Estimation of Air Quality Status due to Quarrying activities and its Impacts on the Environment and Health of the People.

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Abstract

A survey of air quality in an environment informs the safety status or the degree of pollution as indicated by surveillance due to prevalent activities in such area. Results revealed that suspended particulate matter smaller than 10μm in aerodynamic diameter (PM_{10}) values was above acceptable values for ambient air conditions in an area is hazardous to the health of people and the environment. At Umuoghara and environs, dust pollution is a major consideration consequent upon Quarry activities. Exposure to these particles may link to increased hospital admissions. This will eventually lead to gross national productivity, reduction nevertheless, the ambient air quality and index is yet unavailable. This study ascertained the pollution status of the area through the air quality index criterion. The simple random sampling method was adopted to establish the ambient air quality status and index of the area, and its relative contribution to the people and environmental health condition of the area.

Keywords: ambient air, health, quality index, environment, particulate matter, pollution.

Background

An air quality index (AQI) is used to communicate to the public current air status and is used to forecast how it becomes. As the AQI increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects. To extract the economic materials, the earth is drilled with machineries-Mining. While mining yields economic materials for our benefit, it also contributes to a disruption of the nature and appearance of the natural environment around it, creates some major health and environmental geohazards. Mining, generally, is environmentally unfriendly and its impacts irreversible. Blasting and crushing of crystalline rocks generates dust (particulate matters) presence in the immediate and nearby environment. This alters the ambient air quality with its attendant geohazards such as visual impairment, noise, segmental vibration, heat, changes in barometric pressure and ionizing radiation. Onwe et al (2015a, b) states that water pollution is exacerbated due to dust generated by quarry activities. These occur in varying combinations depending on the mine or quarry, its depth, the physical nature, composition of the ore and surrounding rock, prevailing atmospheric condition, equipment and the mining method. Specific manifestations of impacts are on the people and the envir-

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onment. Suspended particulate matter is quite outstanding among all pollutants emanating from quarrying operations (USEPA, 2008). There is a clear connection between exposure to the dust and diseases, where exposure to silica dust during stone crushing in quarries carries the risk of development of silicosis, progressive massive fibrosis, asthma, chronic obstructive pulmonary diseases, and airway obstruction in exposed workers [5]. According to [9], quarrying in Kenya suffers from a number of constraints, including lack of basic knowledge of safety precautions, poor working conditions, low socioeconomic status, and lack of clear quarrying legislation and environmental degradation that calls for special attention. Some workers get maimed, others chronically ill, while some die. Quarrying operations generate large quantities of dust that cause a variety of respiratory diseases amongst workers such as Pneumoconiosis, [6], [11]. Under continued exposure it may develop into chronic bronchitis or emphysema [8]. Silicosis, the most likely form of pneumoconiosis to be dangerous to mine and quarry workers is contracted by breathing respirable silica dust in one of its pure crystalline forms. In view of these, crushing or blasting rocks with crystalline silica is likely to leave nearby workers at a high risk of contracting diseases. Hence, assessment of the environmental impact arising from mines and minerals processing alike is very important in order to control environmental problems [14]. Nwibo et al (2012), states the prevalence of respiratory problems and lung function impairment among quarry workers; the respiratory problems found were chest pain (47.6%), occasional cough (40.7%), occasional shortness of breath (6.5%) and wheezing (5.2%). A similar study by [14], on the impact of granite quarrying on the health of workers, established that, 26% of the workers suffered predominantly from cough, 20% from catarrh and 15% from sinusitis. In view of these, the Nigerian senate committee on environment threatened to shut down five stone mining companies operation at Mpape, a suburb of Abuja, for none compliance with environmental safety laws. These companies have been blasting and crushing rocks in Mpape for years without environmental impact assessment certificate or a plan on how to remedy the environment after mining. Nor did any of them have a corporate social responsibility project in the community [11]. At Umuoghara and environs, dust pollution is major considerations. The problem is taken seriously in Abuja because of its economic and political implications, similarly Umuoghara which is closer to Abakaliki (Ebonyi state capital city and government house, and an economic center), should attract such legislation. As part of our responsibility, it is important not to overlook such imminent problems. This work aims at trying to bring forth ambient air quality status, its index and evidences of geohazards in the environment of Umuoghara, its possible health and environmental implications.

