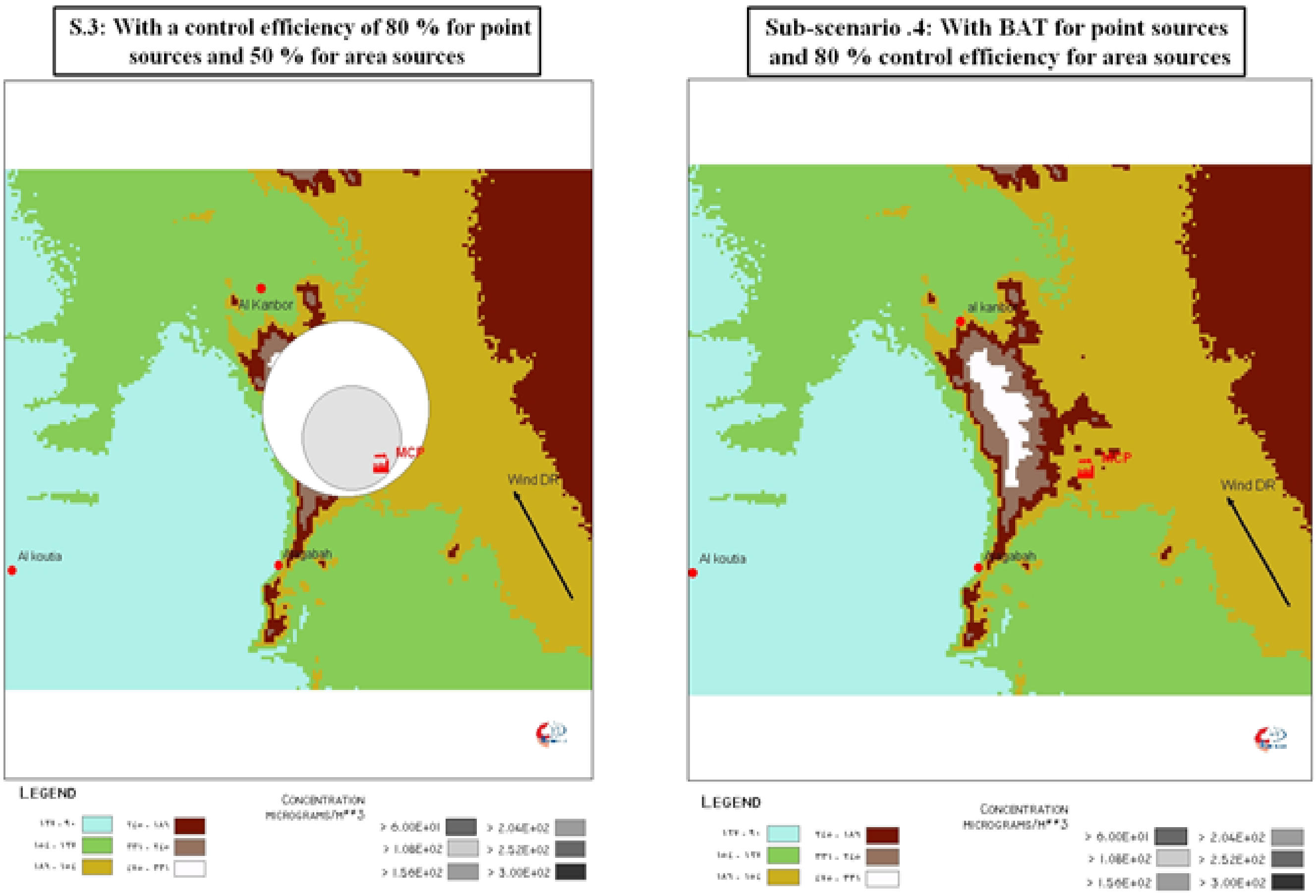
Pollutants	Probabilities	Approved Detailed Probabilities
Dust	S1: proposed Current Production Line	S1.1:Emissions without control systems
		S1.2:Emissions with control systems with 50% Effectiveness for stationary sources 1 and 25% Effectiveness for sources of open spaces
		S1.3:Emissions with control systems with 80% Effectiveness for stationary sources 1 and 50% Effectiveness for sources of open spaces
		S1.4:Emissions with most sophisticated control systems for stationary sources 1 and control systems with 80% Effectiveness for sources of open spaces



(A). S1.1: With no emission control

(B). S1.2: With a control efficiency of 50 % for point sources and 25 % for area sources.

Fig-6.5. Annually PM exposure levels in proposed production capacity of 3,000,000 tons/year (BAT: Best Available Technology). Note the wind direction is pointed in the lower right edge of the photo.



