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Trend Analysis on Air Quality and Lung Function - A Case of Consar Stone Quarry Limited, Barekese

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Abstract: Air pollution emanating from particulate matter exposure has been identified as a major environmental problem worldwide. The stone quarry industry generates enormous amount of particulate matter into the atmosphere because of activities like blasting, crushing and haulage. The study determined the levels of PM_{10} and TSP concentrations (using IOM dust samplers) as well as lung function indicators of inhabitants of the Consar Stone Quarry concessional area from November 2015 to March 2016. PM_{10} concentration exceeded the WHO guideline value ($50\mu gm^{-3}$) and the permissible EPA-Ghana standard of $70\mu gm^{-3}$ except in the month of November and March. The measured TSP concentrations were generally below the EPA Ghana standard of $230\mu gm^{-3}$ except for January and December that recorded concentrations above the EPA-Ghana standard probably due to the low relative humidity resulting from scarcity in rainfall and high atmospheric temperature. Measured lung function indicators were significantly higher than the predicted values suggesting adverse effect of the quarry on inhabitants of the concessional area.

Keywords: Particulate Matter, Concentration, Concessional Area, Significant, Adverse Effect

1. Introduction

Stone has been a resource since ancient times. The Stone Age brought about awareness of the uses of stone and its derivatives. Stone aggregates are used for various purposes that include building, decoration; industrial purposes, lime burning, and production of cement. Stone is however obtained from quarrying, making this activity an important component of man's existence [1]. Vapour, smoke and dust produced during quarry activities are mainly solid materials suspending in the air for a long period. However, particles suspending in the air are capable of travelling to areas very far from point of generation [2]. Particulate matter (PM) has detrimental effects on health when exposed to very low concentrations. PM_{10} causes diseases such as asthma, cancer of the lung and other cardiovascular diseases [3]. [28] argues that quarry operations result in diverse negative health and environmental effects on nearby communities. Some negative impacts which arise from quarry operations apart from land degradation include creation of swamps, ground water deterioration, biodiversity loss, reduced plant growth, soil erosion, percussions and noise [4]. The impact has the potential to cause lung diseases (which may include silicosis-scarring of the lung tissue and other respiratory diseases like catarrh or common cold, cough, whistling chest), destruction of buildings and water-borne or water related diseases [29]. A very high morbidity is associated with the industry. Quarry activities generate different forms of dusts which are carcinogenic when inhaled. In most African countries of which Ghana is inclusive, pollution exposure emanating from quarry operations is of most environmental importance. It is pathetic that in view of the effect, studies are often carried out only on those employed within these quarry companies. Occupationally, those who live within the catchment areas are mostly overlooked. Hence, the study examined the air quality and the lung function of communities within the concessional area of the Consar Stone Quarry Limited with special emphasis on both employees and ordinary inhabitants. The stone aggregates are used in the construction of buildings, roads, bridges and other structures. This has led to the provision of jobs for many people. In totality, the industry has remarkably contributed to the socio-economic development of Ghana. However, it has many adverse impacts on the environment which include health-related issues to humans, generation of large volumes of dust, cracks in buildings, loss in biodiversity among others. Several communities inhabit the concessional area of Consar Stone Quarry Limited at Barekese. The likelihood that the quarry exerts adverse effect on the health of both humans and the environment cannot be ruled out. The size of dust particles determines the health effects it poses. Dust pollution has been a contributory factor to many recorded cases of respiratory diseases. There has been a serious concern raised by people in the study area on the impacts of dust run-offs and vibrations emanating from the quarry site on the health of the surrounding communities. The concerns of the people are valid because Environmental Protection Agency (EPA) guidelines requires that quarrying activities should not cause annoyance around residence, educational centers like schools, or hospitals. The communities have complained severally about the quarry operations due to the effects of deposited dust particles especially the contrast in colour when they settle, on surfaces such as edges of windows, louver blades and other window surfaces, cars, doors and tables. Therefore, assessment of the air quality (PM_{10} and TSP) and health risk would help authorities of the quarry to take the necessary measures to curb any human and environmental hazards associated with such situations. Knowledge generated from such assessment would help law enforcement agencies in limiting the menace. The following question motivated the research: *What is the level of Particulate Matter below 10 microns (PM_{10}) and Total Suspended Particles (TSP) in the ambient air of the study area?, What is the health risk affecting the inhabitants and the measures available to arrest the situation at Barekese and its environs?*

The study is to identify the air quality and lung function of communities found within the catchment area of the Consar Stone Quarry Limited. The notable effect on the people living in this area is adequately monitored by measuring the level of PM_{10} and TSP of the surrounding air. Particulate matter (PM) refers to suspended particles (solid and liquid mixture) in the air. Emission of particulate matter into the air is mostly from anthropogenic and natural sources while TSP refers to Total Suspended Particles (TSP).

