ENVIRONMENTAL IMPACT ASSESSMENT ON THE EMISSIONS OF QUARRY SITE PROCESSING OF AL-NAWASER CEMENT FACTORY, NW YEMEN

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ABSTRACT

Al-Nawaser cement plant is processed to construct in Al-Mahweet, NW Yemen. The quarry area is composed of limestone of Amran Group as a main raw source for cement production, which is exposed in the high mountains beside the plant site. The chemical analysis of limestones shows 50.31% CaO content, with 0.71% MgO. No previous studies were published to discuss the environmental impact assessment in Al-Mahweet, in which Al-Nawaser cement plant is the first to construct in the area. This paper discusses the environmental impacts in the quarry and surrounding area assessing various pollution creates from emitted gases and dust, based on the guidelines of WHO and YEPA specifications. The paper discusses a mitigation plan for dust, gases emissions and noises during the quarrying and trucking processes, to prevent and/or minimize the pollution impacts of CO, CO₂, SO_x and NO_x gases comes from the detonation of the raw materials, viechels and crushers with dust in the quarry site and surrounding area. This study deals with the expected pollution impacts in the quarry site created from blasting and extraction of the raw materials emitted gases and dust directly affect the villages, population, agriculture, surface and ground waters and biodiversity. Moreover, machines (shovels, primary crushers) and trucks operation add another impact source of emitted gases and noises.

Keywords: Al-Ghareb; EIA; Emitted gases; Dust pollution; Quarry; Mitigation plan

INTRODUCTION

Al-Nawaser cement factory is considered as one important project in the development of the Yemeni economic plan for the 2021 year. It is supporting the development of Al-Mahweet to provide job chances and other services. The plant site lies in Wade Ayan beside Jabal Al-Garb

Mountain; the site of the quarry raw materials (Fig. 1). It is elevated 300m a.s.l and lying 100km north Al-Hodiedah main port. This study discusses the pollution impacts on the environmental factors, which are affected by various emissions during extracting processes in the quarry area. These processes include extraction of the limestone rocks, as an essential raw material for cement production. Quarry processes include pitting machine, the detonation of the limestone rocks by dynamite, shovels, primary crushers and trucks traffics all together emit actual and polluted dust and gases impact the surrounding areas.

Fig. 1. Location map of Yemen of Al-Ghareb area shows the site of the cement plant in Wade Ayan valley and site of a quarry of the limestone rocks

Environmental impacts are assessed according to the EPA (2013) guidelines covering environment parameters and the mitigation plan to prevent and reduce the impacts. No previous study was carried out in Yemen except a study of Al-Mashaikie and Al-Karraz (2013) for Al-Marawa'a cement factory in Al-Hodiedah near Bajil City. There are a lot of studies about the environmental impacts of quarry processing edited with all cement factories all over the world.

MATERIALS AND METHODS

Al-Nawaser cement factory is a site of the field study to survey quarry of the limestone rocks in AL-Ghareb Mountain (Fig.1). Limestone rocks are sampled and evaluated by chemical analysis for cement production and their environmental impacts. The field works include: measurement of weather parameters using Kestrael 4500 device for wind direction, humidity, temperatures and compass, dust measuring device PCE-RCM 05 using for dust particles, humidity and temperature, and noise meter / sound Meter PCE-322ALEQ to measure noise in the field of industrial, health, safety and environmental monitoring. The EIA was followed the guidelines of EPA (EPA, 2013; 2014). Exploitation area of 2km² is selected in Al-Ghareb Mountain (Fig.1). Eleven limestone samples are analyzed using XRF in Amran Cement factory followed the procedure in Tucker (1988). Moreover, three water samples were analyzed to evaluate the expected pollution during the quarry operations.

RESULTS AND DESCRIPTION

Description of The Natural Environment

Physiography

The study area is characterized by complex topography comprised high elevated mountains (500 m) cutting by narrow valleys, which are opened toward Tehama plain. The quarry site is height 300m a.s.l. Ayan Valley is flowing northwards and opened to the agriculture plan (GSMRB License and report, 2013). The concision area of the quarry covers 1.8 X 1 km² (Fig.1).

