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Assessing the Impact of Fugitive Dust Emissions from Cement Silos at Cluster of Concrete Batching Facilities Using Air Dispersion Modeling

Ahmed El-Said Rady[1*], Ashraf A. Zahran[2], Mokhtar S. Beheary[3], Mossad El-Metwally[4]

[1]Environment Agency, Abu Dhabi, UAE
[2]Department of Evaluation of Natural Resources, Environmental Study Research Institute (ESRI), Sadat City University, Sadat City, Egypt
[3]Environmental Sciences Department, Faculty of Science, Port-Said University, Port Said, Egypt
[4]Physics Department, Faculty of Science, Port-Said University, Port Said, Egypt
Email: *arady@ead.gov.ae, *arady@live.com

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Abstract

This research assessed the environmental impact of cement silos emission on the existing concrete batching facilities in M35-Mussafah, Abu Dhabi, United Arab Emirates. These assessments were conducted using an air quality dispersion model (AERMOD) to predict the ambient concentration of Portland Cement particulate matter less than 10 microns (PM_{10}) emitted to the atmosphere during loading and unloading activities from 176 silos located in 25 concrete batching facilities. AERMOD was applied to simulate and describe the dispersion of PM_{10} released from the cement silos into the air. Simulations were carried out for PM_{10} emissions on controlled and uncontrolled cement silos scenarios. Results showed an incremental negative impact on air quality and public health from uncontrolled silos emissions and estimated that the uncontrolled PM_{10} emission sources contribute to air pollution by 528958.32 kg/Year. The modeling comparison between the controlled and uncontrolled silos shows that the highest annual average concentration from controlled cement silos is 0.065 μg/m^3, and the highest daily emission value is 0.6 μg/m^3; both values are negligible and will not lead to significant air quality impact in the entire study domain. However, the uncontrolled cement silos' highest annual average concentration value is 328.08 μg/m^3. The highest daily emission average value was 1250.09 μg/m^3; this might cause a significant air pollution quality impact and health effects on the public and workers. The short-term and long-term average PM_{10} pollutant concentrations at these receptors predicted by the air dispersion model are discussed for both scenarios and compared with local and international air quality standards and guidelines.

Keywords

Air Dispersion Modeling, Concrete Batching Facilities, AERMOD, PM_{10}, Fugitive Emissions, Environmental Impact

1. Introduction

Abu Dhabi, UAE, has grown substantially to sustain rapid growth within the country. Due to the increasing demand for concrete, concrete production emissions have contributed to increased levels of PM_{10} by 630 metric tons per year in 2015 [1]. Airborne particles cover a wide range of sizes; 10-micron can penetrate the respiratory tract and 2.5-micron into the gas-exchange region of the lung. The coarse particles PM_{10} are mainly linked to respiratory outcomes and $PM_{2.5}$ with cardiovascular diseases [1].

Particulate Matters (PM) are small inhalable particles that can easily penetrate the thoracic cavity of the respiratory system, causing asthma aggravation, respiratory and cardiovascular diseases, lung cancer, reversible and long-term lung function deficits, and chronic lung growth in childhood. Children, the elderly, and pre-existing heart, or lung disease are particularly susceptible to short-term and long-term exposure, associated with increased hospital admission and mortality. The scientific community has proven that the impacts of PM_{10} short-term exposure are linked to the respiratory system; however, $PM_{2.5}$ is a significant risk factor for long-term exposure health consequences and mortality [2].

Abu Dhabi, UAE, is a fast-growing developing emirate and the construction-associated activities growth substantially increased the demand for concrete products manufacturing contributing to increased levels of PM that may pose serious threats to human health and the environment. The concrete batching facilities processes are potential sources of fugitive dust emissions, mainly from loading and unloading sand and aggregate by front-end loaders or conveyors to feed hoppers and pneumatic transfer of the Ordinary Portland Cement (OPC) to elevated storage silos and trucks movements. The OPC is one of the most widely used materials in construction and is very sensitive to moisture; therefore, it should be stored in an enclosed system (silos) [3]. The most significant potential source of uncontrolled fugitive emissions at concrete batching plants is cement unloading to elevated storage silos [4]. PM emissions from cement storage silos must be controlled using Air Pollution Control Devices (APCD), such as fabric filters on top or central baghouse [5].

The cement dust is fine, light powder, and classified as high dustiness material. When emitted from uncontrolled sources, fugitive dust clouds are observed to form and continue airborne for several minutes [6]. It can be controlled by using fibrous filters, fabric filters, and electrostatic precipitators designed to remove 99.9% of PM_{10} emissions [6] [7].

Portland cement component is a mixture of Calcium oxide (CaO) (62% - 66%), Silicon oxide (SiO_2) (19% - 22%), Aluminum trioxide (AL_2O_3) (4% - 8%), Ferric oxide (Fe_2O_3) (2% - 5%), Magnesium oxide (MgO) (1% - 2%) and Selenium, Thallium, and other impurities [8].

Cement dust is highly alkaline and corrosive to the eyes and skin, especially on contact with moisture when calcium hydroxide (pH of 10 to 12) forms from strongly alkaline calcium-oxide and unlike dust from aggregates and sand, which are relatively inert [9] [10]. The cement dusts heavy metals component such as mercury, chromium, nickel, cobalt, and lead are harmful to environmental and human health. The harmful impact on soil, land, and vegetation is due to acid rain formation by the reaction of cement dust oxides with water droplets [11].

The chemical and physical properties and other factors such as the particle's aerodynamic diameter and the routes via the respiratory system and gastrointestinal playing a key role in the deposition of inhaled cement dust particles in the body [12]. However, despite the negative impact on the environment and health, cement is widely used as a key ingredient in concrete products, construction, and buildings [13].

This research aims to assess the potential for the environmental impact that fugitive dust emissions might cause, if uncontrolled, from 176 cement silos located in 25 concrete batching facilities that emit cement dust during production activities located in M35 Mussafah industrial area, Abu Dhabi, UAE. The PM_{10} quantities emitted from the concrete batching production process were modeled using controlled and uncontrolled emission scenarios. The formulation of the American Meteorological Society (AMS) and U.S. Environmental Protection Agency (EPA) Regulatory Model (AERMOD) (Version: 9.9.0) was applied to estimate the air dispersion of PM_{10} emitted from 176 cement silos and its impact on the sensitive receptors within the study area domain. The foci of this study were to: **1**) Estimate emissions rates of PM_{10} from cement silos; **2**) Perform air dispersion modeling using controlled and uncontrolled silos scenarios; **3**) Compare the results of controlled and uncontrolled scenarios; **4**) Assess the air quality impacts at various identified sensitive receptors; **5**) Study the short-term and long-term average pollutant concentrations values predicted at the sensitive receptors, **6**) Compare the predicted values with applicable standards and guidelines, and **7**) Propose recommendations to control fugitive cement dust from silos.