(C). S1.3: With a control efficiency of 80 % for 80 % point sources and 50 % for area sources

(D). S1.4: With BAT for point sources and control efficiency for area sources

Fig-6.6. Annually PM exposure levels under proposed production capacity of 2,000,000 tons/year (BAT: Best Available Technology). Note the wind direction is pointed in the lower right edge of the photo.

10. Limitations

Several limitations were encountered in the present study. The absence of reliable and long-term site-specific data, which is required drawing on literature reported values that may not accurately describe the actual operational conditions at neither MCP nor the baseline environment in AL-MAROUA'AH area. As such, it is imperative to implement suggested monitoring program and to reassess the results and validate the simulated exposure levels based on long-term and systematic monitoring data. The available models are far from being ideal and are simplifications of reality. Models are only capable of providing rough overview of real time processes and are best used for comparison purposes. Note also that all air dispersion models including ISC exhibit increasing uncertainty with short-term average periods. This uncertainty decreases with increase average periods and as such predicted annual exposure levels tend to be more accurate than daily levels.

10.1. Noise and Vibrations

Noise is defined as “unwanted sound”. It has numerous adverse effects on people’s health as well as environment. Several factors other than the magnitude of exposure typically influence community reaction to noise including duration of intruding noises and frequency of occurrence, time of year (windows open or closed), time of day of noise exposure, outdoor noise level in community when intruding noises are not present, history of prior exposure to noise source, attitude towards noise source, and presence of pure tones and impulses [18].

Activities of quarry heavy machineries are generate high levels of noise, much of which can be reduced by properly sitting and insulating the operations area [21]. Noise generation from the cement industry may either be permanent or intermittent. Intermittent noise is mainly due to blasting, the daily starting of engines, and the loading of rocks into dumpers [22]. Permanent noise generating sources can be divided into three main groups after [23]:

- Dynamite explosion of the raw materials
- Machine generated noise e.g. shovels, tracks, digging compressors and crushers. Generally, the type and age of machines affect the level of noise generated. The older machines are usually emitting higher levels of noise.
- Trucks and conveyers that transported the raw materials from the quarry to the plant site

The assessment of the noise impacts resulting from the operation of the MCP plant under the current production capacity of 3,000,000 tons /year using two digital sound level meters (Fig. 6.9). Measured levels conformed to typical energy-equivalent noise levels that have been reported for the cement industry.

The resulting noise levels exceed both daytime and nighttime Yemeni noise standards set forth for rural and sub-urban residential areas, while the standard set forth for industrial areas is achieved within 2 Km radius.

L L 20log (x 250) 48 *(1)*

The noise action on-site are of concern to on-site workers who are exposed to elevated noise levels for an average period of 8-hr. Most measured noise levels are exceeding the Occupational Safety and Health Administration (OSHA) 8-hour occupational noise exposure standard of 90 (dBA).

Vibrations on the other hand, are produced by blasting of limestone quarry and from heavy traffic on or off-site. The levels of generated vibration are generally below those that cause structural damage to properties. However, vibrations transmitted through the ground and pressure waves through the air ("overpressure") shake buildings and may create nuisance. In this context, blasting is an issue of concern for the local people. For several residential units surrounding MCP, have complain that vibrations from the plant have result in property damage.

Fig-6.9. Proposed noise meters used at MCP to measure ambient and industry related noise levels.

Table-6.13. Show measurement of noise levels at MCP compared to typical energy-equivalent noise levels reported for the cement industry [22]

Location	Noise levels(dBA)	
	Measured noise levels	Typical noise levels1
Quarry	NR	87-106
Crusher	NR	90-105
Raw mill	98-103	97-115
Kiln	91-96	97-115
Cement Mill	93-104	91-107

NR: Not recorded
1: Measured at 7.5 m from source
2: Value measured during the loading and transport of raw materials

11. Environmental Mitigation Plan

The primary potential adverse environmental impacts associated with the operations in MCP can be minimized by careful planning, adopt proper management practices, and relying on effective environmental monitoring. The mitigation plan suggests several potential impact-mitigation or control measures that will earn MCP more acceptability by eliminating or reduce the possible extent of impacts and intended to reduce the effect of potentially significant impacts on the environment. They are highly dependent on the significance of the predicted and the nature of the impact (permanent vs. temporary).

11.1. Mitigation of Air Quality Impact

Several mitigation measures are available to reduce the diverse environmental impacts that ambient air quality. These measures are compound specific and vary in the treatment efficiency as well as in technical and financial requirements. As such, air quality mitigation is ranging between BAT and low-cost treatments. The MCP has planned to adopt several proposed mitigation measures to reduce dust emissions into the environment. The priority is clearly to mitigate PM dust emissions.