Regional Setting

The study area lies within longitude 008^0 00 - 008^0 10 E and latitude 06^0 15 - 06^0 25 N in the Albian Abakbliki shale of Asu group southeastern Nigeria. An area of moderate relief with an average height of 54m asl; the area is densely vegetated with an average annual temperature of 32°C / 89.6°F. Umuoghara is located to the west and within the Abakaliki capital territory. Onwe et al (2015), informed that the settlement dwellers are peasant farmers and hunters.

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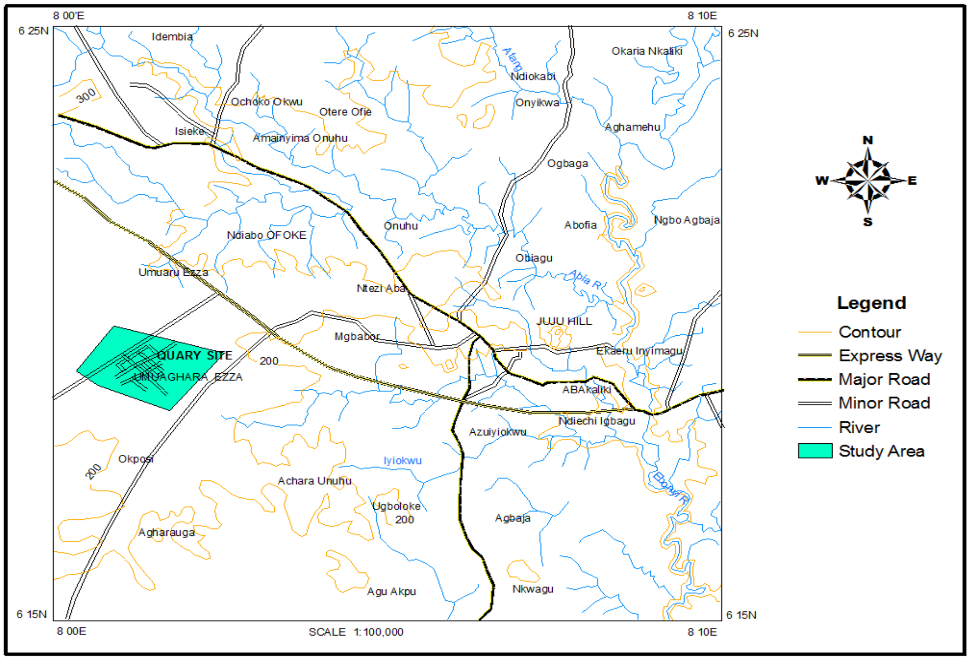

Fig 1: *Topographical map of the Study area*.

Methodology

Initial study of rock types was done by carrying out a detailed geological map of the entire area, figure 1 through traversing and positioning with the aid of a GPS to locate outcrop exposures in the area. To examine the distribution of ambient air particulate matter pollution, sample points (60m, 200m and 500m) from the major emission sources were measured and averaged for the 24 hours duration to get the daily mean PM_{10} particles [18], [2]. The daily PM_{10} concentrations were then averaged to get monthly and annual values. These distances according to [13] and [2] were adopted for spatial coverage and to avoid a point specific measurement. Efe (2006) has adopted the same in a similar study and achieved significant results. A high-volume PM_{10} samplers (HV $PM_{10,}$ locally called pumps) was used to draw a volume of ambient air at a constant flow rate, through a size-selective inlet of one or more filters. Particles in the PM_{10} size range were then collected on the filter during 24-hour sampling period to obtain the air particles as recommended by Giever (1976) and the Federal Ministry of Environment in Nigeria, on an hourly basis for twelve weeks spread at one week per month for one year. The recovered volume was corrected to standard conditions of 25ºC, 760m Hg or 101kPa [2]. The annual mean of the ambient air particulate matter calculated was used for the study. The PM_{10} is determined using this model:

T.S.P. = Ms - Mo/V …………(1)

Where T.S.P. = Total Suspended Particulate matter

Ms = mass of filter paper after sampling with particulates

Mo = mass of filter paper afore sampling, no particulates

V = volume

Therefore, concentration per unit time = $\mu g/m^3$/Hrs…. (2).

