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Impact of stone quarrying on the health of Residents in Nigeria

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Abstract: This study investigated the effect of stone quarry activities and seasonal variation on the concentration of air pollutants. Higher concentration of particulate matter was observed in the dry season than wet season. Concentration of particulate matter ranged from 10.40 ± 0.02 to 18.70 ± 1.40 mg/m^3, dry season; 1.07 ± 0.02 to 2.50 ± 0.09 mg/m^3, wet season (Table 1) for site A and 12.01 ± 1.10 mg/m^3 to 13.60 ± 0.30 mg/m^3, wet season; 16.40 ± 1.30 to 21.30 ± 1.60 mg/m^3, dry season for site B. concentration of H_2S ranges from 0.30 ± 0.05 to 1.70 ± 0.10 ppm, wet season; 2.06 ± 0.02 to 2.10 ± 0.01 ppm, dry season for site A and 0.60 ± 0.05 to 1.00 ± 0.10 ppm, wet season; 3.17 ± 0.02 to 1.30 ± 0.01 ppm, dry season for site B. Mean concentration of NO_2 ranges from 0.50 ± 0.01 to 1.90 ± 0.03 ppm, wet season; 4.30 ± 0.01 to 7.00 ± 0.11 ppm, dry season for site A and 2.01 ± 0.02 to 3.30 ± 0.02 ppm, wet season; 4.70 ± 0.01 to 6.30 ± 0.10 ppm, dry season for site B. Mean concentration of SO_2 in study locations shows the same trend of being higher during dry season than during wet season. This is due to dilution effect of rain on the atmosphere. Its values ranges from 0.70 ± 0.06 to 1.20 ± 0.02 ppm, wet season; 5.14 ± 0.20 to 6.10 ± 0.08 ppm, dry season for site A and 1.30 ± 0.02 to 5.10 ± 0.15 ppm, wet season 6.20 ± 0.10 to 6.80 ± 0.04 ppm, dry season for site B. The concentration of vanadium in the environment ranged from 0.13 ± 0.01 to 0.18 ± 0.03 and 0.10 ± 0.01 to 0.46 ± 0.01 for sample A and B respectively. The concentration of the heavy metal ranged from 14.00 to 42.50 mg/kg, Cu; 23.50 to 38.70 mg/kg, Cr; 45.60 to 136.30 mg/kg, Zn; 0.10 to 0.65 mg/kg, Hg; 10.60 16.80 mg/kg, Pb and 1.60 to 16.40 mg/kg, Ni for site A. Concentration of the heavy metal in site B ranged from 11.30 to 25.10 mg/kg, Cu; 4.70 to 15.20 mg/kg, Cr; 44.30 to 186.10 mg/kg, Zn; 0.01 to 0.20 mg/kg, Hg; 6.60 to 13.90 mg/kg, Pb and 1.00 to 5.40 mg/kg, Ni. This study found that about 99.99 % of air pollution diseases affect the households. Data from this study showed that chronic exposure to dust and polluted air from crushing of stones increased susceptibility to respiratory problems. Percentage values obtained were 24.49 %, catarrh; 28.57 %, coughing; 26.53 %, headache; 9.18 %, chest pains and 11.22 %, eye infections.
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Keywords: stone quarry; air parameters; health effect;

1. Introduction

The monitoring of vanadium (v) oxide and other air pollutants in ambient air has received substantial attention over the past several years because they are among the major pollutants which significantly affect the chemistry of the atmosphere and human health (Wu et al., 2003).

Vanadium is a non-volatile metal, and atmospheric transport is via particulates (Fish and Komlenic, 1984). Vanadium (V) oxide (V_2O_5) is a poorly soluble oxide which, in water or body fluids, releases some vanadium ions which may speciate either in cationic (VO^{2+}) or anionic (HVO_4^{2-}) forms. The adsorption, distribution and elimination of vanadium (V) oxide and other vanadium compounds are similar. There are variations depending on the solubility of the administered (National Toxicology Program, 2002). It is a yellow-orange powder or dark gray flakes (Bauer et al., 2003); yellow to rust-brown orthorhombic crystals (Lide, 2008); slightly soluble in water, soluble in concentrated acids and alkalis; insoluble in ethanol (O' Neil, 2001).