The quarry processes emit considerable quantities of PM as a result of handling and grinding raw materials often to fine-grained size, which render dust emissions almost inevitable. The primary source of PM emissions includes fugitive and area source emissions that are generated from the handling, quarrying, and storage of raw materials. Table 8.1 presents summary of mitigation measures that adopted at MCP.

11.2. Mitigation of Traffic Impact

Primary measures adopted to mitigate traffic impacts include the proper dissemination of information regarding the transport schedule of limestone raw materials from the quarry site to the storage yards. In this respect, proper planning and development of a traffic plan that accounts for the reservations and inputs of nearby residents is essential to minimize potential inconvenience on commuters as well as to ensure the safety of motorists and pedestrians. As such, truck movements should be limited to off-peak hours to the extent feasible. In addition, adequate warning and signing are needed at least 500 m down and up-gradient from the entrance of the MCP to warn people that heavy equipment and trucks are frequent along these intersections. Other traffic mitigation measures are presented in Table 8.2.

Table-8.1. Common control measures for particulate emissions from quarry processes of the raw materials **1:** [17, 23-26].

Category	Source	Measure and description 1	Emission reduction (%)2
Point source	Crusher	• Fabric filters: pulse jet, reverse air, or shaker bag house	99.6 – 99.9
	Raw mill	• Fabric filters: pulse jet, reverse air, or shaker bag house	99.6 – 99.9
Fugitive sources	Quarrying site	• Water sprays with and without surfactants, foams, chemical dust suppressants, wind screens, equipment enclosures, and paving	Not available
	Storage areas	• Closed silos with air-filtering separators, closed sheds (tents/umbrellas) with automatic handling system, wind breaks, pile covers	Not available
	Traffic areas	• Paving, cleaning, wetting, speed limit, housekeeping	Not available
	Packing/loading /unloading points	• Closed sheds with fabric filters, retractable housed chutes or telescopic tubes with suction hoods, reduction of drop height	Not available
	Conveyor system/Transfer points	• Closed pneumatic conveyors, closed hoppers with fabric filters, drop height reduction	Not available

Table-8.2. Traffic control measures in MPC.

Control measure Typical examples	*Control measure Typical examples*
On-site	• Entrance and exit located so as to provide maximum turning space and sight lines • Vehicle movement in the direction of predominant traffic flow • Adequate off-loading and loading space to ensure vehicles can wait on-site • Adequate off-street parking for employees • One-way traffic within the site to prevent obstruction to vehicles entering and leaving • Speed restrictions on vehicles entering and leaving the site
Off-site	• Routing of traffic to and from ACP to avoid residential areas • Scheduling of deliveries and departures to avoid over-night parking • Ensuring that vehicles and containers are appropriate for transport and that they are adequately maintained • Use of locally designated traffic routes

11.3. Mitigation of Noise Impact

The outcome of the noise impact assessment reveals that noise levels in the areas surrounding MCP are higher than both daytime and nighttime according to the [27, 28] set for suburban residential areas. For this purpose, mitigation measures should be adopted in MCP to limit the impacts of noises on affected receptors. For this purpose, the erection of noise barriers to screen noise sources is proposed. Usually, purpose-built noise barriers or screens constructed of appropriate material to be located along active work sites could result in noise reduction of up to 10 dBA. It is anticipated that a movable noise barrier with a suitable footing and small cantilevered upper portion can be located within few meters of a static plant and about 5 m of mobile equipment. The provided insulation barriers can reduce noise impact up to 10 dBA noise attenuation. In this case, noise levels may reach the daytime Yemeni suburban noise standard (50 dBA).

Additional mitigation measures include good site practice, selecting quieter mechanical equipment, as well as adopting proper schedule of construction activities. Scheduling noisy activities during the daytime periods (7:00 am to 6:00 pm) will ensure that the noise standard set for the evening will not be exceeded at several instances. In addition, maintain proper onsite management to minimize noise emissions from the works during all times including:

Continuous maintenance for on-site machines, equipment intermittent in use are shut down between work periods, adopting low noise equipment, installing rubber coating in dumpers and entry chutes, using personal protection gear such as earplugs…etc, developing greenbelt around the quarry site, installing noise barriers around the quarry site,

Concerning mitigation measures that could be adopted to reduce ground vibrations generated particularly from blasting activities at the quarry site, MCP should adopt the following measures [22]: limit blasting to trained personnel, initiate periodic recording of blast vibrations, limit blasting activities to fixed days and hours that are acceptable with nearby receptors, disseminate the blasting schedule to nearby receptors, using mille-second delay detonator, deck charging, or other techniques to reduce vibrations and noise, increase the use of surface mining that do not require.

