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(RESEARCH ARTICLE)

Assessment of air quality at Takoradi technical university (TTU) satellite campus (akatakyi) and it's environ

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Abstract

Air pollution poses a challenge to human life, meanwhile, air quality in human inhabitancy is usually given less attention. Therefore, the study aims at assessing air pollution at Takoradi Technical University (TTU-Akatakyi campus) and its environs. The assessment was done to determine the particulate matter in the study area using a Haz-dust Monitor-5000. Before data collection, the sampler was calibrated and set to start for 24 hours. Data recorded were analysed using Microsoft Office Excel. The results were compared to EPA-Ghana and WHO Guidelines Values. TTU Akatakyi Campus, Bokro Township, and Diamond Cement Factory recorded mean PM1 values of 3.10, 3.19, and 3.56 mg/m3, respectively. The highest PM2.5 mean value (3.57 mg/m3) was recorded at Diamond Cement Factory whereas the least PM2.5 (3.11mg/m3) was at TTU-Akatakyi Campus. The highest PM10 mean value (3.80 mg/m3) was recorded at Diamond Cement Factory while the least (3.12 mg/m3) was at TTU Akatakyi Campus. The highest recorded Total Suspended Particulate (TSP) mean value (3.62 mg/m3) was at Diamond Cement Factory while the least (3.11 mg/m3) was at TTU Akatakyi Campus. The recorded values were above EPA-Ghana and WHO guidelines, which implies that the air quality in the study area at the time of the study was harmful to human health.

Keywords: Air pollution; Particulate Matter; Total Suspended Particulate; Takoradi Technical University

1. Introduction

Air pollution (AP) is characterised as the presence of one or more pollutants in the outdoor environment in amounts or characteristics that are harmful to human, plant, or animal life or property. AP may be a result of dust, fumes, gas, mist, odour, smoke, or vapour [1]. As a result, human activities inevitably pollute the atmosphere, and since air pollution knows no regional or national boundaries, the scale of the pollution will consequence in climate change. Over the last decade, several countries have enacted legislation to help reduce the harmful effects of air pollution on human health.

Acute and chronic pulmonary, cardiovascular, and lung cancer illnesses, as well as death, have all been reported in various studies [2]; [3]. Studies have shown that air pollution severally has an impact on human lung function development [4]. The effect of air pollution on health worsens as pollution levels rise, especially in developing countries. Personal exposure information is typically needed for assessing the risk to personal health from air pollution [5].

Air pollution affects our everyday lives and quality of life. It poses a challenge to the planet's biodiversity and quality of life. Because of increased industrial activities in recent years, there is no doubt about air quality regulation. People must be aware of the degree to which their activities affect air quality. According to the World Health Organisation, a substantial portion of global pollution is breathed, and one out of every eight deaths is caused by air pollution diseases with a projected 28,000 Ghanaians dying annually from air pollution-related diseases [6]. Ghana lost between $226 million and $300 million in 2015 due to air pollution diseases, according to a study by the Environmental Protection

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Agency (EPA). Besides the ill effect of these industry activities, not much has been done to assess the air quality in study areas. This study aims to assess air pollution at Takoradi Technical University (TTU)-Akatakyi campus and its environs, as Diamond Cement's activities seem to pose a threat to healthy air in the area. Therefore, the objectives of the study were to, (a) measure air quality at Takoradi Technical University (TTU) satellite campus at Akatakyi and its environs using Haz-dust EPAM-5000 and (b) analyzed the air particulate matter using standard air quality index (AQI) and (c) to compare air quality index in the study areas in compliance to EPA-Ghana and WHO Guideline Values.

The study would help effective management of our environment, as described by the National Environmental Policy, which states that we must "effectively and efficiently utilize, use natural resources, and preserve the environment in a friendly manner not just for current generations."