A. Climate and meteorology

Meteorological data for the study area is measured in the site and from the meteorological station of Al-Hodiedah City. It is a tropical hot climate and mean monthly temperature ranges from 25 °C in January to 39.5 °C in July/August. Annual precipitation is about 400 mm at the mountains, mostly rainout between 4 to 10 months. The yearly evaporation is about 1864mm. The climate is reported high humidity cf. about 69 to 76 %. Average month temperature is 26 °C to 34 °C. The minimum temperature is in January as 25 °C and 39,5 °C in July/August. The major wind direction

is S-SW in January and N-NW in July with maximum speed of 12.1 m/sec (Table1). The average values of sunshine periods along Tehama Plan is 7 to 10 h/day.

Table 1. Meteorological data was measured in Al-Ghareb area using specific devises

	January/winter	July/summer	Average	Elevation
Temperature °C	25	39.5	32.25	320 m a.s.l.
Relative humidity %	65%	71%	68%	
Wind velocity (m/sec)	10	12.1	4.15	
Wind direction	S-SW	N-NW		
Rainfall (mm/month)	2.3	17.5	9.9	

B. Agriculture

In Jabal Al-Ghareb, various trees are living in the area. In Wade Ayan valley; the area of study, distributed agricultural fields are distributed and down to the open plain. Corn, vegetables, banana and mango are cultivated in the farms (Fig. 2).

C. Natural environments

Al-Ghareb area includes relatively high biodiversity that represents one of mountainous regions. This environment is providing significant habitat of birds and its migration to another region cf. Songbird, Yemeni Apple Bird ...etc. Various natural animals, tress and vegetables are existed in and around the quarry site cf. Arabian Gazelle, Wild Cat, Panther (Alawi and Mezhelovsky, 1999; MoWE/EPA Report 2004).

Fig. 2. Field photograph show the study area including the plant diversity, agriculture farms and natural trees in Jabal Al-Ghareb Mountain. The Banana and corn farms near the site

D. Human population

Al-Ghareb area has low human population in two villages lying near the quarry site. Population is growing at about 3.45 percentage in the last few years. This expansion of high population growth reflects important risk to effect the environmental system and consequently the bio-natural fortune.

E. Water resources

The rainfall-fed is the main source of water in the area. In the dry cropping days, the rainfall feds are about 50% below evapotranspiration. Moreover, the groundwater considered as a main and supplementary source of irrigation. Depletion of the ground waters from 1 to 7m per year is resulted from great pumping for agriculture and drinking uses (Alawi and Mezhelovsky, 1999; NWRA, 1999; MoWE/EPA, 2000). The results of chemical and physical analysis of the groundwater in the study area are shown in Table 3 and lies within the limits of the guidelines.

Quarry Site Characterization

The quarry site of limestone rocks is extended for 2km along the western side of Jabal Al-Ghareb Mountain beside Wade Ayan Valley. Agricultural farms are distributed in the area and surface waters is running during the year. Underground water is found in shallow depths of 5 to 10 m. The land surface is elevated little more than 300 m a.s.l.

Table 2. Analytical results of the groundwater in the study area

Parameters	Result	Specification guide	Parameters	Result	Specification guide
Physical parameters			Chemical parameters		
PH	7.5	6.50 - 8.0	Cl (PPM)	50	Max. 170
T.D.S. (PPM)	705	Max. 400	NO ₃ (PPM)	40	Max. 20
Conductivity (ms/cm)	0.810	Max.0.5	Fe (PPM)	Nil	Max. 0.1
Total Hardness as CaCO ₃ (PPM)	340	Max 107	Mn (PPM)	Nil	Max. 0.05
P. Value (Meq/ltr)	Nil	Max. 0.20	SiO ₂ (PPM)	27	Max. 40
M. Value (Meq/ltr)	6.0	Max. 3.0	HCO ₃ (PPM)	366	Max. 200
Appearance /Color	Normal	Normal	PO ₄ (PPM)	0.2	Max. 0.5
Turbidity	Normal	Normal	Free Cl (PPM)	Nil	Max. 0.5
Odor (Organoleptic)	Normal	Normal	NaCl (PPM)	80	Max. 300
			Na (PPM)	30	Max. 100
			SO ₄ (PPM)	72	Max. 250
Elevation of surface area	300m	Measured by GPS			

Pit drilling and detonation are used to extract the limestones rocks and later transported by heavy trucks to the storage yard to crush by primary jaw crusher to specify the grain size to smaller sizes (Harrison, 1993). The rock fragments are discharged to hopper (funnel-shape container) to separate sizes using multiple sieves and to minimize the load to the primary crusher (Harrison, 1993, Walter and Werner, 2003).