2. Materials and Methods

2.1. Standards and Guidelines Framework

These standards and guidelines specify PM_{10} maximum values for short-term exposure (24 hours) and long-term exposure (annual) limits; the exceedance of concentration limits might adversely affect human health and the environment. Limits values given in **Table 1** are applicable to most individuals in the general population.

Table 1. Overview of the relevant ambient air quality standards and guidelines [14] [15].

Pollutant	Max. Allowable Limits ($\mu g/m^3$)	Average Time	Source
PM_{10}	150	24 Hours	Cabinet Decree No. (12) of 2006 Annex 8
PM_{10}	45	24 Hours	WHO Guidelines, Global Update 2021
PM_{10}	15	Annual Mean	WHO Guidelines, Global Update 2021

2.1.1. National Air Quality Standard (NAQS) Limits

The predicted Ground Level Concentration (GLC) results compared with the allowable limits provided in the UAE Cabinet of Minister's decree No. (12) of 2006 concerning air protection from pollution.

2.1.2. World Health Organization (WHO) Air Quality Guideline

WHO air quality guideline values are used to compare the emission limits; the WHO Air Quality Guidelines: Global Update 2021 guideline limits aim to achieve the lowest possible concentrations of PM_{10}.

2.2. Study Area Description

Mussafah area is an industrial town located 30 kilometers Southeast of Abu Dhabi City, UAE. Also known as "Mussafah Sanaiya", it is one of the most important economic areas of the UAE and has been designated a special economic zone, with numerous factories and port. The concrete batching facilities are mainly located and clustered in the Mussafah industrial area- M35 zone, which is located in the old industrial area of the Abu Dhabi Emirate, surrounded by mixed-use industrial, commercial, and residential areas. The estimated total area is approximately 1,000,000 m^2 as shown in **Figure 1**, and the study area boundary is represented in **Table 2**. M35 has more than 25 concrete batching facilities equipped with 176 cement silos in one location operating under the cement and cement products industrial sector. Consequently, it is imperative to conduct an environmental assessment of this industrial area to determine and assess the impacts on the environment and sensitive receptors.

2.3. Data Collection Surveys

Field visits and interviews were conducted on 25 concrete batching facilities located in the study area to collect facility-specific information such as annual production, raw material usage, additives, energy consumption, and other process-related details. Data collection surveys to each plant were distributed to get sufficient data to calculate emissions rates. Critical review and quality check on survey responses using statistical software to ensure the data is adequate to provide robust and accurate input to the model.

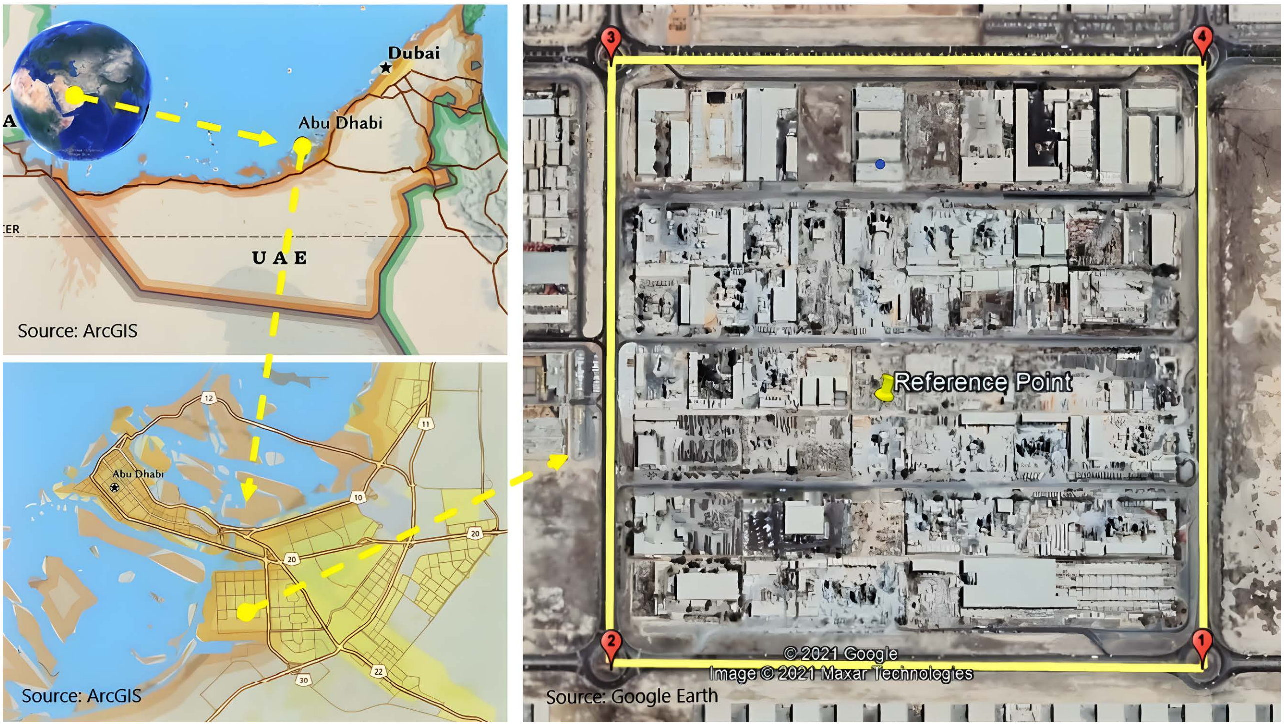

Figure 1. Study area location (Google earth aerial photo).

Table 2. GPS coordinates of the study area boundary.

No	UTM-X	UTM-Y	Direction	Local Mean Sea Level (meter)
1	247627.73	2693801.58	SE	2
2	246635.75	2693793.86	SW	2
3	246605.53	2694777.80	NW	4
4	247606.14	2694790.12	NE	3

2.4. Emissions Rates Calculations

One of the critical steps in conducting air dispersion modeling is to quantify the emission rates for each single cement silo at the 25 targeted facilities in M35. The emission rates for the sources identified were derived from US EPA Air Pollutant Emissions Factors (AP-42), Section 11.12 Concrete Batching emission factors. Cement annual consumption for each facility (average per facility is **88 159.72 MT/year)** and emissions factor for controlled pneumatic transfer of cement to a storage silo using efficient air pollution control devices (APCD) was **0.00017 kg/Mg** of cement transferred. The emissions factor for uncontrolled emissions for the pneumatic transfer of cement to a storage silo was **0.24 kg/Mg** of cement transferred. The uncontrolled scenario means the filter was not operating properly, and there was no level of control [16].