Vanadium (V) oxide is used as an oxidation catalyst in heterogeneous and homogeneous catalytic processes for production of sulfuric acid from sulfur dioxide, phthalic anhydride etc. (O' Neil, 2001; Bauer et al., 2003). It is also used as a corrosion inhibitor in industrial process, as a coating for welding electrodes. Vanadium is a trace metal that is found naturally both on soil and water (Nriagu, 1998). Under environmental conditions, vanadium may exist in oxidation states +3, +4, and +5. V^{3+} and V^{4+} act as cations but V^{5+}, the most common form in the aquatic environment, reacts both as a cation and anionically as an analogue of phosphate. Mineral dissolution rapidly oxidizes V^{3+} and V^{4+} to the pentavalent state.

Vanadium has been characterized as a constituent of several enzymes systems and complexes within living organisms. Adsorption through the skin is thought to be quite minimal due to its low lipid/water solubility.

In human, acute vanadium poisoning can manifest itself in a number of symptoms including eye irritation and tremors of the hand, a greenish coloration of the tongue has been observed in humans exposed to high concentration of vanadium (V) oxide and is probably due to the formation of trivalent and tetravalent vanadium complexes; obstructive lung disease (National Toxicology Program, 2002); inflammatory lesions of the respiratory tract (Ress et al., 2003); chronic inflammation of the bronchi.

Vanadium is a by-product of oil-burning furnaces when vanadium pentoxide (M_R 181.88) is deposited in the flues. It is an odorless gas (Environmental Health and safety, 2005) Inhalation is the principal route of entry into the body and may result acutely in severe pneumonitis with associated mucus membrane irritation and gastrointestinal disturbances. Ambient vanadium pentoxide dust produces irritation of the eyes, nose and throat (Hauser, et al., 1995). Most absorbed vanadium is excreted in the urine within one day after a long-term moderate exposure to vanadium dust (Kiviluoto et al., 1981).

Vanadium is widely distributed in body tissues; principle organs of vanadium retention are kidneys, liver, testicles, spleen and bones. Inhalation of vanadium pentoxide can injure the lungs and bronchial airways (Environmental Health and safety, 2005) possibly involving acute chemical pneumonotis, pulmonary edema and/or acute tracheobronchitis (Nemery, 1990) Symptoms include irritation and inflammation of the mucus membranes, nasal passages and pharynx.(Environmental Health and safety, 2005). Chronic ingestion of vanadium may have significant consequences for infertility by damaging spermatogenesis. Studies in mice have demonstrated that inhalation of vanadium pentoxide results in necrosis of spermatogonium, spermatocytes and Sertoli cells (Fortoul et al., 2007). Other atmospheric pollutants will include dust generated during the maintenance works through materials handling, vehicle movements on loosely surfaced roads, transportation of uncovered construction materials (e.g. sand), and exhaust emissions from static equipment.

Workers in quarries as well as residents living around quarries are also likely to inhale dust particles into the lungs which normally results in silicosis, tuberculosis and bronchitis, which leads to pulmonary fibrosis and premature death (Decardi-Nelson *et al.*, 2015; Madhavan and Raj, 2005). However, this study revealed the concentration of vanadium and some air quality parameters in stone quarry in Abia State Nigeria.

2. Material and Methods

The study area:

The study area is located in Uturu, Isuikwuato L.G.A. and Umunneochi L.G.A Abia state,

Determination of air quality parameters

Crowcon Gasman Monitors were used for the determination of the ambient concentration of air parameters in each location from December, 2016 to July, 2017 with the months of December, January, February representing dry season and May, June July representing wet season (Asuoha and Osu, 2015). The instrument is calibrated before use and was moved from one site to the other between the hours of 8 am to 12 pm.

Determination of vanadium pentoxide in ambient air.