A. Quality of limestone raw material

The main quarry is composed of limestone rocks (Fig. 2). While the second quarry site is of sandstone rocks lying 2-3 km southward of Wade Ayan. The exposed limestones rocks are bedded, massive and have marl interbeds with total thickness of about 500 m (Beydoun, et al., 1998 and Al-Mashaikie, 2010). Calcite (CaCO_3) is the main component of the studied limestone including very low dolomite content (0.5%) and attain various types of texture mostly of grainstone and wackestone microfacies (Flugel, 1982; Scholl and Ulmer-Scholl, 2003). It considered of very good quality for cement production (Harrison, 1993 Walter and Werner, 2003). The sandstone rocks are composed of silica grains partially cemented by calcite and clays.

B. Chemical analysis of limestone rocks

The limestone samples are analyzed by XRF-device (THRMO type) using laboratory of Amran Cement plant. The chemical analyses are listed in Table 4.

Table 3. The chemical analysis of the limestone raw materials shows percentages of major oxides with sulfate, phosphate and chloride content

Sample No.	Major oxides %												
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	MnO	TiO ₂	SO ₃	P ₂ O ₅	Cl	LOI
WA-1	2.5	0.7	0.3	50.8	0.51	0.05	0.07	0.02	0.1	0.37	0.01	0.01	40.88
WA-2	0.0	0.0	0.24	54.8	0.33	0.1	0.01	0.02	0.06	0.1	0.01	0.0	42.94
WA-3	0.0	0.0	0.36	55.5	0.34	0.1	0.01	0.02	0.06	0.15	0.01	0.0	43.22
WA-4	0.0	0.7	0.3	52.7	0.42	0.1	0.04	0.09	0.01	0.32	0.01	0.0	43.35
WA-5	0.0	0.0	0.4	54.9	0.47	0.04	0.03	0.02	0.07	0.25	0.01	0.0	43.45
WA-6	0.0	0.0	0.4	55.4	0.42	0.09	0.03	0.02	0.06	0.15	0.0	0.0	43.0
WA-7	0.0	0.0	0.33	55.6	0.41	0.1	0.02	0.02	0.05	0.2	0.0	0.0	42.58
WA-8	0.0	0.0	0.34	55.4	0.31	0.1	0.03	0.02	0.06	0.11	0.01	0.01	43.47
WA-9	0.0	0.0	0.34	55.5	0.32	0.1	0.02	0.02	0.06	0.12	0.0	0.01	43.47
WA-10	0.0	0.0	0.35	53.8	0.39	0.07	0.01	0.02	0.06	0.21	0.01	0.0	42.48
WA-11	0.0	0.0	0.34	55.0	0.29	0.11	0.0	0.02	0.06	0.09	0.0	0.0	42.97

The chemical analysis reveals high CaO% content with low MgO% content. The silica, aluminum, iron oxides and alkalis are very low percentages and not affect the quality of limestones. For this composition, the raw mixture needs additional correction using clayey soil or mudstones with silica sandstone and iron ore. The rocks are also containing very low phosphate PO_3 salt NaCl and nitrates. During the explosion, the resulted high temperature make reaction between these components and gases will be liberated. Some of these gases are poisonous in certain amount, which are dissolved in the rainfall waters, forming polluted solutions for the waters.

Ambient Air Quality and Levels of Noises

Yemen authorities have no real data for the quality of air pollution and noise levels. In Al-Ghareb site, an effort was carried to make informational data for air quality and noise level. It is worth mentioned that this area lies near villages, populations and cried markets. Distributed villages and farms are the specific characters of the study area where agriculture and cried of sheep are the main works of the peoples. The traffics is far from the studied site and it is not polluted. The area is of quiet life atmosphere and low-density population (Table 4). In Al-Ghareb quarry site, air quality and dust content is coinciding with the limits of EPA standards Guidelines (1986); USEPA (2002a); EPA (2013) (Table 5). Production of 3000 ton/day cement of Al-Nawaser factory needs large quantities of raw materials, which act to pollute the air directly from quarry operation processes.