The daily PM_{10} concentrations were then averaged. Further, three 10ml test tubes were filled with 5ml water and placed at three locations at a height of the nose (whether sitting or standing position) and readings were taken at 10 am daily for seven days/month for a year. The weight difference between the test tube with water and the test tube with water and dust in ppm (parts per million) were also recorded. Result show PM 152$\mu g/m^3$.

Result.

Table 1.0 shows the annual mean ambient particulate air pollution data collected for the study. The data is a monthly representative by a week's sampling using pumps.

	Monday (µg/m^3)	Tuesday (µg/m^3)	Wednesday (µg/m^3)	Thursday (µg/m^3)	Friday (µg/m^3)	Saturday (µg/m^3)	Sunday (µg/m^3)	Monthly average
January	151	166	170	178	177	175	167	**169.14**
February	168	167	171	177	180	179	170	**173.14**
March	168	170	170	182	185	182	177	**176.29**
April	170	172	174	174	175	172	172	**172.71**
May	165	168	170	169	169	171	168	**168.57**
June	160	165	169	169	167	163	160	**164.71**
July	159	155	154	158	158	153	150	**155.29**
August	148	152	150	149	145	146	145	**147.86**
September	147	148	143	143	140	140	136	**142.43**
October	140	138	141	140	138	140	134	**138.71**
November	149	140	143	149	144	148	141	**144.86**
December	152	149	159	164	164	171	169	**161.14**
***January**	160	165	168	174	174	178	170	169.86
Daily av.	**156.42**	**157.5**	**159.5**	**148.58**	**161.83**	**161.67**	**157.42**	**159.57**

*Used as a control sampling and included in the annual mean

The mean ambient particulate air pollution in the area is generally characterized by high levels of PM_{10}, with an overall mean value of 159.6$\mu g/m^3$. WHO considers 55 $\mu g/m^3$ as acceptable value and above 90 $\mu g/m^3$ as unacceptable value of dust in ambient air [1]. Figures 2 and 3 (a, b), shows a graphical representation of weekly and monthly averages air quality status.