2.5. Air Dispersion Modeling

In this work, a commercialized air dispersion model utilizes EPA's AERMOD is used (AERMOD View, Version: 9.9.0, Lakes Environmental Software). It calculates the hourly and annual air concentrations and deposition fluxes resulting from air pollutants emitted from the cement silos at selected downwind sensitive receptors to address the potential air quality issues by estimating and predicting the GLC of air pollutants. The required input files were created using sources' emissions rates and meteorological inputs to run the chosen study area domain model.

2.5.1. Model Domain

Centroid reference point positions at 247072.00 m E, 2694212.00 m N zone 40 R were selected, and 25 km radius for the modeling area to cover all the study area topographical surface features.

2.5.2. Meteorological Data

Meteorological data such as cloud cover, lower ambient temperature, relative humidity, barometric pressure, wind direction, wind speed, ceiling height, hourly precipitation, and sun radiations are essential for air dispersion modeling. It represents the primary environment through which the pollutants under study migrate. The meteorological data set was defined using an Environment Agency, Abu Dhabi (EAD) monitoring station, as shown in **Figure 2**, approximately 200 meters to the North of the study area boundary line, upon quality check and review of the missing data from the EAD monitoring station were completed from Abu Dhabi international airport published climate data.

Accordingly, data from this station are considered a great representative of the meteorological conditions of the study area using the AERMET meteorological

Figure 2. EAD monitoring station.

processor program has been used to generate the wind rose for cumulative six years for the period from 1st January 2014 to 31st December 2019 based on hourly sequential meteorological records utilized for these simulations.

The wind rose shows that the predominant wind direction blowing from the northwest (NW) as presented in **Figure 3** and the average wind speed is 3.16 m/s, and the calms wind average was more or less constant for the six years approximately (1.6%). The wind direction is mostly blowing from Northwest (NW) 40%, Northeast (NE) 18% and, Southwest (SW) 15%, Southeast (SE) 27% regions.

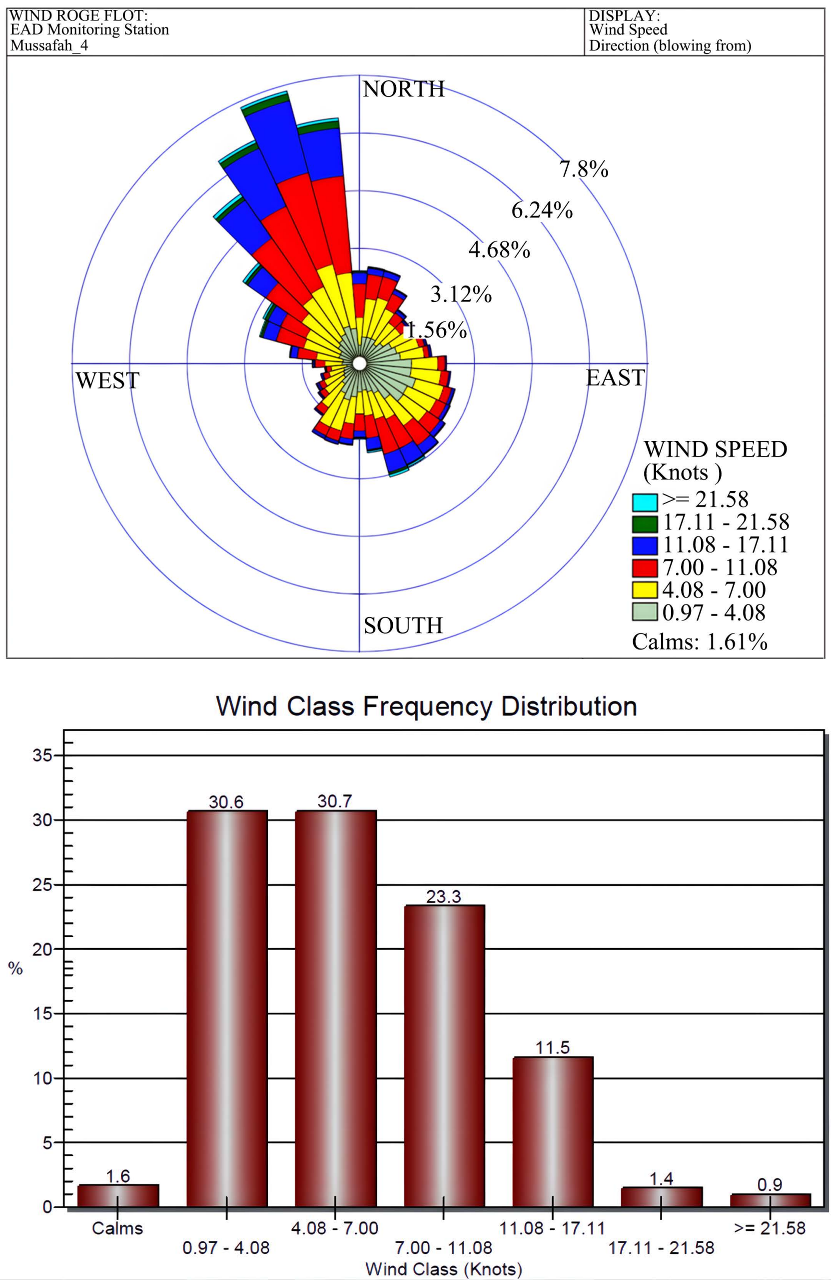

Figure 3. Wind rose diagram and wind class frequency distribution for the meteorological data (2014 to 2019).

2.5.3. Study Area Characteristics (Terrains)

The flat and elevated terrain was specified in the model by considering topographical elevations for all receptors, as presented in Figure 4.

