



(RESEARCH ARTICLE)



ATMOSPHERIC DISPERSION MODELING OF PM₁₀ AND SO₂ FROM OPEN BURNING OF SOLID WASTE IN IBADAN, NIGERIA

Oyerinde K. K ^{1,*}, Ogunsola A. D ¹, Popoola A. O ¹, Adeniyi S. A ², Saliu M. E ¹ and Olu-Arotiowa O. A ¹

¹ Department of Chemical Engineering, Faculty of Engineering and Technology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

² Department of Petrochemical, Faculty of Engineering, University of Ibadan, Ibadan, Nigeria.

* Corresponding Author

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ABSTRACT

Rapid urbanization and inadequate municipal waste management in sub-Saharan Africa have exacerbated severe environmental and public health crises, prominently characterized by the operation of uncontrolled open dumpsites. In Ibadan, Nigeria, major disposal facilities such as La Awotan dumpsite rely heavily on open dumping and unmitigated burning. This present study aimed to examine the atmospheric emissions generated from the open burning of solid waste across these four sites from 2018 to 2024 using dispersion modelling. The criteria air pollutants (CAPs) such as particulate matter (PM) and Sulfur dioxide (SO₂) were determined using the emission factor approach. The ground level concentrations of each of the CAPs within a 15 km radius were predicted using the AERMOD software. The results showed that the emission inventory for PM and SO₂ is in the range of 2553.91–7654.10 and 66.10–198.11 tons per annum between 2018 and 2024, respectively. The maximum 1, 8, 24 h, and annual concentrations were 268475µgm–3, 45065µgm–3, 15155µgm–3 and 614µgm–3 for PM and 6049µgm–3, 1166µgm–3, 392µgm–3 and 15.9µgm–3 for SO₂, respectively. Research indicates that open burning of solid waste emits hazardous gasses and has negative impacts on nearby communities. These findings will serve as a baseline for environmental protection agencies.

Keywords: Municipal Solid Wastes (MSW), Open Burning, Criteria Air Pollutant (PM and SO₂), Emission Inventory and Dispersion Modelling

1 INTRODUCTION

Solid waste are materials or items that are thrown away, disposed of, or meant for disposal. (Fakule, 2025). Solid waste could be garbage or wasted materials and items from commercial, mining, industrial, agricultural, and daily operations (Gupta and Gaur 2026). Municipal solid wastes (MSWs) are the majority of the well-known discarded wastes that comprise the everyday objects that the general population discards, and it includes all substances or objects thrown away as products of packaging, lawn cuttings, furniture, clothing materials, bottles/glasses, food scraps, electric appliances, newspapers, paint, and batteries (Prasad et al., 2025). As a result, managing municipal solid waste (MSW) properly has become crucial in Ibadan (Okamgba et al., 2025). The open burning of municipal solid waste is a poorly defined and underestimated contributor to air pollution in developing nations (Anyanwu et al., 2025). In Ibadan and other developing nations, municipal solid waste is intentionally burned either at the point of generation, at open dumps,

or in uncontrolled, un engineered disposal sites (Aladejebi et al., 2024). Many urban areas in Ibadan prefer burning their rubbish, while municipal waste managers employ incineration as a rapid, efficient, and cost-effective method to diminish the amount and mass of refuse at disposal sites (Appiah et al., 2026), so as to create space for new batches. In several states around the nation, open burning is prohibited by law. However, the practice is widespread, which suggests inadequate enforcement or a dearth of better options. Other factors include inadequate funding and the lack of suitable alternatives for managing or disposing of the garbage (Ezeudu et al., 2025). One of Nigeria's most difficult environmental problems is MSW management. MSW is a type of waste that comes from homes, commercial and industrial wastes (Mohajan, 2025). Open burning (distinct from controlled burning) is Combustion at low temperatures (between 250 and 700 °C) in an oxygen-deficient environment, lacking control over temperature and duration of combustion. The absence of air pollution control measures leads to incomplete combustion (Delkash, 2026, Escamilla-García et al., 2026). The practice has been connected to social, environmental, and public health concerns (Rautela et al., 2025).