2. Methods and Materials

2.1. Study Area

The study areas that include the Consar Stone Quarry site, Barekese Zongo and Poho are located in the Atwima Nwabiagya District in the Ashanti Region of Ghana.

According to the Ghana's 2010 population and housing census (PHC), the district covers an estimated land area of 294.84 km^2 and has 126 settlements. The district has a population of 149,025. Of this, 71948 are males and 77,077 are females. Majority (68.5%) of the indigenes in the district are rural settlers. Atwima Nwabiagya District is located within the wet semi-equatorial zone. Throughout the year, the rainfall range is between 1700 mm and 1850 mm. annually, the rainfall distribution pattern is not even. The pattern and density of the rainfall is unpredictable and poses substantial risk to rain-fed agriculture. The district has a fairly uniform temperature range of 27°C-31°C and a humidity range of 87%-91% [5]. The abundance of granite rocks in Barekese is responsible for a number of quarry companies in the area. In addition, the readiness of market within the Kumasi city because of rapid urban expansion account for the high demand of quarry products for various construction works. Mostly, the vegetation type is semi-deciduous. The district can boast of various types of rocks that include phyllites, gneiss, greywaches and granite among others. Some of these rocks are of substantial economic importance since they bear precious minerals like gold. Good clay deposits can also be found which are used for brick and ceramic making. Granite deposits in Barekese and Tabere and Ntensere provide dimension stone for the road and building construction. Consar Stone Quarry is located at Barekese about 25 km away from the Kumasi city. The study areas made of the mine site and two communities located in the concessional area of the quarry. The site is embedded with a lot of granite rocks. The quarry has a large quarry phase, and two crushing points. The study areas include Barekese Zongo and Poho communities. These two selected communities have an estimated total population of 3,730 and are located within the concessional area of the stone quarry.

2.2. Method of Sampling

A multi- stage clustering technique was utilized to select the study participants since the study is a quantitative social survey. It was appropriate to use cluster sampling technique because it tends to presume that, the elements in the cluster were just heterogeneous as the total population [6]. Self-structured research instrument was used to collect data that has been inferentially and statistically analyzed to determine the lung function and respiratory health of the study participants.

In all ninety-five (95) study participants were recruited. Thirty-three (33) participants were workers of the quarry and thirty-one (31) participants each from Barekese Zongo and Poho communities. This sample size is a true representation of about 10% of the total population of 938 [6]. Particularly, multi-stage clustering sample technique was used to select the representative group of people between the ages of 18 to 55 and who have resided in the area for at least 5 years. This is because lung function has been reported to decrease with increasing age [7, 8].

2.3. Data Collection

Data collection for the study involved administration of questionnaire, dust level measurements (PM_{10} and TSP) and testing of lung function of the study participants. The questionnaire crafted for this study was titled "respiratory health questionnaire" Dust monitoring took place at the quarry site (crushing area and the blasting area) and the communities within the catchment area of the quarry (Barekese Zongo and Poho) from November to March. It catered for both the wet and dry seasons. Lung function testing and administering of questionnaires were done in April 2016. At each point of monitoring the dust exposure, there were two Institute of Occupational Medicine (IOM) samplers to measure PM_{10} and TSP. The monthly monitoring lasted for two days. Usually, the first day was used to monitor particulate levels at the quarry site and the second day was used to monitor particulate levels at the communities. The study participants were administered with the questionnaires and they were given one week period to finish responding. The lung function tests were performed on the study participants simultaneously with anthropometric measurements (age, weight and height).

2.4. Instrumentation

The instruments that were used for data collection included: Questionnaire, Vitalograph and Institute of Occupational Medicine (IOM) Samplers (224-52MTXK)

2.5. Questionnaire

Quantitative cross-sectional data was collected by the use of self-structured administered questionnaires with standardized closed-ended and sequenced items. In the process of gathering of data, questionnaires administered were of uniformity and standardization. The socio-demographic characteristics of respondents were set and operationalized on nominal level. There was a pilot testing of the questionnaires in order to identify inherent ambiguity in the research instrument. Questionnaire for the pilot study were administered to 15 people by the researcher to confirm that the items to be tested were not ambiguous to understand and as such, the research instruments piloted can be evaluated as effective, easy and proficiently crafted. The questionnaire was administered in both English and Asante Twi depending on the literacy and understanding of the items by the respondents. The questionnaire was administered to the 95 respondents to ascertain their socio-demographic characteristics, medical history, physical activity levels, and household characteristics.