2.5.4. Receptors Grid Domain

The selection and location of the receptor network are essential in determining the maximum impact from a source and the area where there is significant air quality impact. Therefore, the receptor's locations were selected as a multi-tier grid as presented in Figure 5, which is defined by discrete cartesian receptors, square in shape, and with origin at the centroid of the study area, including three tiered segments [4]:

- 50-meter grid within 2000 m from the study area centroid
- 200-meter grid within 5000 m from the study area centroid
- 1000-meter grid within 25,000 m from the study area centroid

2.5.5. Sensitive Receptors

PM_{10} concentrations were identified on seventy (70) discrete cartesian receptors, as shown in Figure 6. The selected sensitive receptors within the model domain concerning air pollution impacts are typically taken to be those where people may be exposed regularly for long periods and have been selected from available mapping and site visits, including but not limited to residential areas with high populations, educational establishments, parks, hospitals, protected areas, mixed-use commercial areas, airports, shopping malls, hotels, and worship places.

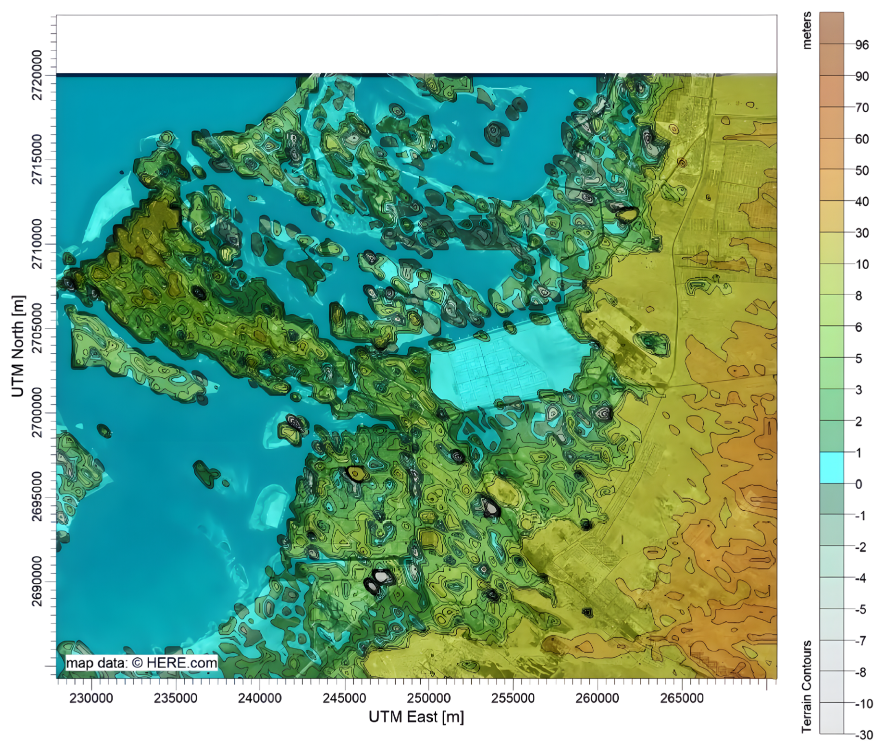

Figure 4. Terrain elevation in and around the study area.

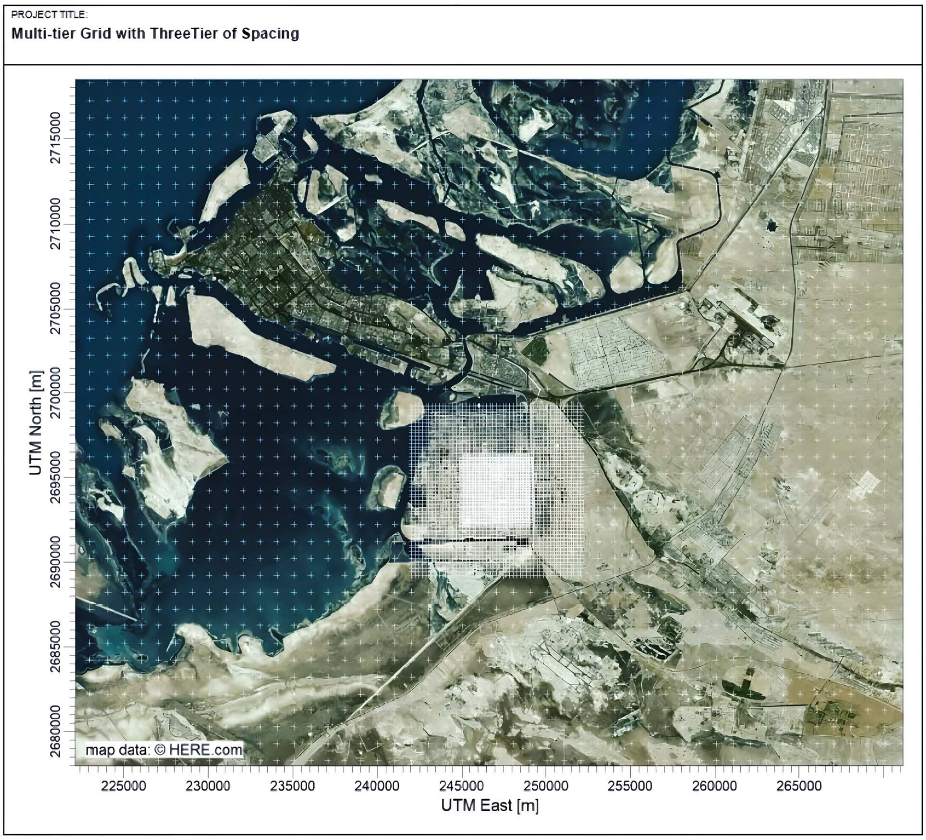

Figure 5. Three segments of multi-tier grid receptors spacing.