Vanadium pentoxide was collected by drawing air in a stationary or personal sampler through a membrane filter made of polycarbonate, cellulose esters and/or teflon. The filter containing the collected air particulates was analyzed for vanadium using destructive method, the filter is digested in a mixture of concentrated mineral acids (hydrochloric acid, nitric acid, sulfuric acid, perchloric acid) and the vanadium concentration in the digest determined by Atomic Absorption Spectrophotometer (Kiviluoto *et al*., 1979) .

Air Pollution Related Diseases Affecting Households

Well-structured questionnaire was administered to ninety eight residents randomly selected from the communities hosting quarries. Questions were asked on residency period in the community, perception about quarrying activities in the area and air pollution related diseases affecting households.

3. Results

Result and Discussion

Table 1: Concentration levels of air quality parameters in stone quarry environment A

Period	V_2O_5(Mg/L)	SO_2	H_2S	NO_2	SPM(mg/m^3)
December	0.18 ± 0.03	5.14 ± 0.20	2.07 ±0.04	7.00 ± 0.11	18.70 ±1.40
January	0.14 ± 0.01	6.10 ± 0.08	2.10 ± 0.01	4.30 ± 0.01	15.20 ± 0.60
February	0.17 ± 0.01	5.30 ± 0.06	2.06 ± 0.02	4.50 ± 0.40	10.40 ±0.02
May	0.13 ± 0.01	0.80 ± 0.04	0.60 ± 0.01	1.90 ± 0.03	2.16 ± 0.01
June	0.13 ± 0.01	0.70 ± 0.06	0.30 ± 0.05	0.84 ± 0.10	1.07 ±0.02
July	0.15 ± 0.01	1.20 ± 0.02	1.70 ± 0.10	0.50 ± 0.01	2.50 ±0.09

Table 2: Concentration levels of air quality parameters in stone quarry environment B

Period	V_2O_5(Mg/L)	SO_2	H_2S	NO_2	SPM(mg/m^3)
December	0.46 ± 0.01	6.20 ± 0.10	3.17 ± 0.02	6.30 ± 0.10	21.30 ± 1.60
January	0.36 ± 0.02	6.80 ± 0.04	3.10 ± 0.07	5.12 ± 0.06	19.20 ± 0.60
February	0.18 ± 0.02	6.40 ± 0.40	1.30 ± 0.01	4.70 ± 0.01	16.40 ± 1.30
May	0.11 ± 0.02	5.10 ± 0.15	1.00 ± 0.01	3.30 ± 0.02	13.60 ± 0.30
June	0.10 ± 0.01	1.30 ± 0.02	0.60 ± 0.05	2.01 ±0.02	13.11 ± 0.70
July	0.11 ± 0.03	1.60 ± 0.03	0.90 ± 0.01	2.10 ± 0.01	12.01 ±1.10

Table 3: Concentration levels of heavy metals in dust of stone quarry A

Period	Cu	Cr	Zn	Hg	Pb	Ni
December	42.50	38.70	136.30	0.65	16.80	16.40
January	31.80	32.30	98.80	0.80	13.40	14.50
February	29.90	23.50	91.00	0.50	11.06	8.10
May	18.90	34.70	74.70	0.10	15.10	5.10
June	14.40	25.60	45.60	ND	11.80	2.00
July	14.00	25.80	48.80	ND	10.60	1.60

Table 4: Concentration levels of heavy metals in dust of stone quarry B

Period	Cu	Cr	Zn	Hg	Pb	Ni
December	25.10	15.20	186.10	0.20	13.90	5.40
January	19.30	11.80	128.70	0.05	11.20	4.10
February	14.60	9.90	101.00	0.01	9.00	2.10
May	13.90	4.70	91.40	ND	11.10	1.60
June	13.00	5.90	74.30	ND	8.80	1.08
July	11.30	7.70	44.30	ND	6.60	1.00