1.1. Particulate matter

Particulate matter (PM) has an impact on people. Sulphate, nitrates, ammonia, sodium chloride, carbon, mineral dust, and water are the main components of PM [7]. PM is made up of heterogeneous small solid or liquid particles suspended in a gaseous medium that are normally invisible to the naked eye [8]. Combustion, factories, mining, demolition, agricultural operations, volcanoes, forest fires, motor vehicles, and wood combustion are all sources of PM. Chronic respiratory disease is increased by inhaling enough PM over time [9]. The toxicity of particles varies depending on their composition.

The composition and origin of particulate matter vary. Since: (1) they regulate the transport and removal of particles from the air; (2) they also govern their deposition within the respiratory system; and (3) they are concerned with the chemical configuration and origins of particles, PM is graded according to their aerodynamic diameter [10]. Small particulates or respirable particles are those with a diameter of fewer than 2.5 micrometers ($PM_{2.5}$). They usually stay in the air for days or weeks before being drawn into the lungs and causing harm. Asbestos fibre and cigarette smoke are examples of respirable particles. $PM_{(10-2.5)}$ is a coarse particulate with a diameter greater than 2.5 micrometers but less than 10 micrometers that settles out quickly (sedimentation) [11]. They are primarily formed when bigger portions of matter and mineral pollutant constituents disintegrate, which is one cause of coarse particulates in the air [8]. PM_{10s} are particulates either solid or liquid with a diameter of less than or equal to 10 micrometers that are likely to cause health problems because they can penetrate deep into your lungs and even into your bloodstream [12]. The ranges of smallest members of the fine and coarse particles are referred to as thoracic particles. Particles with radii of less than 0.1 micrometers are referred to as Aitken or ultrafine particulates. Because of their ability to infiltrate the lungs' innermost channels, they are the leading source of lung injury. They are hazardous and lead to indoor air pollution as shown in (Figure 1) [13].

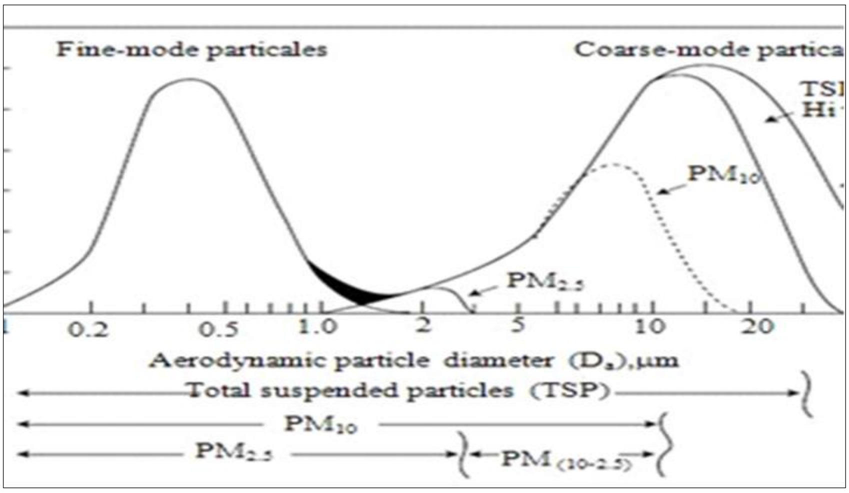

Figure 1 Distribution of particulate matter in ambient air [14]

1.2. Particulate physiological effects

The capacity of Particulate matter (PM) to harm humans by accumulating in the breathing tract is determined by particle size, shape, anatomy of the respiratory tract, and density [14]. These characteristics affect the rate of deposition. Size and aerodynamic properties are the most significant factors affecting particle deposition in the respiratory system. The aerodynamic diameter of a particle, whatever its size, shape, or density, is the diameter of a unit-density sphere with the same settling velocity as the particle in question [15]. The size of the particles has a direct relationship with the rate at which they settle [16]. For particles smaller than 0.5 m, the Brownian diffusion process surges with declining particle size and is prevalent in the gas exchange alveolar area of the lung [17]. Factors that affect particle deposition include breathing patterns (oral breathing allows particles larger than 10 m to move through to the lungs), physical activity (exercise), age, tidal volume, and environmental conditions [15].