11.4. Mitigation of Soil, Surface and Groundwater Impact

The primary sources of potential impacts to water quality come from site runoff, which may directly enter soil, surface and groundwater waters. As such, open stockpiles of raw material should be covered with tarpaulin or similar fabric during rainstorm events to prevent the washing away, while earthworks at the quarry should be well compacted to prevent erosion especially during the wet season. Furthermore, the installation of appropriate drainage system coupled with sedimentation tank is also imperative to re-duce exposure time to potential discharge sources. Water from the settling tanks can be reused by MCP as process water or for irrigation and groundwater recharge purposes.

Efforts should also be made to clean the existing spillages in the wades where dried fuel spills should be collected and transported to a landfill while fresh fuel pools should be pumped in containers and re-used later on. Other sources of potential water pollution include oil/fuel leaks and spills to the soil as well as the uncontrolled disposal liquid effluents. The improper handling of fuels at the fuel receiving area constitutes potential source of pollution at MCP. As such, fuel tanks should be bundled to limit the environmental damage, which is result from accidental spillage. Bunds should be impermeable and resistant to the stored materials to avoid drains or taps that lead to blind collection point incorporate the distribution pipes within the bounded areas. In addition, oil and fuel residue that are generated from vehicle and machine service, vehicle wash bays and lubrication bays should also be mitigated to avoid potential soil, surface and ground water pollution. As such, oil-water separators and sand precipitators should be constructed, while oil collection trays should be provided to the operators at the vehicle and machine servicing areas [29]. Spent motor oils should be collected in sealed containers and stored within closed drums located within the workshops until they are reused or recycled. Oil contaminated cooling water should be treated in oil-water separators to remove oil. The treated water can be re-used to cool the flue gases in the conditioning tower as well as the cement mill [23, 29-31]. In case the suspended solids in the effluent are high in relation to the receiving waters, treatment may be required to reduce levels to maximum of 50 mg/l, which is the effluent requirement for direct discharge to surface waters [19, 23, 29-31].

11.5. Mitigation for Terresterial Biodiversity

Efforts should be made to preserve existing vegetation, avoid fires, prohibit hunting activities and the disposal of wastes of fuel and oil, hazardous in non-allocated areas, initiate a landscaping program on-site, as well as endorse well-planned restoration and reforestation plan for the quarry. The restoration and reforestation plans should be closely coordinated with Al-Hodiedah Governorate and should use indigenous flora in re-vegetation schemes on-site since the use of exotic species hampers the re-colonization of the area by the local fauna. Following closure to the quarry, several steps must be carried out to ensure the reintegration of the site with its surrounding including [15]:

a) Removal of wastes, b) Reshaping of quarry walls to prevent unloading cracks and potentially dangerous collapse, c) Reshaping of walls and loosening of compacted floors to facilitate re-vegetation and ensure the aesthetic quality of the restored landscape, e) Retaining natural drainage on-site, f) Re-vegetation using indigenous stocks of local vegetation such as the *Tamarix aphylla, Salvadora persica, Acacia spp, Ziziphus spina-christi, Commifora kataf and Cadaba rotundifolia*

12. Conclusion

Environmental impact assessment and sedimenta logical study includes chemical analysis were carried out for the quarry site of Al-Maroua'ah cement factory in Tehama plane, Al-Hodeida district NW Yemen. The assessment of the quarry operations includes blasting of dynamite, shovels, trucks and primary crusher of the limestone raw materials was evaluated. The pollution includes dust emission, noise, gas emission from heavy duty Viechels and fuel and oil waste were evaluates. Mitigation plans was proposed to decrease the environmental impact for the minimum levels, which effected actually on the surrounding environments e.g. farms, populations, natural fauna and flora…etc. One of the most important point for mitigate pollution is the selection of quarry far From the villages and human populations to prevent the environmental impacts followed the specifications of WHO and YEPA. The emitted dust and gases from the operations of the quarry machine makes impacts on the surrounding environments especially for the farms and the natural plants and animals, which are living in the region. For this, the site of quarry is selected in a mountain far from the vegetation, population and villages to avoid the expected environmental impact. Mitigation plan for prevent or decreases the pollution impact to the minimum, was discussed.

Moreover, quality, chemical and mineralogical analysis for the limestone raw materials were also evaluated and expected pollutions impact was estimated.

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