Concentration of SPM ranged from 10.40 ± 0.02 to 18.70 ± 1.40 mg/m^3, dry season; 1.07 ± 0.02 to 2.50 ± 0.09 mg/m^3, wet season (Table 1) for site A and 12.01 ± 1.10 mg/m^3 to 13.60 ± 0.30 mg/m^3, wet season; 16.40 ± 1.30 to 21.30 ± 1.60 mg/m^3, dry season for site B (table 2). Highest concentration (18.70 mg/m^3) of SPM was observed in the dry season in site A. Concentration of SPM in the dry season is higher than in wet season because of higher production activities in dry season than that of wet season in the same location (stone quarry production plant) and also during wet season water from the atmosphere dissolves some of the particulates. These results were higher than FEPA limits. Presence of SPM may be from dust particle, gas flaring and vehicular emission or bush burning at the studied areas. Fine particles in the atmosphere provide suitable loci for various atmospheric conditions to occur. Water forms fine films which dissolves or absorbs various contaminants presence in the atmosphere which reacts with each other. When two or more than two particles fuse higher and heavier particles are formed. Being heavier they tend to drift down and cause dry precipitation. The entire content of the atmosphere can be wash down by rain or dew, thus acid rain is caused (Osu and Asuoha, 2015).

Mean concentration of H_2S ranges from 0.30 ± 0.05 to 1.70 ± 0.10 ppm, wet season; 2.06 ± 0.02 to 2.10 ± 0.01 ppm, dry season for site A and 0.60 ± 0.05 to 1.00 ± 0.10 ppm, wet season; 3.17 ± 0.02 to 1.30 ± 0.01 ppm, dry season for site B. H_2S were present in all the study locations at a higher quantity. This shows that there are other contributory factors to emission of H_2S such as fumes from automobile exhaust and power generators. Results obtained was higher than results (with the range from 0.18 to 0.76) obtained by Aliyu et al., (2013) and ranged of 0.15 ± 0.05 to 0.30 ± 0.14 by Osu and Asuoha, (2015).

Mean concentration of NO_2 ranges from 0.50 ± 0.01 to 1.90 ± 0.03 ppm, wet season; 4.30 ± 0.01 to 7.00 ± 0.11 ppm, dry season for site A and 2.01 ± 0.02 to 3.30 ± 0.02 ppm, wet season; 4.70 ± 0.01 to 6.30 ± 0.10 ppm, dry season for site B. NO_2 is recorded in all study locations. Higher concentration of NO_2 was observed in the dry season than the wet season which is attributed to higher rate of activities in the site than the wet season and also it may be due to the use of fertilizer in agriculture.

Mean concentration of SO_2 in study locations shows the same trend of being higher during dry season and lower concentration during wet season. This is due to dilution effect of rain on the atmosphere. Its values ranges from 0.70 ± 0.06 to 1.20 ± 0.02 ppm, wet season; 5.14 ± 0.20 to 6.10 ± 0.08 ppm, dry season for site A and 1.30 ± 0.02 to 5.10 ± 0.15 ppm, wet season 6.20 ± 0.10 to 6.80 ± 0.04 ppm, dry season for site B. Higher values during dry season may be attributed to vehicular emissions, refuse dump and other combustion activities within the area. SO_2 is known as an acid precursor and was identified in all samples studied. The concentration of SO_2 is lower than ranges of 3.21 to 5.18 ppm, 7.4 to 15.5 ppm, and 16 to 64 ppm reported by Ettouney et al. (2010), and Kalabokas et al. (1999), respectively but was higher than range of 0.03 to 0.09ppm reported in Kano metropolis, Nigeria (Okunola et al., 2012) and range of 0.022 to 0.087 ppm reported by (Aliyu et al., 2013), Osu and Asuoha (2015) with range of 0.95 ± 0.06 to 2.00 ± 0.11ppm. Comparing data with the FEPA standard level of 0.06 ppm, the results obtained from this study was found to be higher.