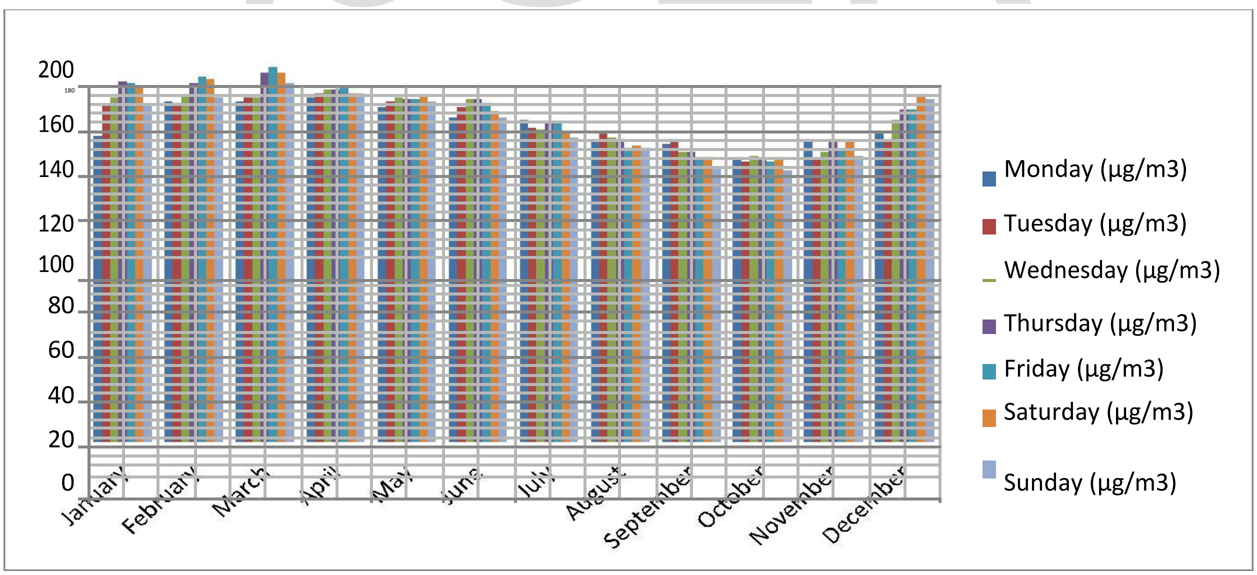

Fig. 2: Daily representation per week

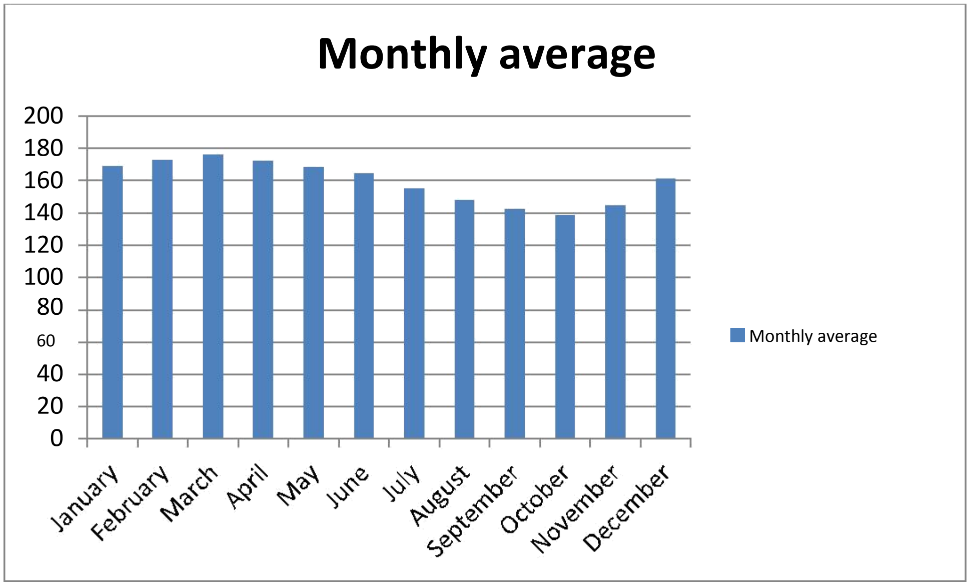

Fig. 3a: Monthly average of air status.