2.6. Lung Function Test

A lung function test was conducted among the study participants. The vitalograph was used for the measuring of the lung function of participants. The expiratory parameters measured include Forced Vital Capacity (FVC), Forced Expiratory Flow (FEV_{25-75}), Peak Expiratory Flow (PEF), Forced Expiratory Volume (FEV1%), and Forced Expiratory Volume in one second (FEV1).

The ambient room temperature at which the spirometry was conducted was between the temperatures of 23°C and 34°C. Anthropometric details (age, height and sex) of study participants were entered into the vitalograph before the spirometry measurement process began.

The study participants were allowed to relax while a demonstration was made as to how the whole measurement process will be done. Some of the participants were made to rehearse to check accuracy and precision of work but no reading was recorded. Participants were made to put on a nose clip to avoid air from coming out their nose. The participants were then made to undertake the test when it was certified that everything was in order, a correct work can be done. For accuracy, and precision, a number of tests were carried on an individual at least twice to obtain the correct test.

2.7. Ambient Air Quality

PM_{10} and TSP were measured within the study areas (crushing and blasting sites of the stone quarry, Barekese Zongo and Poho communities) using Institute of Occupational Medicine (IOM) sampler (Model: 224-52 MTXK). The samplers are serialized 07518041, 07518042, 07518043, and 07518044. Also, each IOM sampler had its own calibrated flow rate. The filter holder assembly of the sampler was configured purposely to measure PM_{10} and TSP.

IOM Sampler sampling dust at a location at the Consar Stone Quarry site. The samples were analyzed using the formula below:

$$PM_{10}/\ TSP\ (\mu g m^{-3}) = \frac{w_2 - w_1}{Fr \times T} \quad (1)$$

Where: TSP –Total Suspended Particles
PM10 –Particulate Matter below 10 microns
w_1 -Weight of filter paper before sampling
w_2 – Weight of filter paper after sampling
Fr – Flow rate
T – Sampling period

3. Results and Discussions

3.1. Demographic Characteristics of Study Participants

As indicated on Table 1 below, the highest participants of 33 (34.8%) were recruited from the Consar Stone Quarry Limited while 31 (32.6%) participants were recruited each from Barekese Zongo and Poho Communities. However, males dominate the age category with 59 (62.1%) whereas females recorded 36 (37.9%).

Approximately, 32 (33.6%) of the participants had their ages ranging from 28 to 37 years followed by those with the ages above 47 years recorded 26 (27.4%), 18 to 27 year group recorded 20 (21.1%) while the least record, 17 (17.9%) for 38 to 47 years. Conversely, participants whose ages were more than 55 years were not included. This is because lung function decreases with increasing age as studied by [27] who found a rise in pulmonary function in adolescent boys and peak at age 18 and then fall with rise in age. [9] also, identified in their study a positive relationship when some variables were compared with age.

Table 1. *Breakdown of Social Demographic Characteristics.*

Variable	Characteristics	Number of Participants (%)
Study Area	Barekese Zongo	31 (32.6%)
	Consar Stone Quarry Site	33 (34.8%)
	Poho Community	31 (32.6%)
Sex	Female	36 (37.9%)
	Male	59 (62.1%)
Age (years)	18 - 27	20 (21.1%)
	28 - 37	32 (33.6%)
	38 - 47	17 (17.9%)
	> 47	26 (27.4%)

3.2. Ambient Air Quality

3.2.1. Trend of PM10 Concentrations at the Sampling Location

The dynamics of PM_{10} concentrations showed similar trend for all the sampling locations namely Consar Blasting site, Consar Crushing site, Barekese Zongo and Poho Community. Thus, the PM_{10} concentration increases from November to January (where the peaks occurred) and declined to March where the lowest concentrations were recorded for all the locations.

In November, the PM_{10} concentrations were below the EPA Ghana standard level of 70µgm^{-3} in all the locations except the Consar Blasting Site where 70.88µgm^{-3} was recorded probably because it is a point of generation of dust. In the months of December, January and February concentrations above the EPA Ghana standard were recorded. This may be due to dryness of the air that might have facilitated dispersal of the dust. The weather conditions in December, January and February were relative to those in November and March. This may account for higher PM_{10} concentrations for the three locations.