Vanadium is a redox-sensitive metal that is released to soils by weathering and anthropogenic emissions. Vanadium is released naturally to the atmosphere by the formation of continental dust, marine aerosols, and volcanic emissions. Vanadium is a constituent of nearly all coal and petroleum crude oils. The concentration of vanadium in the environment ranged from 0.13 ± 0.01 to 0.18 ± 0.03 and 0.10 ± 0.01 to 0.46 ± 0.01 for sample A and B respectively. Combustion of heavy fuels, especially in oil-fired power plants, refineries, and industrial boilers, and coal are the major source of anthropogenic emissions of vanadium into the atmosphere (Mamane and Pirrone 1998; Sepe et al. 2003). During the combustion of residual oils organovanadium compounds found in fuel oils are oxidized and transformed into various compounds (e.g., vanadium pentoxide, vanadium tetroxide, vanadium trioxide, and vanadium dioxide). These compounds are emitted as fly ash into the atmosphere (Mamane and Pirrone 1998).

Vanadium is the 22^{nd} most abundant element in the earth's crust (Baroch 2006). There are about 65 different vanadium-containing minerals; carnotite, roscoelite, vanadinite, and patronite are important sources of this metal along with bravoite and davidite (Baroch 2006; Lide 2008). It is also found in phosphate rock and certain ores and is present in some crude oils as organic complexes (Lide 2008).

Distribution of Pb, Hg, Cu, Zn, Cr and Ni in dust from stone quarry environment were shown in tables 3 and 4. The concentration of the heavy metal ranged from 14.00 to 42.50 mg/kg, Cu; 23.50 to 38.70 mg/kg, Cr; 45.60 to 136.30 mg/kg, Zn; 0.10 to 0.65 mg/kg, Hg; 10.60 16.80 mg/kg, Pb and 1.60 to 16.40 mg/kg, Ni for site A. Concentration of the heavy metal in site B ranged from 11.30 to 25.10 mg/kg, Cu; 4.70 to 15.20 mg/kg, Cr; 44.30 to 186.10 mg/kg, Zn; 0.01 to 0.20 mg/kg, Hg; 6.60 to 13.90 mg/kg, Pb and 1.00 to 5.40 mg/kg, Ni. Concentration of lead is high in the studied samples . The dust samples showed significant higher values of the heavy metal contents. This may be due to the quarry activities and accumulation of the automobile wastes in the sampled soils.

The health problems suffered by the residents are those that associate with inhalation of dust in the air. According to reports, the detonation of explosives in quarrying operation causes ground vibration, which produces effects such as stress, anxiety, and increased pulse rate, loss of sleep, fatigue and excessive contraction of pupil among residents living near quarry site (Salvato, 1992., Alloway and Ayres, 1995). This study found that about 99.99 % of air pollution diseases affect the households. The workers had no safety measures. Data from this study showed that chronic exposure to dust and polluted air from crushing of stones increased susceptibility to respiratory problems and increased length of service is an additional risk factors. Percentage values obtained were 24.49 %, catarrh; 28.57 %, coughing; 26.53 %, headach; 9.18 %, chest pains and 11.22 %, eye infections. Nwibo *et al.*, (2012) found out that the workers had various respiratory problems including chest pain, cough, wheezing and shortness of breath. Ugbogu, *et al.*, (2009) studied the occurrence of respiratory and skin problems among manual stone workers and found out that up to 85% of the workers had respiratory symptoms while 77% had skin infection. Ilyas *et al.*, (2010) established that dust related problems were exacerbated by cases of owners of the crushing stone unit not providing appropriate measures to protect the workers. the health problems experienced by quarry workers are identical, and are similar to those identified by Olusegun et al.,2009.

Conclusion

Stone quarrying has been shown as a human activity that generates particulates pollution in the environment. Varying concentrations of air contaminants were detected at all sampling points. The high level of particulates generated at the drilling and crushing areas depicts them as hazard zones. Higher concentration of air parameters were observed in the dry season than wet season. Moreover, exposures of quarry workers to air contaminants dispose them to several health problems (respiratory ailments) which is common among residents living near quarry sites. Considering the various prevailing health problems associated with inhalation of air contaminants, environmental impact assessment should be conducted for all quarries.

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