Table 4. Measured weather data and dust concentrations in in Al-Ghareb area morning

Time	Location	PM1 $\mu\text{g}/\text{m}^3$	PM2.5 $\mu\text{g}/\text{m}^3$	PM4 $\mu\text{g}/\text{m}^3$	PM10 $\mu\text{g}/\text{m}^3$	PM10 $\mu\text{g}/\text{m}^3$	TSP	Ambient Temp. $^{\circ}\text{C}$	Relative Humidity%
08:30	Al'loha area beside the main road of Hajjah	16	13.7	40.7	71.2	91.1	116	35	48
08:38	Villages at the open area front of Wade Ayan	19	16.4	54.3	100.7	125.9	143.4	34	52
08:48	Open limit of Wade Ayan, northwards	17	13.9	42	78.7	103.6	136.9	35	49
08:50	The farms between Al'loha and Wade Ayan	16	13.1	38.4	73.1	103.7	135.3	34	52
08:55	Al-Daher area at the main road	19	13.3	36.6	58.5	68.8	79.2	34	49
09:27	North Al-Hamedah area	17	14.1	42.1	75.9	95.4	109.5	35	49
9:35	Wade Ayan, South Al-Hamedah area	17	13.8	42.1	75.7	97.2	119	36	44
10:05	Al-Ghareb village	20	17.4	54.1	100.9	131.8	159.2	36	49

Table 5. Proposed standards in view of air quality

Pollutant	Pollution Ratio ($\mu\text{g}/\text{m}^3$)	Average Duration of Measurement	Competent Authorities
Fine Dust (PM-10)	50	Annual	Yemen
	100	Daily	
Dust / Suspended Particulates	50	Annual	American Authority for Environment Protection
	150	Daily	
	60 - 90	Annual	World Health Organization
	150 – 230	Daily	
	150	Annual	European Union
	300	Daily	
Sulfur Dioxide (SO_2)	50	Annual	Yemen
	150	Daily	
Nitrogen Dioxide (NO_2)	100	Annual	Yemen
	150	Daily	

The source of pollution is resulting from; (1) blasting of dynamite, (2) drilling machine and poclain operations, (3) Shovels, (4) Vehicles and trucks (5) Three types of primary crushers in the site to get smaller pieces (Lilic et al., 2018).

Potential Environmental Impacts

Potential environment impacts are resulted from operations in the quarry site. The expected polluted parameters represented natural resources including surface ground waters, soil, biological activates, landscape and air and populations. Health and safety factors are affected. Impacts is assessed by measurement devices and the data is presented by computer programs. Another impacts are defining by qualitative comparison with previous observations, USEPA (1974), USEPA (1997) and ELAW (2010) guidelines. Agricultural area is exposed near villages and residential units in which pollution impact is linked with exposed locations such as local areas, schools and offices (Fig. 3) and (Table 6).

Table 6. Types of emitted dust during cement processes (VD, 1985 and USEPA, 1995a)

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

Fig. 3. The works in the quarry of raw materials shows the shovel, trucks and poclin

Types of Air Pollution

Expected environmental impact assessment is focused on the air quality, which produced during the quarry processes. Extraction of the raw materials is emitted immense quantities of dust and gases generated from pitting, blasting of dynamites and the crushing of the rocks to finer size. The composition and size of dust particles are depending on the characteristics of the raw materials, where CO₂ and other gases are emitted in real quantities during the quarry operations.

Climate and Landscape

Climatic data of weather forecast and topography give important data of impact parameters for dust and gases, which are emitting from the quarry site. Changes of weather conditions act to change pollution levels at the exposure sites. Collected data from Al-Hodiedah City have the same weather conditions in Al-Ghareb area and the monitoring air station is not existing.