1.3. Industrial hazards

Diamond cement company has contributed much to some communities and the country but there is a need to look at the effect the company alleged to possess on the environment. Some key threat factors related to cement manufacturing methods are shown in Table 1.

Table 1 Hazards possessed by diamond cement limited

Cement Manufacturing Process	Main Hazard Factor
Quarrying	Dust, Noise
Raw material preparation	Dust, toxic, gas (CO, CO2, NO, SO2) noise, heat pollution
Clinker burning	Dust, toxic, gas, high heat radiation, high workload
Clinker cooling and cement milling	Auxiliary materials and additives, dust, heat noise
Packaging, storage, and delivery	Dust, high worked

2. Material and methods

2.1. Description of the study area

The Takoradi Metropolitan with a total land area of 49.78 km^2 and a population of 946,000 people [18], is the capital of the Western Region. The study area was located in Ahanta West District, one of the fourteen districts (TTU-Akatakyi). TTU-Akatakyi shares its boundaries with Awasiaju, Bokro, and BEQUIA Microfinance. The study locations are shown in Table 2. The TTU-Akatakyi campus, the Bokro village, and Diamond Cement Road (Bokro) were chosen because of their proximity to the Diamond cement factory.

Table 2 Description of study location

Site	Location	District	Latitude	Longitude
Site 1	TTU-Akatakyi Campus	Ahanta West	4.78340N	2.10880W
Site 2	Bokro Community	Ahanta West	4059'560N	2012'10W
Site 3	Diamond Cement Road	Ahanta West	4053'020W	1052'330W

2.2. Techniques and procedures for air sampling

Particulate matter ($PM_{1,2.5,10}$) and total suspended particulate (TSP) were tested for 24 hours at three (3) different points in the Ahanta West District. Due to high usage and access to several sources of air pollutants (dust, automobile emissions, and dust) created by the Diamond Cement Company, the roadside station at Diamond Cement Company and the other station in Bokro village were established. The TTU-Akatakyi campus was utilized as a control station for the sampling because of the low levels of automobile traffic and human activity.

2.3. Equipment for data collection

The Haz-Dust Epam-5000 (EPAM-5000) (Figure 2**)** is a highly sensitive particle concentration measurement equipment that scatters light and was used for measuring particulate matter in the study sites. Its features are 47 mm filter holder as well as particular filters that produce accurate gravimetric samples and several types of sample checking kits depending on the amount of particulate matter. It's a gravimetric and real-time tool for analysing the quantity and type of particles with more precision. The device covers and monitors within a 2.6-kilometer radius.

The device was positioned three (3) meters above the ground and placed at a distance of 2.3 kilometers between the TTU-Akatakyi campus and the Bokro community, and 0.44 kilometers between the Bokro community and Diamond Cement Company. To avoid blockage of air by obstacles such as trees and other things, it was positioned in an open location.

The Haz-dust (EPAM-5000) was set to sampling mode for Particulate Matter (PM) and Total Suspended Particulate (TSP). The device was calibrated before data collection. To acquire an accurate and precise result, the EPAM-5000 was run for 24 hours to maintain a constant 4.0 l/min flow rate. The experiment stages were replicated three times.

Figure 2 Haz-dust (EPAM-5000)

2.4. Calculation of particulate matter, total suspended particulate, and air quality index

The particulate matter in the TTU-Akatakyi campus, Bokro community, and Diamond Cement Company was measured using a Haz-dust EPAM (Environmental Particulate Air Monitor-5000). The mass concentration was calculated using the increase in filter mass and the amount of air passing through the filter throughout the sample period under real-world conditions. The Particulate Matter ($PM_{1,2.5,10}$) and Total Suspended Particulate (TSP) concentrations from the stations were converted to an air quality index in compliance with EPA-Ghana and WHO guidelines. To determine the $PM_{1,2.5,10}$ and TSP concentration, Equations 1, 2, and 3 were used.

$$\text{The volume of air in cubic meters } (m^3)\ V_a = Q_{avg} \times T \ldots\ldots\ldots\ldots(1)$$