An uneven trend of PM_{10} concentration was recorded at all the sampling locations Figure 1. The lowest concentration of 52.6µgm^{-3} was recorded in the month of November for the Consar Crushing site at temperatures and relative humidity of 23-31°C and 78% respectively. The low concentration recorded may be due to high relative humidity resulting from relatively high rainfall recorded in November. This might have suppressed the dust particles or caused them to settle and therefore are unavailable for capture by the IOM Sampler.

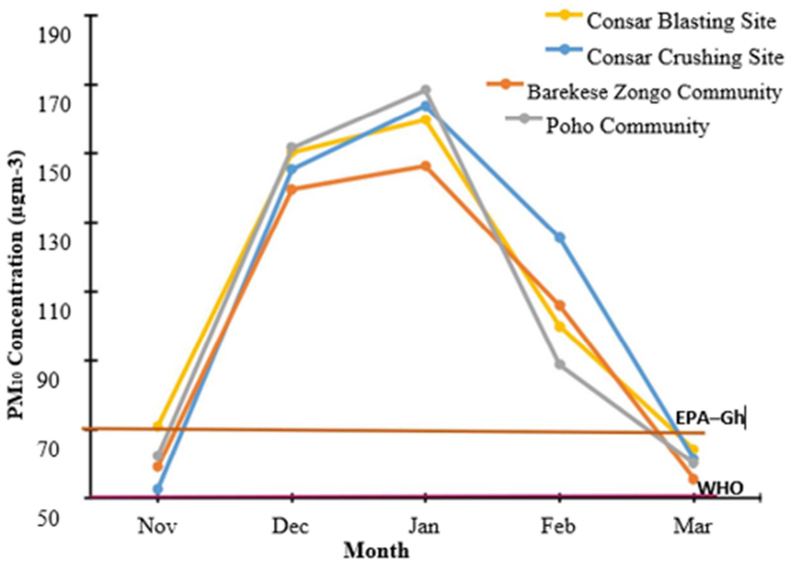

Figure 1. *The trend of the dynamics of PM10 concentrations at the sampling locations.*

The highest concentration of 168.4 µgm^{-3} was recorded in January for the Poho Community at temperatures and relative humidity of 25-39°C and 12% respectively. The highest concentrations of PM10 were recorded in the month of January. This may be attributed to the dryness of the air, which was at its peak in January and thus facilitating dispersal of the dust. This is consistent with studies by [10] and [11] who indicated that particulate matter concentrations increase with increase in temperature as a result of low relative humidity.

The study revealed that the Poho Community recorded the highest PM_{10} concentration in December and January although it may be expected that the point of generation of the dust (Consar crushing and blasting sites) should record the highest concentrations as in November, February and March. The closeness of the Poho Community (about 10 meters), to the Consar Quarry Site and change in wind direction (North-West to South-East) during the sampling period could account for this observation. This agrees with a study by [2] that particulate matter is able to travel far from the generation source.

Realistically the WHO guideline of 50µgm^{-3}, which is stricter than the EPA–Ghana standard of 70µgm^{-3}, might not be of economic benefit to quarrying in Ghana. However, EPA-Ghana setting an allowable threshold up to 70µgm^{-3} considers that this is realistic in terms of economic benefits to quarrying in Ghana therefore arrived at this regulatory standard to check air pollution. The results were compared to EPA–Ghana standard on acceptable PM_{10} concentrations. The concentrations of PM_{10} measured in all the sampling locations from December to February exceeded the EPA acceptable limit of 70µgm^{-3}. This gives an indication of air pollution within the three months may be attributed to the dry season, which resulted in low relative humidity. In Ghana, the dry season peaks during the months of December, January and February accounting for fast movement and suspension of particulate matter in the air for longer time thereby making particulates easily detected by the IOM samplers for measurement.

[11] citing [12] in his study demonstrated a significant relationship between average PM_{10} emission levels and mortality at concentrations lower than the existing United States standard of 150 µgm^{-3} for short-range of PM_{10} levels. This study implies that even though industries may be polluting below the WHO and EPA-Ghana standards there might still be some health dangers. [13], conducted a study on over five hundred thousand people in 151 metropolitan areas in the United States and identified that areas mostly polluted with PM_{10} experience higher death rate about 17% more than less polluted areas. A research by [14] suggest that any 10µgm^{-3} increase in concentration of annual average PM10 causes a rise in death rate ranging from 0.3%-1.6%. This advances the argument that although PM_{10} concentrations recorded for November (52.55µgm^{-3}, 59.11µgm^{-3} and 62.26µgm^{-3}) and March (61.4µgm^{-3}, 64.1 µgm^{-3}, 55.5 µgm^{-3} and 60.1 µgm^{-3}) generally, were below the EPA-Ghana standard, the health effect on the people should still be considered as important.