Al-Ghareb region reveals complex topography, high mountains and steep valleys. The measured factory's surface level is 340m a.s.l. and Al-Ghareb Mountain is 600m a.s.l. The Google Earth utility is used and GIS program and Earth' DEM (NASA.USA). Classification of land uses is important to classify the lands uses near the site according to variable average dispersion between the villages and city environments followed the outlines of the USEPA (1974; 1986). Density factor of population and land uses are hiring as standards to classify the air quality simulation programs, which is relevant in EPA. The plant site is occupied 5 km² is suggested to considered the dispersion factors of the village environment (Table 7).

Table 7. Emissions from various sources of the open spaces of Al-Nawaser Cement plant site

Source of emissions	Area (m ³)	Level of emissions (mg/sec×m ³)			
		Without control systems	Effectiveness of controlling methods		
			25 %	50 %	80 %
The quarry site	40,000	0.33	0.25	0.17	0.07
Quarry after expansion	106,929	0.33	0.25	0.17	0.07
AL-Nawaser Cement plant	263,000	0.30	0.22	0.15	0.06
AL-Nawaser Cemen after expansion of production line	263,000	0.68	0.51	0.34	0.14

Dispersion Modeling System

Potential data of dust dispersion used in GIS modeling is applied for annual pollution plotted on the google map covering the plant site, villages and surrounding areas (Fig. 4). GIS pro version 4.13 model of BREEZE ISC program used to get real data, followed the model of (USEPA, 2002)

to evaluate the impacts of emitted gases and dust. Interpretative data of dust levels is shown in Table 7 and absence of pollution control in the site led wide areas is subjected to emission levels exceed permitted standards of EPA (2013).

Fig. 4. Annually PM exposure levels for Al-Nawaser cement quarry site under proposed production capacity of 3,000,000 tons/year (BAT: Best Available Technology)

Note the wind direction in the lower right edge of the photo

(above left) S1.1: With no emission control

(above right) S1.2: With a control efficiency of 50 % for point and 25% of area source

(lower left) S1.3: With control efficiency of 80 % for point sources and 50% of area source

(lower right) S1.4: With BAT for point sources and 80 % control efficiency for area sources

Limitation

Many limitations are used to define the impacts during the quarry operations. The absence of real and long-term specific data may not give a precise description of the real conditions for NCP operation processes and environmental parameters in Al-Ghareb area. It is necessary to use the monitoring program and re-assess the data and validity of the same exposure levels based on data of long-time/systematic monitor. Program models are only compatible to provide approximate general view of exact processing time and to make best comparison purposes. Models of air dispersion including ISC program show increases of uncertain short-term periods and average increase/decrease of average periods to get more correct annual exposure levels than daily levels.

A. Vibration and noise levels

The Noise is abnormal sound having many different effects on the human health and surrounding environment. Many parameters other than the exposures are largely influence the community to react with noise such as duration and noises frequency of open/closed windows, day time effect, outdoor noise level in absence of quarry noises, noise source relative to time of previous exposure, exposure towards noise source and presence of pure vibrations (USEPA, 1974; EPA, 2013; Hernique and Zannin, 2013; Hegan and Hatton, 2016; Lili et al., 2017 and Lilic et al., 2018).

Intense quarry activities of heavy machines are resulted intermittent/ permanent high noise levels, can be reduce by accurate sitting and isolate the processing site (EPA, 2014). The intermittent noise is mainly resulted from drilling pit machines, blasting, the daily starting machines and rocks loading into dumpers (WBCSD, 2002). While the permanent noise can be generated from three main factors (WBCSD, 2002 and Lilic et al., 2018): 1) blasting of raw materials, 2) machines noise, the type and age of machines, older machines are generating higher noise levels, 3) transport limestone rocks by trucks and conveyer belts, 4) Noise crusher when crushing and grinding stone.

Noise levels impact is measured by Noise Meter/Sound Meter type PCE-322ALE, and data are compared to guidelines of the energy-equivalent noise levels for cement industry (EPA, 2013). Generated noise levels are exceeded the day and night times noises of the Yemeni standards for population and surrounding areas. Moreover, the standard for industrial areas is recommended to 2 Km radius according this equation:

$$Leq = 42.3 + 10.2 \log(Vc + 6Vi) - 13.9 \log D + 0.13S$$
 (Hajek 1977) in Alexander and Banaadornwi (2013).