Where;
Qavg is the average flow rate (m/min)
T is the total elapse time (min)

$$\text{Mass of } PM_{1,2.5,10} \text{ and TSP in microgram } (\mu g)\ M_{pm} = Mf - Mi \ldots\ldots\ldots\ldots(2)$$

Where Final mass of filter, Mf (μg), Initial mass of filter, (Mi) (μg)

$$PM_{1,2.5,10} \text{ and TSP concentration } (\mu g/m^3) = \frac{Mpm}{V_a} \quad \ldots\ldots\ldots\ldots(3)$$

The PM and TSP concentrations recorded from the study areas were converted to an air quality index in compliance with EPA-Ghana guidelines. The conversion of guidelines was done using Equation 4.

$$\mu - m\text{: } \frac{\mu}{1000} = m \ldots\ldots\ldots\ldots(4)$$

Table 3 shows PM and TSP Guidelines values by EPA- Ghana, and WHO, while Table 4 shows the description of AQI Ranges. Index for pollutant was determined using Equation 5.

Table 3 PM and TSP Guidelines values by EPA- Ghana, and WHO

Pollutant	EPA- Ghana (µg/m3) 24-hour mean	WHO (µg/m3) 24-hour mean
(PM1)	50	50
(PM2.5)	35	10
(PM10)	70	50
(TSP)	50	50

Table 4 Description of air quality index (AQI) ranges

Readings AQI	Description of AQI
0-50	No danger to one's wellbeing
51-100	Moderate- Only sensitive people should consider reducing excessive.
101-150	Dangerous- to vulnerable groups such as people with heart or lung disease, infants, and older adults.
151-200	Dangerous- people with heart or lung disease, infants, and the elderly should avoid physical activity outside
201-300	Dangerous- People with heart or lung problems, youngsters, and the elderly, in particular, should stay indoors, etc.

Source: USEPA, 2018.

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}} \times (C - C_{low}) + I_{low} \quad \text{………………….}(5)$$

Where;
I – Index for the pollutant,
C – Truncated concentration,
C_{high} – Breakpoint that is greater than or equal to C, C_{low} – Breakpoint that is less than or equal to C, I_{high} – AQI value corresponding to C_{high}, I_{low} – AQI value corresponding to C_{low}

2.5. Data analysis

The $PM_{1,2.5,10}$ and TSP data were statistically analysed using Microsoft Office Excel. Assumptions were made before the analysis of the data due to limitations, such as a lack of air pollutant data from the EPA-Ghana for some months in 2021 and a lack of 2021 temperature data from the Ghana Meteorological Agency due to weather station damage for the analysis and the keeping of records in various institutions. Particle concentrations of $PM_{1,2.5,10}$ and TSP measured were compared to EPA-Ghana and WHO guideline values.

3. Results and discussion

Figure 3 presents the PM and TSP means (mass concentration density) results in the study areas against EPA- Ghana and WHO values. TTU Akatakyi Campus, Bokro Township, and Diamond Cement Factory recorded mean PM_1 readings of the mass values of 3.10, 3.19, and 3.56 mg/m^3, respectively. The PM_1 levels for all the study areas are above that of EPA-Ghana Guidelines. The highest $PM_{2.5}$ mean value (3.57 mg/m^3) was recorded at Diamond Cement Factory whereas the least $PM_{2.5}$ (3.11mg/m^3) was at TTU Akatakyi Campus. Also, the highest PM_{10} mean value (3.80 mg/m^3) was recorded at Diamond Cement Factory while the least (3.12 mg/m^3) was at TTU Akatakyi Campus. The highest recorded Total Suspended Particulate (TSP) mean value (3.62 mg/m^3) was recorded at Diamond Cement Factory while the least (3.11 mg/m^3) was at TTU Akatakyi Campus.

The recorded particle concentration of $PM_{1,2.5,10}$ and TSP measured as compared to EPA-Ghana and WHO Guideline Values indicates that the values are more likely to penetrate the deeper sections of the lungs and deposit on the surface.

Since the PM and TSP results of the study areas contradict the EPA-Ghana and WHO criteria, the values cannot be recognized following the EPA-Ghana regulations (see Figure 4).