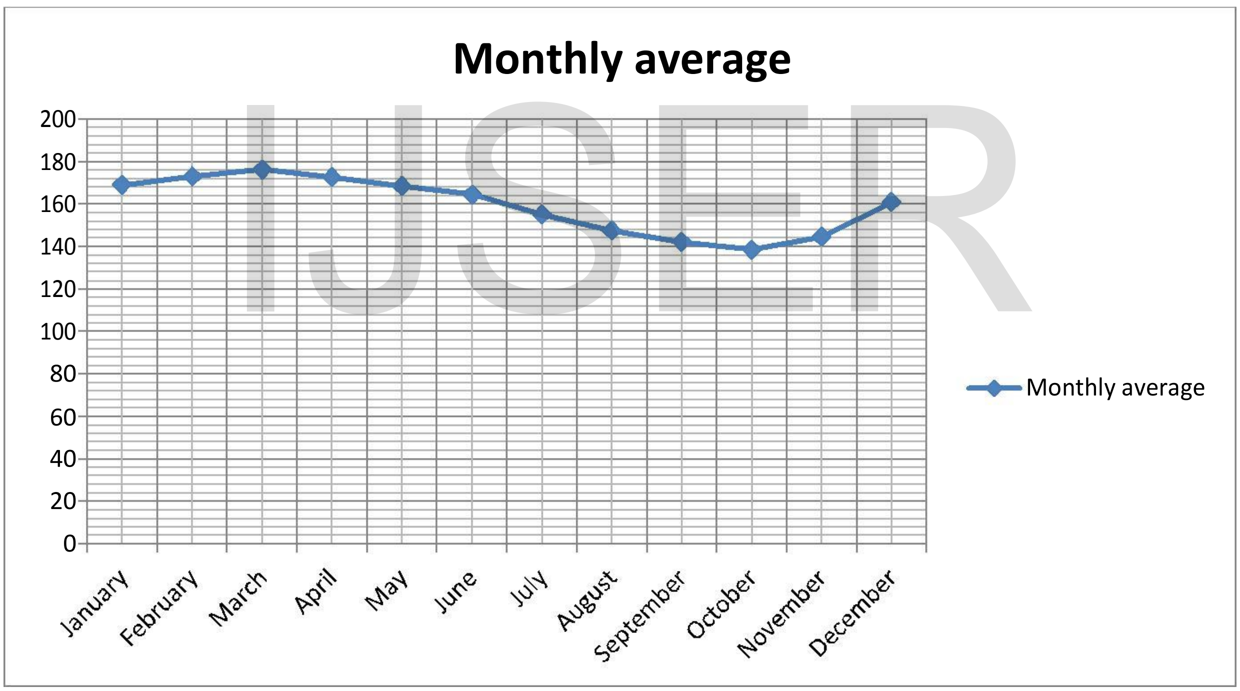

Fig. 3b: Monthly average of air status.

Computing the AQI

The air quality index is a piecewise linear function of the pollutant concentration. To convert from concentration to AQI this equation is used:

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

Where: I = the (Air Quality) index,

C = the pollutant concentration,

C_{low} =the concentration breakpoint that is ≤ C,

C_{high} = the concentration breakpoint that is ≥ C,

I_{low} =the index breakpoint corresponding to C_{low},

I_{high} =the index breakpoint corresponding to C_{high}

Table 2: EPA's table of breakpoints

$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	AQI
C_{low}- C_{high} (avg)	C_{low} - C_{high} (avg)	I_{low} - I_{high}
0.0-12.0 (24-hr)	0-54 (24-hr)	0-50
12.1-35.4 (24-hr)	55-154 (24-hr)	51-100
35.5-55.4 (24-hr)	155-254 (24-hr)	101-150
55.5-150.4 (24-hr)	255-354 (24-hr)	151-200
150.5-250.4 (24-hr)	355-424 (24-hr)	201-300
250.5-350.4 (24-hr)	425-504 (24-hr)	301-400
350.5-500.4 (24-hr)	505-604 (24-hr)	401-500

Applying EPA breakpoints for the result obtained, Air quality index, I for the month with lowest mean concentrat ion,138.71µg/m^3,
Where, I_{high} = 100; I_{low} = 51; C_{high} = 154; C_{low} = 55; C = 138.71
Substituting these values accordingly, the air quality index, I = 92.43

For the month with the highest mean concentration, 176.29 µg/m^3, the air quality index = 111.54 for the annual mean con centration, 159.57µg/m^3, the air quality index = 103.26

Discussion

EPA retains levels of standards for $PM_{2.5}$ and PM_{10} to address PM-related effects such as ecological effects, damage to materials and climate impacts. Those standards are: an annual $PM_{2.5}$ standard of 15.0µg/m^3; a 24-hour $PM_{2.5}$ standard of 35µg/m^3; and a 24-hour standard of 150µg/m^3 for PM_{10}. At the boundary between AQI categories, there is a discontinuous jump of one AQI unit.

The study revealed high levels of air particulate pollution over the period of the study where annual average levels soared around 159µg/m^3-176.29 µg/m^3 with an index of 103.26-111.54. This indicates an unhealthy environment for sensitive groups, table 3.

Certainly, this has strong health implications for the dwellers over the years. For instance, studies in the developed countries have linked particulate air pollution with the prevalence of respiratory diseases such as Silicosis thereby increasing hospital admissions for respiratory and heart diseases, increased school and job absence from respiratory infections [2]. This in turn aggravates their chronic conditions.