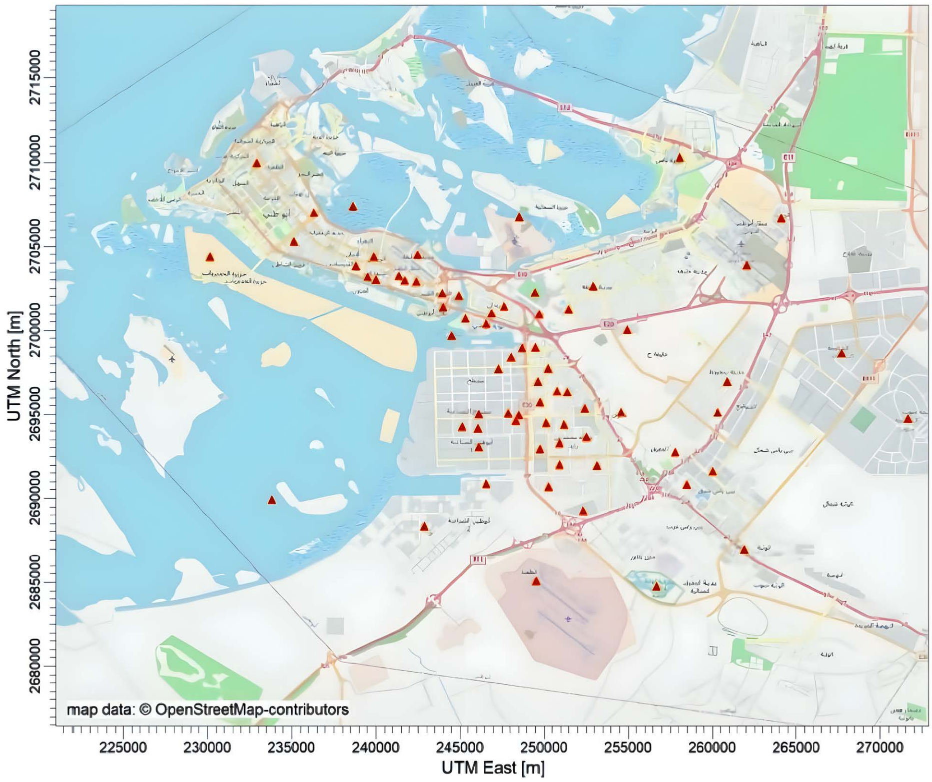

Figure 6. Locations of sensitive receptors.

2.5.6. Emission Sources

The volume source type is used to model releases over a three-dimensional volume [17]. The emission rate for each controlled or uncontrolled emission source of the 176 cement silos presented in **Figure 7**, was calculated and identified using USEPA AP-42 as part of this research project to fulfill the data inputs required to run the model.

2.5.7. Modeling Considerations

The following have been considered for the air pollution dispersion modeling study to ensure a conservative approach to the assessment:

- Concrete Batching facilities operate continuously for 24 hours daily, 365 days per year.
- No building downwash was considered in the study as there is no high-rise building in the study area and the cement silos are the highest structure in each facility.

2.5.8. Modeling Scenarios

Air dispersion modeling was conducted for controlled and uncontrolled cement dust emission scenarios for cement silos, as shown in **Figure 8**, to evaluate the impacts of cement dust PM_{10} on air quality. Both scenarios used the same production and cement consumption data but differed in the presence or not of APCD that collects particle size from 1 to 10 μm during pneumatic cement transfer prior to release to the atmosphere for long-term (annual) and short-term (24-hour) averages. AERMOD generates output files, concentrations

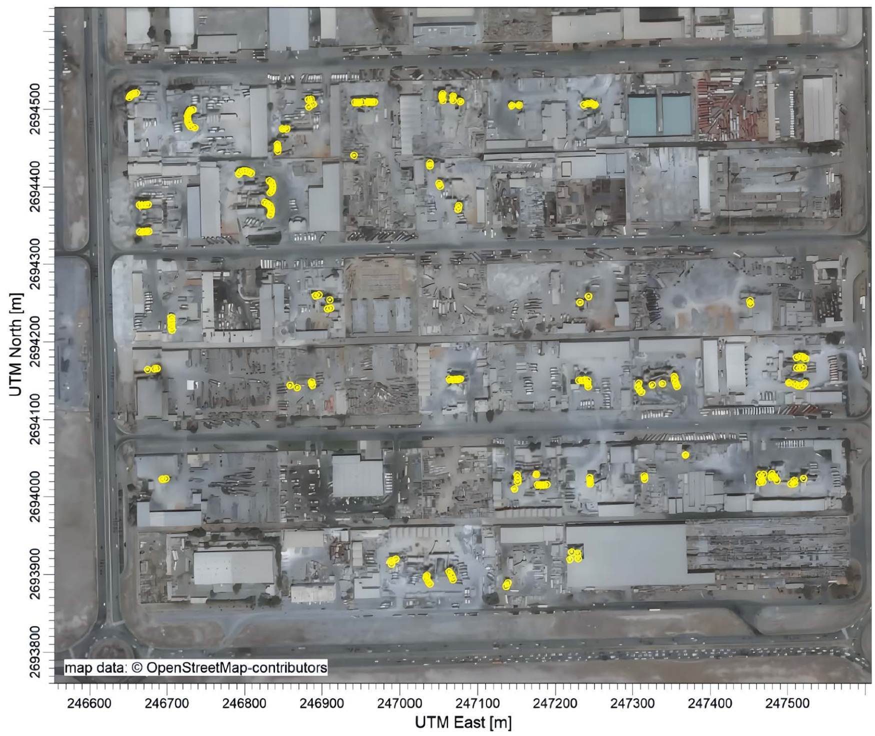

Figure 7. Locations of emission volume sources (176 Cement Silos).

(a) (b) (c)

Figure 8. Controlled and uncontrolled cement silos. (a) Controlled Silos; (b) Un-Controlled Silos; (c) Fugitive Cement Dust Emissions from Uncontrolled Silos.

contours, and color-coded scales that demonstrate the impacts of the maximum predicted concentrations and multiple concentration levels.

3. Results and Discussion

3.1. Controlled Cement Silos—APCD with 99.9% Efficiency

Scenario 1: represents the ideal operations of the concrete batching facilities, where all the 176 cement silos capture emissions to APCD, such as fabric filters that are capable of collection efficiencies greater than 99.9 percent [6] [7]. Cement annual consumption for each facility and emission factor (0.00017 kg/mg) was used to calculate PM_{10} emission rates (g/s) for every single controlled silo.

The calculations estimated that the PM_{10} cement dust emissions from 176 controlled cement silos located in the selected domain would contribute to air pollution by a total of **374.68 kg/year**, and the average emission value per facility is **14.99 kg/year**.

The maximum annual average PM_{10} resulting from regular concrete batching facilities operations in M35 is presented in the form of contour plots in Figure 9. The highest average yearly concentration predicted outside the M35 area towards the West was 0.065 $\mu g/m^3$. Within the M35 boundary area, the highest concentration predicted was 0.199 $\mu g/m^3$. PM_{10} maximum annual average values at all sensitive receptors were predicted to be negligible, corresponding to (15 $\mu g/m^3$) WHO guidelines.

The maximum daily average PM_{10} resulting from controlled cement silos are presented in the form of contour plots in Figure 10. The highest daily average concentration predicted outside the M35 area boundary line towards the East was 0.6 $\mu g/m^3$; however, the highest concentration value predicted in 2190 days (6 years) within the M35 area boundary line was 0.725 $\mu g/m^3$. The maximum daily average PM_{10} predicted values at all the sensitive receptors are not significant and negligible compared to the 24-hour average (150 $\mu g/m^3$) NAQS and (45 $\mu g/m^3$) WHO guidelines. Therefore, the incremental increase incurred by the 176 controlled cement silos for annual and daily concentrations of PM_{10} will not lead to significant air quality degradation in the entire study domain.