The PM_{10} concentrations recorded in the months of December, January and February were above the EPA-Ghana standard. These were periods where the atmospheric temperature was relatively high (up to 39°C) and the relative humidity was very low (12%) leading to no or little moisture to promote the precipitation of liberate particulates.

This supports the findings by [12] who reported a significant increase in hospital admissions in areas where the PM_{10} threshold exceeded the United States standard. [15], carried out a study in the United States and identified an association between respiratory symptoms and long term exposure to PM_{10} concentrations between 30-35 µgm^{-3} with no proof of threshold point below which there exist no health implications.

3.2.2. Trend of TSP Concentrations at Various Sampling Locations

The trends of measured TSP concentrations were also uneven throughout the sampling period. Generally, the lowest TSP concentrations for all the sampling locations were observed in March where the relative humidity was high and the atmospheric temperature readings were generally low. The highest concentrations for all sampling locations were also recorded in the month of January following a trend similar to that of concentration of PM_{10} recorded Figure 2.

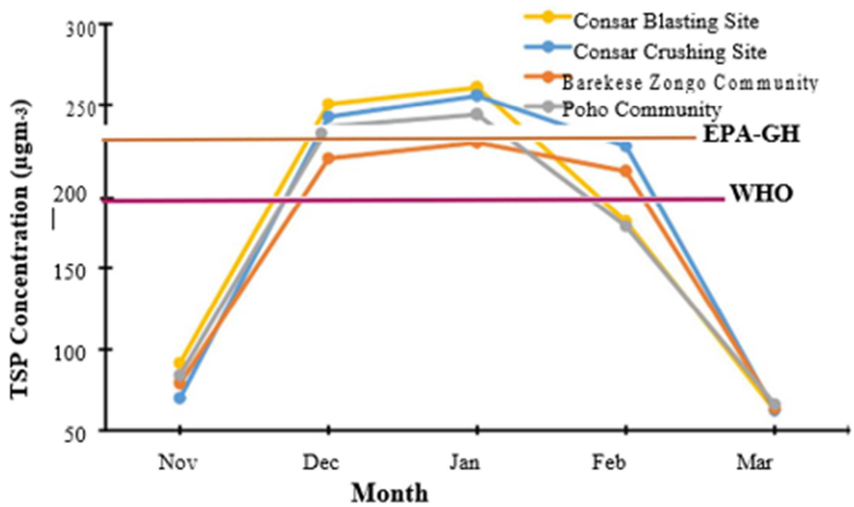

Figure 2. *Trend of TSP concentrations at the sampling locations.*

The crushing site recorded the lowest TSP concentration of 62.4µgm^{-3} at a temperature and relative humidity of 21-32°C and 91% respectively. The low concentration may be due to high relative humidity restricting particulate matter precipitation and movement. This may cause easy settlement of particulate matter thereby escaping detection by the IOM samplers.

The highest TSP concentration was recorded in the month of January for all sampling locations where the relative humidity was low due to the severe nature of the harmattan. The Consar blasting site recorded the highest TSP concentration of 260 µgm^{-3} at temperature and relative humidity of 24-37°C and 14%. The trend of TSP concentration over the period of dust sampling was not constant Figure 2. [11] reiterated that the concentration of particulate matter is uneven over a period of time due to change in meteological conditions.

Realistically, economic benefits in Ghana allow quarry operations to be conducted at concentrations not exceeding the EPA-Ghana standard of 230µgm^{-3} for total suspended particles. There was pollution during the months of December and January when concentrations were compared to EPA-Ghana standard for all the sampling locations except Barekese Zongo that recorded concentrations of 217.2µgm^{-3} for and 226.7µgm^{-3} which were below the permissible EPA-Ghana standard of 230µgm^{-3}. This may be attributed to the fact that the crushing site and the blasting site are the point of generation of dust and during December and January relative humidity was low (about 17%). The dry season was severe and atmospheric temperature was high (up to 40°C). Although relatively, the area recorded TSP concentrations below the acceptable EPA-Ghana standard of 230µgm^{-3} the situation does not necessarily indicate that the area is of safe health. This is because studies conducted in some developed countries which in those by [16] found an association between long-term exposure to particulate matter and respiratory symptoms even within the concentration range of 30-35 µgm^{-3}.