Globally, air pollution is still a major problem for the environment and human health (Xu et al., 2025), and its impacts are becoming more noticeable in areas that are industrializing quickly (Hassan et al., 2025). It causes dangerous materials to be released into the atmosphere, such as gasses, particulate matter and heavy metals, this may result in serious cardiovascular and pulmonary issues as well as harm to ecosystems (Fahim et al., 2026). Air pollution may elevate the risk of several malignancies, including lung cancer (Yang et al., 2026). It has the capacity to exacerbate global warming, damage forests and agriculture, acidify lakes and streams (Sahoo et al., 2025), can have a detrimental effect on the economy (Kousar et al., 2025, Zhou et al., 2025). A series of events from the production of pollutants are involved in air pollution at the origin and the release into the atmosphere, the movement and alteration of these contaminants, and their impact on the overall ecosystem (Saxena, 2025). While both natural and man-made factors contribute to air pollution, industrial emissions, particularly from volume sources, point sources, are among the most significant contributors in urban and per-urban environments (Pongpiachan et al., 2025, Sasia et al., 2026). Unclean air is making the worldwide public health situation worse. More than 90% of people on the planet reside in places where air pollution is higher than what the World Health Organization recommends (Cho et al., 2026). According to several scientific investigations, there is a connection between PM₁₀, NO_x and SO₂ emissions (Turhan, 2026) Yang reported that NO_x play an important role in the formation of PM₁₀ contributing to summertime air pollution under certain humid conditions. Their report suggested that some VOC groups may promote an increase in PM concentrations unless PM levels exceed 140 µgm–3 under humid conditions.

PM₁₀ (particulate matter having an aerodynamic diameter of ≤10 µm) is recognized as a criteria pollutant and a significant cause of the worldwide disease burden linked to air pollution (Arca-Lafuente et al., 2025). The PM emissions from the open burning are often fugitive in nature and an order of magnitude larger than those from other occupational settings (Kaya et al., 2025). Particulate matter refers to a broad category of air pollutants made up of suspended particles with different compositions, and size due to different human activities (Damiani et al., 2025). The type of gasifies and its operating conditions, including temperature, gas velocity, and moisture content, determine the size, composition, and concentration of the particulate matter in fuels as well as the gasification rate. Particulate matter ranges in size from less than one micron to more than one hundred microns. In addition to being harmful to health, particulate matter also capable of producing downstream equipment corrosion, erosion, and fouling (Matei et al., 2025). The primary cause of air pollution is particulate matter. It decreases the clarity in air and therefore affects the visibility and makes it difficult to breathe such air (Boso et al., 2025). All solid and liquid particles that are suspended in the atmosphere are referred to as particulate matter. A large number of them are typically dangerous and serve as significant risk factors for a high rate of co-morbidity in people (Zhu et al., 2025).

Nitrogen oxides (NO_x = NO + NO₂) is a great indicator of human activity because anthropogenic combustion sources are the main source of NO_x emissions, including household combustion, transportation, power plants, and industry (Liu et al., 2025). Natural sources of NO_x include wildfires, soil, and lightning (Borgohain et al., 2025, Lamothe et al., 2026). The primary source of NO₂ is the oxidation of NO, which is created at high temperatures from atmospheric nitrogen and oxygen (Xia et al., 2025). NO_x is a significant precursor to ozone and particulate matter (Tan et al., 2026). NO₂ can cause respiratory problems and is also harmful to the ecosystems by forming nitric acid and acid rain (Singh, 2025). Satellite retrievals are widely employed to detect NO₂ changes (Acker et al., 2025, Holloway et al., 2025). However, increases in NO₂ concentrations could be due to changes in emissions, meteorology, or both. As a result, changes in NO₂ concentrations do not correspond to changes in emissions and are not reliable indicators of human activity (Van Der A et al., 2025).

Sulfur dioxide (SO₂) is a gas-phase air contaminant that is reactive, SO₂ exposure has an impact on human health via raising respiratory (Gul et al., 2026) and cardiovascular morbidity (Shukla et al., 2025). SO₂ is mostly oxidized in the environment with interactions with the OH radical in the gas phase, or by hydrogen peroxide (H₂O₂) and ozone (O₃) in the aqueous phase to create sulfuric acid, which can result in particle sulfate and acid rain (Wu et al., 2026). Sulfate, which makes up 10%–67% of aerosol mass in the mid-latitude Northern Hemisphere, is a crucial component of specific matter with aerodynamic diameter less than 2.5µm (PM_{2.5}) (Seckar-Martinez et al., 2025). Exposure to ambient PM_{2.5}

is projected to cause 4.2 million premature deaths in 2015 (Ghosh et al., 2026). SO₂ also causes the production of haze, which lowers visibility (Bharti et al., 2025).

Mathematical models can be used to model polluted air dispersion from a source (Kafle et al., 2024). Dispersion models can estimate pollutant distribution in the atmosphere depending on emission source and atmospheric conditions (Upadhyay et al., 2025). These models are often used to forecast pollution concentrations at downwind receptor locations. Das (2025) noted these models are often used for managing the environmental impact of pollutant emissions. Air dispersion modeling is a popular approach for managing pollutant emissions and their environmental impact. The Models predict the dispersion of pollutants in the atmosphere and analyze their possible impacts on human health and the environment. Air dispersion models significantly influence policy and decision-making. Emission information assists policymakers in making educated decisions about environmental laws and regulations, such as limiting emissions and creating air quality standards. These models help identify regions for air quality control and evaluate the efficiency of various mitigation techniques. Although open waste burning is popular in low- and middle-income nations, there is a lack of systematic and modeling studies and evidence supporting this practice. (Ogunkunle et al., 2026). This work was limited to the Oyo state Government approved dump site located at Awotan dumpsite, along Akufo Road Apete in Ibadan. It involves the estimation of the emission inventory from 2018 to 2024, determination and forward trajectory modelling of the pollutants resulting from the combustion activities using AERMOD.