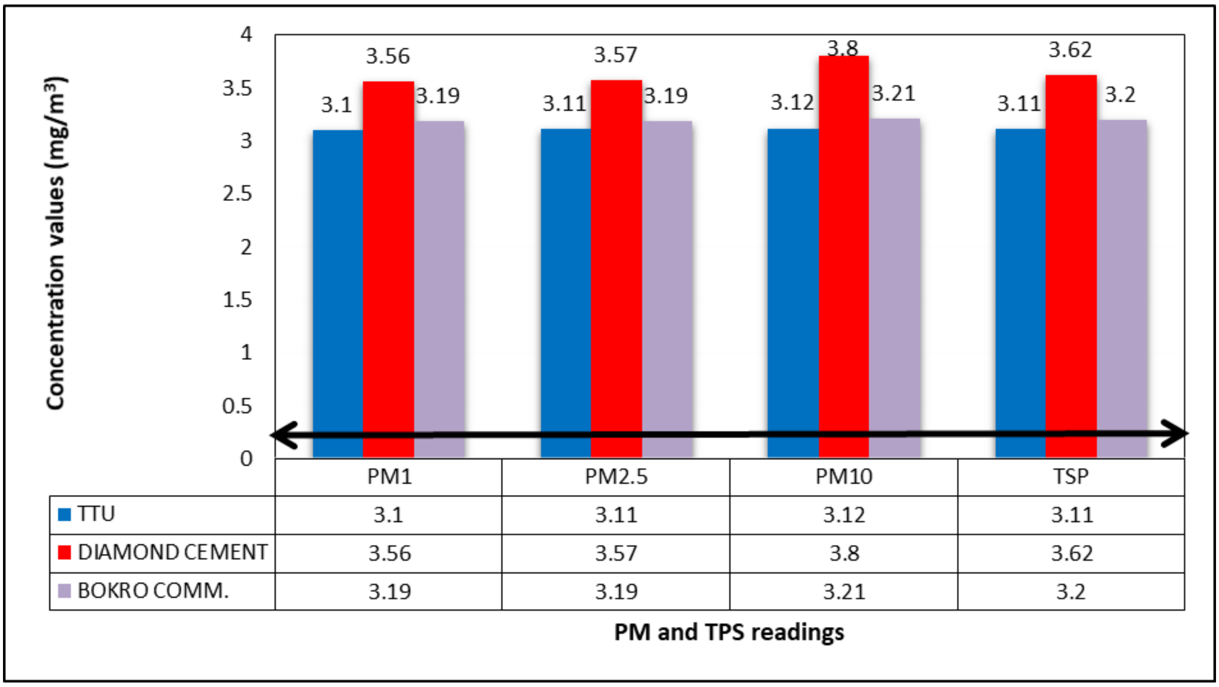

Figure 3 Comparison of particle concentration with EPA-Ghana guideline values

4. Conclusion

Takoradi Technical University (TTU) Akatakyi Campus, Bokro Township, and Diamond Cement Factory recorded mean PM_1 readings of the mass values of 3.10, 3.19, and 3.56 mg/m^3, respectively. The study concluded that particulate matter and Total Suspended Particulate at the study sites were above that of EPA-Ghana and WHO Guideline values. The results imply that students and community members will be exposed to the negative health effects of ambient air pollution at the time of the study. The Total Suspended Particulate (TSP) mean value (3.62 mg/m^3) was recorded at Diamond Cement Factory while the least (3.11 mg/m^3) was at TTU Akatakyi Campus. The PM and TSP results of the study areas exceed the EPA-Ghana and WHO criteria.

Recommendations

The study recommended that the Management of Takoradi Technical University should collaborate with EPA-Ghana to encourage the Diamond Cement Company to strengthen its procedures in controlling the emission of particulates during their activities.

Data availability

Data that support the finding of the study area with the corresponding author will be submitted upon demand

Compliance with ethical standards

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Disclosure of conflict of interest

We the authors have declared that there is no conflict of interest concerning the publication of this paper

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