The TSP concentrations measured compared to WHO guideline of 200µgm^{-3} shows that the study area was polluted in the months of December, January and February. The concentrations exceeded the permissible WHO standard except in the month of February where the crushing site and Poho community respectively recorded concentrations of 178.5 µgm^{-3} and 175.4 µgm^{-3} below the of WHO standard of 200 µgm^{-3}. Realistically, economic benefits in Ghana allow quarry operations to be conducted at concentrations not exceeding the EPA-Ghana standard of 230µgm^{-3}.

Generally, the study area is not polluted when compared to EPA-Ghana standard except in the months of December and January Figure 2 where the crushing site, blasting site and the Poho community recorded concentrations above the permissible EPA-Ghana standard of 230µgm^{-3}. This may be attributed to the fact that the crushing site and the blasting site are the point of generation of dust and during December and January, the relative humidity was low (about 17%). The dry season was severe and atmospheric temperature was high (up to 40°C).

3.2.3. Relationship Between TSP and PM_{10} Trend

Concentrations of PM_{10} and TSP measured at the various sampling locations from November to March shows a direct relationship between TSP and PM_{10} trends. Averagely, the crushing site and the blasting site recorded the highest concentrations of 109µgm^{-3} and 170.8µgm^{-3} for PM_{10} and TSP respectively. This may be attributed to the fact that the crushing and blasting sites of the quarry are the point of generation of Particulate matter Figure 3.

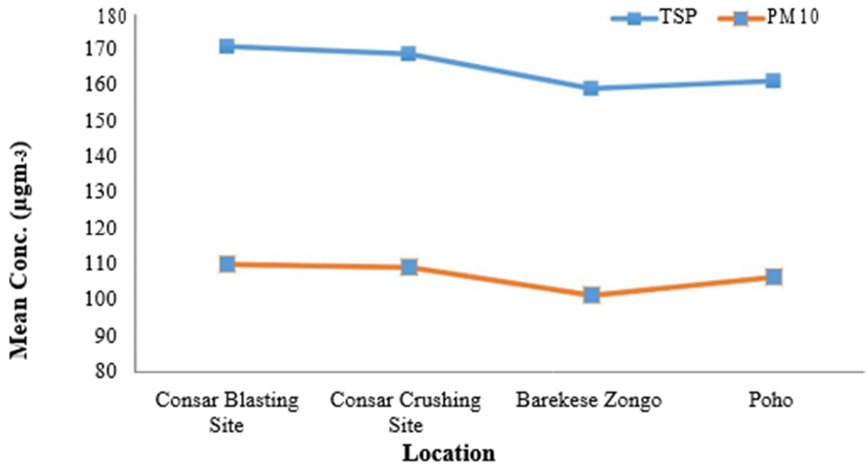

Figure 3. *PM10 and TSP concentration distribution at the sampling locations.*

The Poho community followed with concentrations of 106µgm^{-3} and 161.4µgm^{-3} for PM_{10} and TSP respectively. Barekese Zongo recorded the least average concentrations of 102µgm^{-3} and 159.2µgm^{-3} for PM_{10} and TSP respectively. The Poho Community recorded higher concentrations of PM_{10} and TSP than Barekese Zongo suggesting the closeness of the Poho community to the quarry site than Barekese Zongo. This was in conformity with [17] who revealed that there exists a direct relationship between measured PM_{10} and TSP as far as they are generated from the same source and been driven by similar factor like precipitation.

The similarity in trend in PM_{10} and TSP is therefore not surprising. However, during the rainy seasons, the PM_{10} is suspended leaving the heavier particulates to settle. This may cause respiratory problems in humans and reduction in photosynthesis in plants when they are deposited on plant leaves.

3.3. Respiratory Symptoms and Lung Function

3.3.1. Comparing Measured and Predicted Lung Function Test

The lung function parameters measured include Vital Capacity (VC), Forced Vital Capacity (FVC), Forced Expiratory Volume 1 (FEV1), Peak Expiratory Flow (PEF), and Forced Expiratory Flow 25%-75% (FEV25%-75%). The study revealed a significant difference in the measured and predicted parameters of lung function with p-values of

<0.000 Table 2.