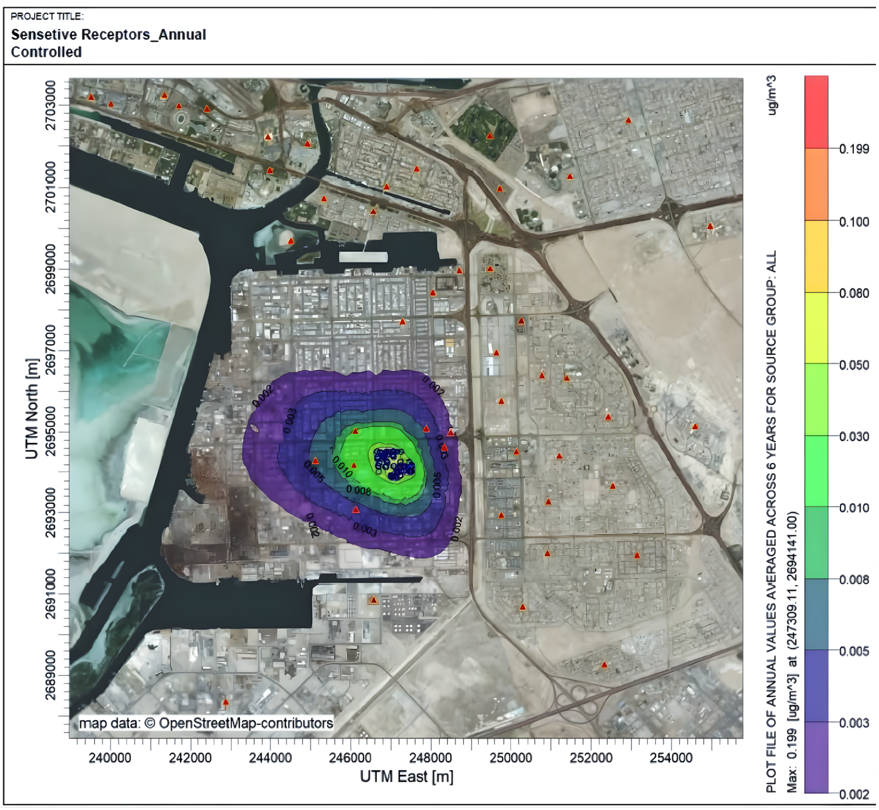

Figure 9. Predicted maximum annual PM_{10} average from controlled cement silos.

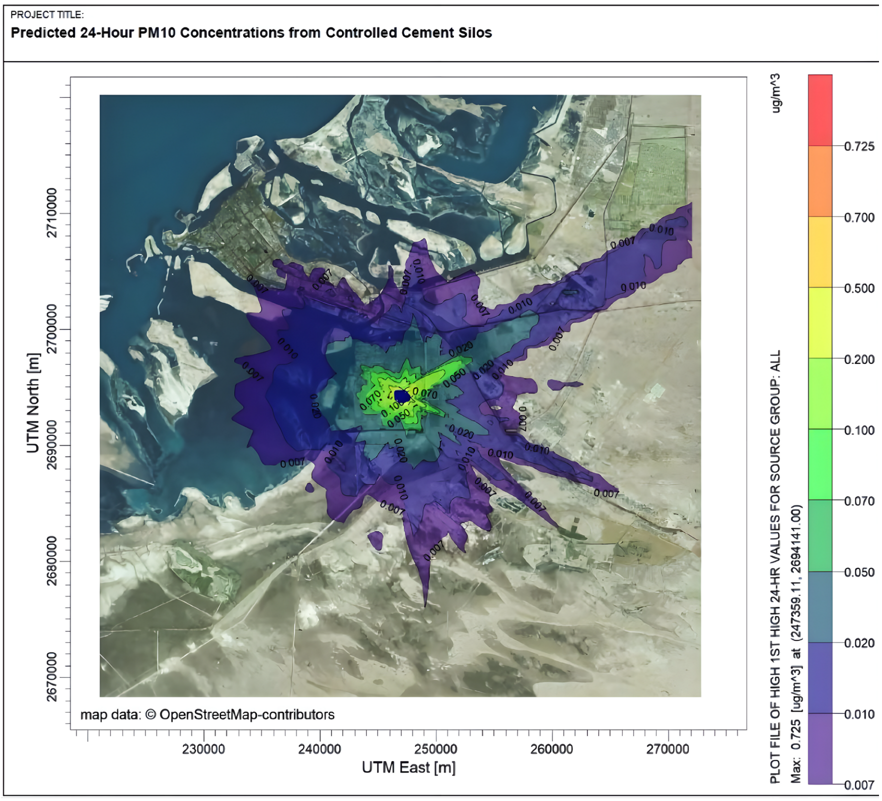

Figure 10. Predicted 24-hour PM_{10} concentrations from controlled cement silos.

3.2. Uncontrolled Cement Silos

Scenario 2: represents the worst-case operational scenario of concrete batching facilities, where all 176 cement silos fail to capture cement dust PM_{10} emissions. Cement annual consumption for each facility and emission factor (0.24 kg/mg) was used to calculate PM_{10} emission rates (g/s) for every single uncontrolled silo. The calculations of total PM_{10} emissions from entire facilities are estimated to be **528958.32 kg/year**, and the average PM_{10} emissions value per facility is **21158.33 kg/year**. These calculations indicated that the uncontrolled PM_{10} emission sources would significantly contribute to air pollution by multiplying PM_{10} emission quantities emitted to the atmosphere by 1400 times than quantities emitted from controlled sources, as shown in Figure 11.

The maximum five daily average PM_{10} emissions predicted are 1250.09 μg/m^3, 1236.57 μg/m^2, 1187.06 μg/m^2, 1078.47 μg/m^{3,} and 992.59 μg/m^{3,} respectively, inside the study area boundary line as presented in Table 3. These elevated concentrations in the vicinity of the study area boundary may have a short-term impact on the local air quality within the study area boundary; consequently, this will significantly affect the overall air quality.