L- energy equivalent sound level during 1hour (in dBA), V_i - volume of automobiles (vehicles. h), V_c - volume of trucks (vehicles. h), D- distance from edge of pavement to receiver (m), S- average speed of traffic flow during 1hour (km/h^{-2}).

The on-sit noise effect is the workers subjected to increase noise levels for 8 hr as average period. Almost noise levels data measured in the site are more than 90 (dBA) 8-hour occupation to noise according to the standards of the Occupational Safety and Health Administration (Marmaya and Mahbub, 2018; OSHA manual, 2011 and OSHA, 2015). The vibration levels generated by detonation of the raw materials and heavy machine on or outside the area. The vibration levels generated by operation are less than to cause damage in the buildings. Moreover, the pressure waves moveable vibrations via air and ground (“overpressure”) are shaking the houses and populations. For this case, detonation is important to avoid the local people and residential units surrounding NCP.

Table 8. Expected noise levels measurement in NCP compared with typical energy-equivalent noise levels reported for the cement industry (ETPI 1999)

Location	Noise levels(dBA)	
	Measured noise levels	Typical noise levels
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

Table 9. Estimated noise levels of mining, transported and extraction vehicles and crushers.

Equipment	Noise level (dB(A))
Trucks	110
Shovels	115
Bulldozers	118
Drilling rigs	103
Primary and secondary crushers	117
Crushers (overburden)	107

DISCUSSION

Mitigation Protection Plan

Negative primary potential impacts produced by quarry processes can be decrease by mitigation plan, adopted suitable managing practices depending of effective monitoring plan. The proposed

mitigation plan suggests many expected impact-control measures to decrease the probable distributed impacts and to decrease the permanent or temporary effects of potential EI.

A. Mitigation to reduce the air quality-dust impact

Many mitigation plans are available to decrease various impacts of air pollution, including specific efficiency treatments, economic and techniques demands. Mitigation of air quality is ranging between BAT and low-cost treatments. NCP suggests many mitigation plans, where PM emitted dust is the prior to reduce. Quarry operations emit real quantities of PM by extracting, transporting and grinding limestone rocks. The source of emitted PM comes from extraction, transportation and storage of raw limestone materials (Table 9). These factors are generating real quantities of dust effected directly the areas around the site. mitigation plans are discussed in the Table 10 below.

Table 10. Common control measures for particulate emissions from quarry operations for cement manufacture (I LO Codes, 1984; USEPA, 1997 and IEA, 2007)

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	Quarry 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
	Conveyor system/Transfer points	Closed pneumatic conveyors, closed hoppers with fabric filters, drop height reduction	Not available

1 EA 2001; Cembureau 1999; Inece 1998; Usepa 1995a; Awma 1992; VDI, 1985, 2 Awma, 1992

B. Mitigation of traffic impacts

Suggested mitigation plan for traffic impacts need primary schedule to order the transportation of the limestone pieces to the storage yards. Respectively, a suitable specific plan for vehicle accounts to prevent and decreases the potential noises to proper safety state. The traffic vehicle must be decreases to off-peak time for feasible effect. Moreover, enough distance needs at 500 m around the quarry to save people from the frequent effects of heavy machines traffic (Table 10).

Table 10. Traffic control measures in the quarry site of NPC

Control measure Typical examples	Control measure Typical examples
On-site	<ul style="list-style-type: none"> • Local entrance and exit to provide maximum turning space and sight lines • Predominant traffic flow direction of vehicle movement • 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 enter and exit • Speed restrictions on vehicles entering and leaving the site
Off-site	<ul style="list-style-type: none"> • Routing of traffic to and from NCP to avoid residential areas • Scheduling of deliveries and departures to avoid over-night parking • Ensure that vehicles and containers are suitable for transport and are adequately maintained • Use of locally designated traffic routes