Table 2. *Comparison of measured and predicted lung function tests results.*

Lung Function	Measured			Predicted			P-values
	Mean	SD	95% CL	Mean	SD	95% CL	
VC	3.28	0.79	3.12 – 3.44	3.78	0.72	3.63 – 3.93	<0.00
FVC	3.31	0.79	3.15 – 3.48	3.66	0.64	3.53 – 3.79	<0.00
FEVI	2.77	0.70	2.63 – 2.92	3.09	0.52	2.98 – 3.20	<0.00
PEF	6.19	1.81	5.81 – 6.56	8.38	1.23	8.13 – 8.64	<0.00
FEF_{25-75}	3.07	1.15	2.84 – 3.31	4.26	0.52	4.15 – 4.36	<0.00

Individuals exposed to particles having aerodynamic diameter lesser than or equal to the nominal ten microns may experience health problems. Some of these particles are capable of penetrating and being retained deep in the lungs. Obstruction in the airways was considered in the results of the measured lung function. Reduced lung function tests show an obstruction in the airways. This culminate in many health problems such as wheezing, coughing, and chest pains which is consistent with a study by [18] who posited that toxicological and epidemiological studies showed a relation between air pollution and adverse health effects.

A level of significance of 5% was observed to be the difference between measured and predicted lung function tests. The difference in significance level may be due to the ability of particulates to penetrate deep down the respiratory system. On the contrary, defensive mechanisms by the respiratory system are able to remove 99% of particulate matter bigger than 10 microns inhaled air [19]

3.3.2. Compared VC, FVC, FEV1, PEF and $FEF_{25\%-75\%}$ by Location

Results indicate significant difference between the measured lung function parameters (VC, FVC, FEV1, PEF and $FEF_{25\%-75\%}$.) of the study participants in the various locations (Consar quarry site, Barekese Zongo and Poho). P-values for the measured lung function were less than the 0.05 significance level as indicated in Table 3 beneath.

Table 3. *Lung function compared between Consar quarry site, Barekese Zongo and Poho.*

Lung Function	Location	Mean	SD	P-values
	Consar quarry site	3.05	0.91	0.000
VC	Barekese Zongo	3.40	0.54	0.000
	Poho	3.40	0.54	0.000
	Barekese Zongo	3.45	0.82	0.000
FVC	Poho	3.37	0.93	0.000
	Consar quarry site	3.12	0.90	0.001
	Consar quarry site	2.66	0.79	0.000
FEVI	Barekese Zongo	2.88	0.73	0.000
	Poho	2.76	0.68	0.003
	Consar quarry site	5.75	2.03	0.000
PEF	Barekese Zongo	6.49	1.77	0.000
	Poho	6.32	0.48	0.000
	Consar quarry site	3.05	1.13	0.004
$FEF_{25\% - 75\%}$	Barekese Zongo	3.29	1.10	0.001
	Poho	2.82	0.75	0.000

This is consistent with a study conducted by [11] at Chirano Gold Mines who found significant difference among two communities where lung function tests were conducted. This may be due to particulate matter concentration being uneven at the various sampling locations at a particular time of measurement.

3.3.3. Effects of Body Mass Index (BMI) and Age on VC, FVC, FEV1, PEF and $FEF_{25\%-75\%}$

It could be emphasized on Table 4, Body Mass Index (BMI) and age effect on measured lung function parameters (VC, FVC, FEV1, PEF, and $FEF_{25\%-75\%}$) showed no significant difference. This may be due to the recorded P-values for BMI and age being greater than the 0.05 level of significance.

Table 4. *BMI and Age effect on measured Lung Function.*

P-value					
	VC	FVC	FEVI	PEF	$FEF_{25\% - 75\%}$
BMI	0.89	0.54	0.63	0.59	0.74
Age	0.46	0.29	0.43	0.64	0.54

This study is therefore inconsistent with findings by [20] who found a progressive rise in Peak Expiratory Flow Rate (PEFR) and arm span per rise in age in children. They witnessed an increase in the PEFR values with increase in age and arm span. In addition, [21] found a positive correlation among lung function variables with height and age among some welders and controls. This is therefore contrary to this study which found otherwise. The research is also inconsistent with studies by [22] who reiterated that significant difference is seen when age is compared with lung function variables.

3.3.4. Some Respiratory Health Symptoms Occurrences in the Study Area

The study revealed 36.26%, 28.26%, 39.13%, 43.48% and 8.70% participants responding "Yes" for shortness of breath, coughing, wheezing, chest pain and medicinal use respectively. Lung function test in addition to symptoms identification is very important when diagnosing for respiratory diseases. Particulates are capable of retarding carbon dioxide and oxygen exchange in the lungs that cause shortness in breath. The lung has to strain itself to compensate for oxygen during this situation. Smaller number of respondents gave negative responses to the respiratory occurrence symptoms as revealed in Table 5 below.