Table 3: EPA Air Quality Index Categorization

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Table 4: Maximum Concentration Levels Listed for Occupational Health

	NH_3 ppm	H_2S ppm	CO ppm	CO_2 ppm	Total Particulate Matter (mg/m^3)	Respirable dust (mg/m^3)
ACGIH	25	10	25	5000	4 (grain dust), 10 (nuisance dust)	3 (grain dust)
NIOSH	25	10	35	5000	4 (grain dust)	Not listed
OSHA	50	20	50	5000	10 (grain dust), 15 (nuisance dust)	5

From the result, figure 2, it is noticed that the pollution followed a particular trend for each week except for October and November that staggered. In other weeks of January, February, March, April, May, June, July, August, September and December, the pollution begin to increase from Mondays peaking on Thursdays and Fridays and then dropping. Further, it is noticed that monthly trend, figures 3a and b, shows the pollution status begins to increase from January, February, reaching its maximum in March and then begins to decrease from April, May, June, July, August, September, lowest in October, and begin to rise from November through December. This observed pattern is most probably controlled by two factors: (i) rate of activities due to business turnover and (ii) climatic weather conditions. The weekly pattern is most likely controlled by rate activities whereby the dust accumulates from the beginning of the working days where as the monthly trend is likened to be controlled by prevailing weather condition. This means that humidity affects dust resilience. It is noticed that during the low humidity months, the level of dust in the environment is high, but this begins to decrease with the incoming of the high humidity months. This monthly pattern, however further coincides with peak business periods.

Implications

The environmental implication of particulate matter in the area includes visual impairment, defacing civil structures and plants; precipitation of acid rain with its attendant encumbrances. On land, the dusts penetrate and block the soil air spaces. Dusts are conspicuously seen on vegetation. Plant metabolism is affected thus productivity is impaired thereby impoverishing the people. Water resource in the area is degenerated. Summarily, this contributes to the greenhouse effect.

On human health, the exposure-threshold dose-response assessment for particulate matter is as in table 4. The variability in response expected for different individuals is treated by combining estimates of interindividual variability in pharmacokinetic and pharmacodynamic parameters from a database of human susceptibility to a variety of biological responses. The Occupational Safety and Health Administration (OSHA) established a Permissible Exposure Limit for nuisance dust of $15mg/m^3$ for respirable particles, $5mg/m^3$. Threshold limit values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH) include $10mg/m^3$ for nuisance dusts, $4mg/m^3$ for grain dusts, $3mg/m^3$ for respirable dusts (Table 4, NIOSH, 1994; ACGIH, 1994). However, several published research manuscript documents that these limits are too high for Concentrated Animal Feeding Operation (CAFOs) where a mixture of biologically active agents can combine to produce respiratory and systemic effects at much lower levels.

There should be implementation of medical surveillance programs that provide clinical evaluation for the quarry workers. In addition to health history and physical examination, specific laboratory tests should be carried out on workers at least annually. Such test includes spirometry and chest radiography in quarry workers exposed to dust, fumes, and gas, audiometry in those exposed to noise, and cold test with measurement of finger systolic blood pressure in users of vibratory tools so as to identify imminent health problems and potential preventive strategies. This is important because many occupational diseases are chronic in nature, having minimal early signs and may be difficult to treat or even incurable. The regular medical examination of the workers who are exposed to particular health hazards at work can detect abnormalities or diseases at the early stage so that timely treatment can be given to increase the prospect of cure and reduce the cost of care. The government should also ensure that all places carrying out pollution related industrial activities are well researched on and Code of practice communicated to the public in order to enhance safety of human beings and the environment. The prevention of occupational health related problems associated with quarrying activities call for a multi-disciplinary approach such as controlling health hazards at source by engineering measures; use of administrative control, use of suitable personal protective equipment (PPE), education, training and supervision of workers, environmental monitoring and health surveillance. Sensitive groups, such as the elderly, children, and those with respiratory or cardiovascular problems should be advised to avoid outdoor exertion, declare an "action day" to encourage voluntary measures to reduce air emissions, recommend the use of masks to keep fine particles from entering the lungs, adjust activity levels during increased levels of air pollution.

Summary

A short period series of ambient air status at Umuoghara were investigated and the quality index generally indicates the pollution level above allowable limits. This presents great risks and devastating effect on the health of people, environment and civil structures in the community. In view of this, further studies that will span for longer time series is suggested to determine the resilience of the pollution status. Meanwhile, the government should set up a task force to investigate operators that are not complying with Environmental regulations or code of Practice for Quarrying activities, offenders should be prosecuted.

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