Uncontrolled or dis-repaired cement silos have no control efficiency. They would lead to high PM_{10} emissions resulting in a predicted maximum daily average PM_{10} of 800 μg/m^3 outside the study area boundary towards the West and East directions, as presented in Figure 12. The predicted concentration value

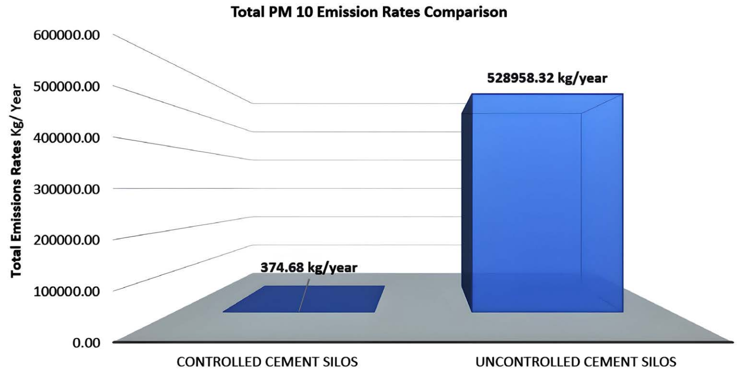

Figure 11. Comparison of total PM_{10} emission rates between controlled and uncontrolled silos.

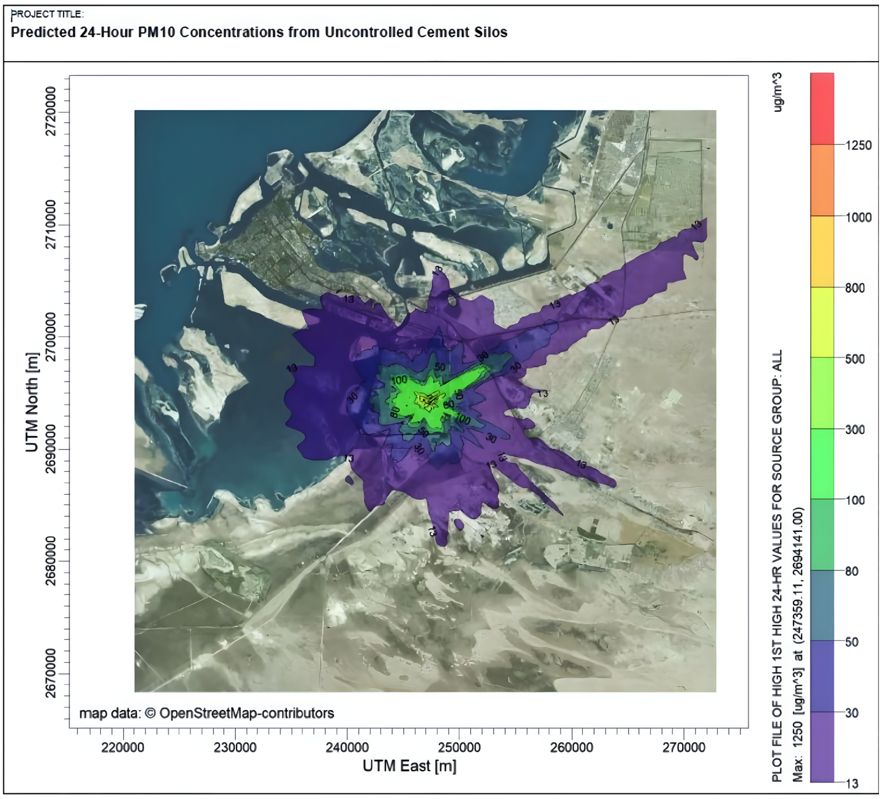

Figure 12. Predicted 24-hour PM_{10} concentrations from uncontrolled cement silos.

Table 3. The maximum predicted PM_{10} concentrations from the uncontrolled silos.

Averaging Period	Rank	Peak (μg/m³)	UTM-X (m)	UTM-Y (m)	Peak Date, Start Hour
24-HR	1ST	1250.1	247359.1	2,694,141	3/19/2019, 24
24-HR	2ND	1236.6	247359.1	2,694,141	12/12/2019, 24
24-HR	3RD	1187.1	247359.1	2,694,141	11/2/2019, 24
24-HR	4TH	1078.5	247359.1	2,694,141	9/2/2015, 24
24-HR	5TH	992.6	247359.1	2,694,141	2/5/2019, 24
ANNUAL		328.1	247309.1	2,694,141	

was 5.3 times the maximum PM_{10} daily average of NAQS (150 μg/m^3) and 16 times the 24-hour mean of WHO guidelines (45 μg/m^3).

The maximum PM_{10} predicted concentration values at the top 8 impacted sensitive receptors locations within the computational domain were presented in Table 4. The maximum predicted PM_{10} concentration value is 393.92 μg/m^3 at the school 720 meters away from the study area boundary towards the North direction. The maximum daily average PM_{10} predicted values at eight sensitive receptors are significant compared to the 24-hour average of NAQS (150 μg/m^3) and WHO guidelines (45 μg/m^3) and may cause significant health effects.

The maximum annual average GLCs of PM_{10} resulting from uncontrolled cement silos are presented in the form of a contour plot in Figure 13. The highest annual average concentration of **328.08 μg/m^3** was predicted inside the study area boundary and was presented in Table 3. The highest concentration predicted outside the M35 boundary towards the West direction was 100 μg/m^3. This predicted value is five times higher than the (15 μg/m^3) WHO annual mean. However, at all sensitive receptors, the maximum annual average GLC was predicted to be more than or equal to 20 μg/m^3 at only two residential area locations, as presented in Table 5. This may cause significant health effects on residents. However, guideline values would not be expected to protect everyone because human responses do not occur at precise exposure levels.

Comparable results have been found in the Environmental Impact Statement (EIS) of Hanson Eastern Creek's Concrete Batching Plant in NSW, Australia, operating 24 hours a day, seven days a week. The estimated particulate matter (PM_{10}) emissions from unloading 131 tons of cement per day, equating to 47,808 tones annual average into four controlled silos, is 81 kg/year on a typical operational day and 168 kg/year on a peak operational day. The annual average predicted downwind concentrations of PM_{10} at 30 sensitive receptors recorded a minimum value < 0.01 (μg/m^3) and a maximum value of 0.828 (μg/m^3) from the overall activities [18]. Also, Windlectric Inc Ready Mix Concrete Batching Plant

Table 4. Daily PM_{10} Exceedance predicted at eight sensitive receptors.