C. Mitigation of noise impacts

The expected noise impact in the quarry site is exceeding than the day and night times as reported in Barrientos, et al. (2004) and Al-Mashaikie, Al-Karraz (2013), Hernique and Zannin, (2013), Hegan and Hatton, (2016), Lili et al., (2017) and Lilic, et al. (2018). Mitigation plan should be dependent to decrease the impacts of noises to save receptors. Suggested noise barriers are used to insulate and reduce noise sources to 10 dBA, which usually built by suitable material to put along active work sites. The noise barriers are movable with proper distance and small cantilevered. Removable barriers must be sited within few meters of NCP site and about 5m of movable machines to attenuate noise to 10 dBA (EPA 2013). Additional mitigation measures include select quiet machines, adopting suitable operations schedule during 7:00 am to 6:00 pm time. Moreover, onsite suitable managed mitigation steps suggest reducing day emitted noises, including; Maintain machines on-site, using low noise machines, using rubber coating insulators in dumpers, using earplugs for safety, using greenbelt agriculture and installing barriers around the quarry. NCP should follow standards of WBCSD World Business Council for Sustainable Development (2002) for mitigation and minimize ground vibrations resulted from detonation in the quarry site:

- 1) limit blast to trained persons,
- 2) periodic vibrations records of detonation,
- 3) blasting limit to acceptable work hours for nearby receptors,
- 4) giving the blasting schedule to receptors,
- 5) using mille-second delay detonator,
- 6) using another technique to minimize of noise and vibrations, and
- 7) recommend uses of surface mining.

D. Mitigation for soil, surface and ground water impacts

Expected impact sources of soil and water quality come from direct runoff of wastewaters and surface and groundwater. Therefore, open tanks covered by tarpaulin should be used during rainfall to prevent washing away. The quarry earthworks must be compacted to prevent erosion by wind or rainfalls. Moreover, make a suitable drainage regime with settling tank is proper to minimize the subjected period to effective discharge sources. Clearwater of settling tanks can be reused in NCP operations, irrigation and groundwater recharge. Spillages of fuel/waste should be clean and dried fuel are carried to landfill, and fuel should be collected in containers and re-used later.

Another impact of potential water pollution is the leak of oil/fuel, seeps to soil with disposal liquid effluents. Improper fuels handle at receiving area led to potential pollution source. Impermeable and resistant fuel tanks must collect and store oils to prevent drains or taps that act to blind collection point affected the pipes within the restricted areas and to prevent environmental damage. Moreover, suggested mitigate to avoid potential pollution of oil-fuel waste from machine services, wash and lubrication bays is to construct oil-water separators and sand precipitators pools and provides oil collection trays at the service sector (World Bank, 1998). The waste of motor oils in the service sector must be collected in sealed tanks and stored in closed drums to recycle. Oil must be removed from contaminated cooling water to treat in separators and re-used the conditioning tower and mill to cool the flue gases (World Bank, 1993; IEA, 2007; NPI, 2008 and EPA, 2018). The discharge of suspended solids is high relative to the receipted waters, while treatment required to minimize levels to maximum of 50 mg/l needs to discharge to surface waters (PM10 SIP, 1986; World Bank, 1998; IEA, 2007; NPI, 2008 and EPA, 2018).

E. Mitigation plan for protect Biodiversity

The existing vegetation and trees should be protected to avoid fires, prevent hunting and fuel and oil dispose wastes. Effort should also be made to prevent hazards in opened areas, an on-site program to mitigate the landscaping, suggest plans to restorative and reforestation around and inside the quarry site. These plans should be coordinate with Yemini Governorate to use original flora in re-vegetate on-site since to re-vegetate the area with local fauna. Several suggested steps must be considered close to the quarry to ensure the reintegration of the area with around (EPA, 1986) including: A) wastes removing, B) construct walls to prevent cracks and dangerous collapse, C) facilitate re-vegetation of the walls and decrease compacted floors to ensure beautiful landscape, D) Keep the natural drainage on-site, and E) Re-vegetation using original national vegetation.

CONCLUSIONS

Environmental impact assessment is studied for the limestone quarry of Al-Nawaser cement plant in Al-Mahweet, NW Yemen. Processing at the quarry site was assessed to cover the detonation of dynamite, heavy machines working and traffics of shovels, trucks and crushers. Pollution impacts of dust, noise, gas emissions from machines, vehicles, fuel/oil wastes were evaluating. Mitigation plans are suggested and discussed to avoid the impacted pollution, which is affected by the surrounding environments. The selection of the quarry site is an important point to mitigate pollution impacts to save villages and human populations followed the national and international guidelines. Operational machines emitted dust and gases making impacts on environmental parameters.

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