Table 5. *Respiratory Symptoms Occurrences of Inhabitants in the Study Area.*

Respiratory symptom	Frequency		Percentage (%)	
	Yes	No	Yes	No
Shortness of breathe	26	69	36.26	63.74
Coughing	26	69	28.26	71.74
Wheezing	36	59	39.13	60.87
Chest pain	40	55	43.48	56.52
Medicinal use	8	87	8.70	91.30

The responses from the study participants do not correlate with the lung function test conducted in the Consar stone quarry site, Barekese Zongo and Poho. [26] in their study on chronic bronchitis prevalence found a prevalence between of 3% and 17% in developed countries and 13% and 27% in developing countries. Nevertheless, currently there is no credible data on chronic bronchitis prevalence and breathlessness in Ghana. It can be inferred from the results Table 6 that the response from the study participants does not suggest much respiratory or breathing problem on the inhabitants. This is at variance with a study by [16] who found an association between particulate matter exposure and respiratory symptoms but supports [11] who found no significant correlation between long term exposure to particulate matter and symptoms of respiration.

3.3.5. Effects of Smoking and Vigorous Activities on Lung Function

The results obtained from Table 6 shows that there exist no significant relation of respondents smoking history and activities (vigorous) on measured VC, FVC, FEV1, PEF and $FEF_{25\%-75\%}$

Table 6. *Effect of smoking and vigorous activities on lung function.*

Variable	P-value				
	VC	FVC	FEVI	PEF	$FEF_{25\% - 75\%}$
Ever smoked	0.15	0.43	0.56	0.11	0.33
Currently smoking	0.14	0.24	0.33	0.43	0.21
Vigorous activity	0.32	0.36	0.12	0.53	0.54

Smoking status of study participants had no significant difference on the measured lung function parameters, VC, FVC, FEV1, PEF and $FEF_{25\%-75\%}$ since p-values recorded were greater than 0.05 significant level. The study is at variance with a study conducted by [23] in the U.S who found an adverse effect on the pulmonary function growth of cigarette smokers. [23] made a proof that, smoking of cigarette is associated with mild obstruction of the airways and lung function limitations. Investigation of the effect of smoking on lung function revealed a dramatic fall in respiration symptoms in those who stopped smoking, a fair decline in those who reduced smoking by 25% and a small change in those who do not adjust their cigarette consumption habit.

Nevertheless consistency is shown by studies by [24] in some parts of Africa who found smokers having large p-values for FVC and FEV1 in young people than non-smokers. The study demonstrated that current and previous smokers had larger p-values for FVC than those who had never smoke. "Healthy smoker effect" may be attributed to this because a smoker is likely to develop lungs resistant to effects of smoking. [25] attributed this to smokers having their lower level airways responsive enough to inhaled particles.

4. Conclusions

The months of December, January and February had measured PM_{10} concentrations exceeding both the WHO guideline limit (50µgm^{-3}) and EPA-Ghana standard of 70 µgm^{-3}. These months were the months where relative humidity was relatively lower as compared to the months of November and March.

The TSP concentrations recorded were generally below the EPA- Ghana standard of 230 µgm^{3} except the months of December and January where concentrations recorded at Consar crushing site, Consar Blasting site and Poho recorded were above the EPA-Ghana standard. Also, The TSP concentrations measured generally exceeded the WHO guideline of 200µgm^{-3} for the months of December, January and February but not November and March.

The Consar crushing and blasting sites generally recorded the highest TSP and PM_{10} concentrations because those areas are the point of generation of particulate matter. There occurred significantly higher measured lung function parameters (VC, FVC, FEV1, PEF and $FEF_{25\%-75\%}$) than their respective predicted values. The study therefore revealed that the ambient air of the concessional area of the Consar Stone Quarry Limited is polluted with PM_{10} and TSP in the periods of low relative humidity significantly impacting negatively on the lung functions of the inhabitants.

Based on the results of the study, it is recommended that, environmental education with emphasis on the causes and effects of air pollution must be intensified in stone quarry communities by the EPA., further studies taking into consideration weekly or daily measurement of particulate matter within the month and for an extended period would ascertain the ambient air quality over such periods. This would enhance long-term decisions by management of the quarry and also law enforcement agencies. Greater attention should be paid to some air pollution mitigation measures such as frequent watering of the roads in the concessional areas of the Consar Stone Quarry Limited.

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