Averaging Period	Peak Concentrations (μg/m^3)	Description	UTM-X (m)	UTM-U (m)	Distance from Study Area Boundary (m)	Direction
24-HR	393.9	Driving School	248333.8	2694628.86	720	N
24-HR	354.3	Worship Places	247889.36	2695090.91	400	NE
24-HR	328.3	Commercial area	246117.59	2695028.25	550	NW
24-HR	315.1	Residential Area	246078.58	2694190.16	520	W
24-HR	200.1	Commercial Area	248637.00	2694914.00	1040	NE
24-HR	200.1	Hospital	250318.00	2695700.00	4280	NE
24-HR	193.1	Schools and Residential Area	251439.14	2696500.25	1400	W
24-HR	167.1	ICAD Residential City	245120.7	2694288.99	2830	NE

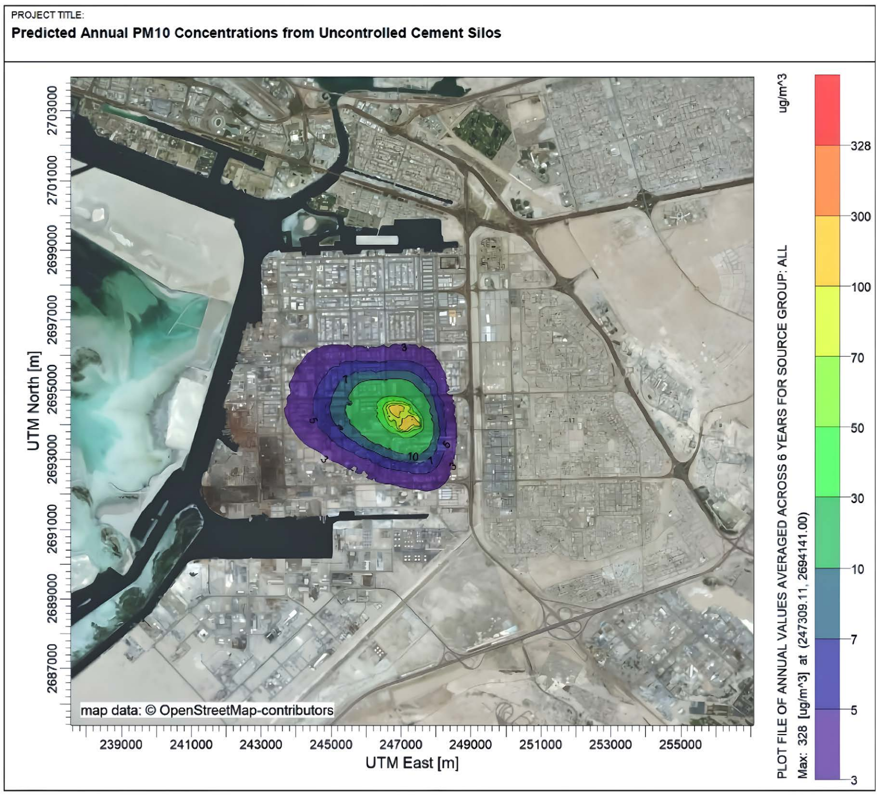

Figure 13. Predicted maximum annual PM_{10} average from uncontrolled cement silos.

Table 5. Annual PM_{10} Exceedance predicted at eight sensitive receptors using AERMOD Dispersion.

Averaging Period	Peak (μg/m^3)	Description	UTM-X (m)	UTM-U (m)
ANNUAL	40	Residential Area	246,394	2,694,245
ANNUAL	20	Residential Area	246078.6	2,694,190
ANNUAL	14.4	Commercial area	246117.6	2,695,028
ANNUAL	7.7	ICAD Residential City	245120.7	2,694,289
ANNUAL	6.2	Worship places	247889.4	2,695,091
ANNUAL	5.79	Hospital	250,318	2,695,700
ANNUAL	3.96	Commercial area	248333.8	2,694,629
ANNUAL	2.62	Hospital	248492.6	2,694,995
ANNUAL	1.36	Hospital	247289.6	2,697,720
ANNUAL	1.32	School	246573.5	2,690,865
ANNUAL	1.14	Residential	249759.3	2,692,955

in Ontario, Canada, operates 12 hours daily, five days a week, and has two controlled silos. The PM_{10} emissions estimate is 0.0002856 (kg/day) from the daily usage of 335 (kg/m^3) of cementation material, and the maximum daily predicted concentration from all the facility emission sources is 3.9 (μg/m^3) [19]. Both cases undertook air quality assessment for permitting purposes and were conducted using AERMOD air dispersion modeling. Emissions rate inputs and predicted concentrations observed vary based on several main factors that affect the calculations, such as cement loading quantities and flow rate into the silos, APCD efficiency, facility capacity, production rate, and operating hours.

4. Conclusions

This study shows that in an uncontrolled scenario, there will be identified limits exceedance of PM_{10} in the ambient air at the sensitive receptors around and within the study area in Scenario 2 (uncontrolled cement silos). This may pose a serious negative impact on air quality and health by increasing the risk of asthma, respiratory, cardiovascular, lung cancer, and chronic lung growth diseases due to short and long-term exposure. The release of cement dust emissions into ambient air is a major concern due to its constituents which are harmful elements to the health of humans and the environment. Based on the calculated PM_{10} emission quantity in Scenario 2, the uncontrolled PM_{10} emission sources multiplied the emissions quantity by 1400 times more than the controlled sources' emissions and the predicted emission values from controlled silos modeling Scenario 1. The study demonstrates that fibrous filters, fabric filters, and electrostatic precipitators are the best management practices that collect particle sizes from 1 to 10 μm and reduce emission by 99.9%, positively impacting the ambient air quality and limiting the cement dust exposure health effects.

The field visits' outcomes show that predominantly the reason for PM_{10} exceedance is the non-compliance of concrete batching facilities with regulatory permit conditions and the federal environmental law No. (24) of 1999, Chapter 4, concerning the protection of air pollution articles (48), (52), and (55). The non-compliance due to violating national air quality standards and regulatory requirements will lead to enforcement actions and legal escalation against violated facilities under article (82) of law No. 24/1999.

EAD, the Abu Dhabi local environmental regulatory authority, plays a crucial role in protecting the environment and public health by preventing air quality deterioration due to emissions from uncontrolled sources through the existing robust EAD environmental inspection, compliance, and enforcement program. EAD is conducting routine and compliance assistance follow-up inspection visits in addition to taking decisive enforcement actions to enforce environmental laws and regulations that significantly increase concrete batching facilities compliance by installing high-efficiency filters to capture cement dust generated during silos loading and unloading activities, keeping silos maintenance records, implement fugitive dust emissions control plan, filters replacement on regular bases, monitor emissions, and maintain proper housekeeping.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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