2 METHODOLOGY

This case study focused on pollutants dispersion (PM and SO₂) caused by open solid waste burning. The dispersion simulations of pollutants were conducted using the Industrial Source Complex Short Term Version 3 model, which is part of the United States Environmental Protection Agency (USEPA) Regulatory Model, AERMOD software. It was used to predict the change in ground-level air quality associated with the study area at communities within a defined radius of the location to the source of the pollutants. It can be used to model the impact of pollution sources on air quality in a variety of ways. It bases its functional organization on the pathway that makes up the run stream. These pathways include Control Pathway (CO), Source Pathway (SO), Receptor Pathway (RE), Meteorological Pathway (ME), Terrain Grid Pathway (TG), and Output Pathway (OU). This model has two pre-processors: AERMAP, which determines the elevation of the receptor grid and produces gridded terrain data, and AERMET, a meteorological data preprocessor that computes boundary layer meteorological parameters (such as wind speed, wind direction, temperature, and cloud cover) and prepares these data in a format readable by AERMOD (Popoola et al., 2023)

2.1 Description of the study Area

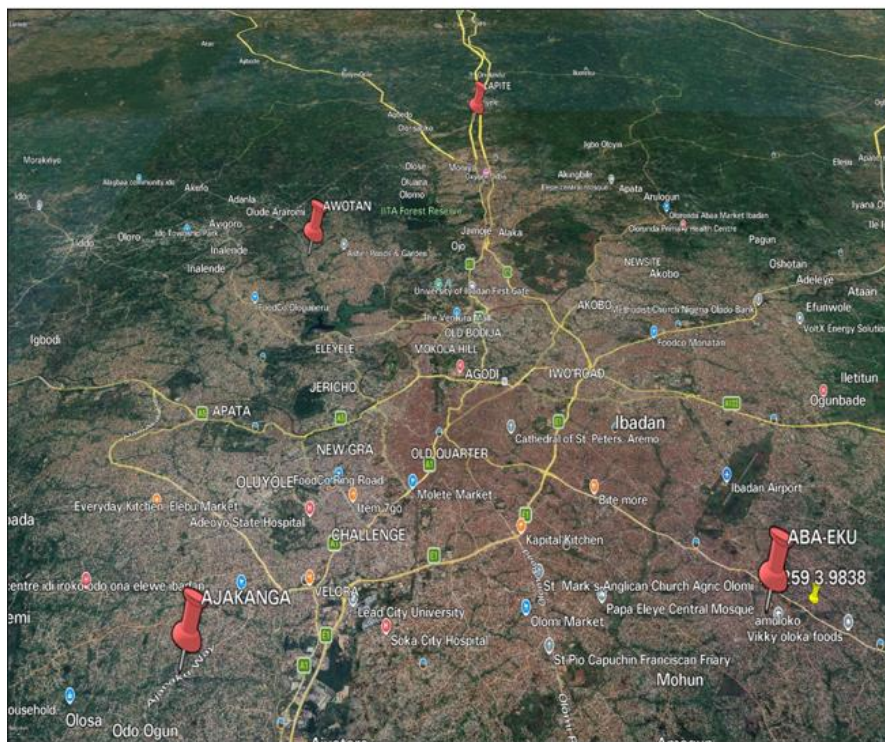


Figure 1: Map showing the study dumpsites (Source: Goggle Map, 2025)

The research site is a 5000-plot (390000 sqm) government approved disposal site with different burning points in Awotan Ibadan, Oyo State (Fig. 1 and 2), within latitude 7° 35N and longitude 3° 30E. The surrounding environment includes densely populated residential areas, agricultural lands, and commercial zones, with communities like Apete and Ojoo within 2–3 km of the sites, making them vulnerable to air pollution. Ibadan's topography, with its hilly terrain and variable wind patterns (averaging 2.3–2.5 m/s from the northeast) further complicates pollutant dispersion, a factor that was explored in the modelling. The city's proximity to the Ogunpa River and its tributaries raises concerns about leachate, though the focus of this research remained on air quality impacts. This study area, with its rich cultural heritage and growing environmental challenges, provided a compelling context for the analysis, and it was found that the complexity is both a hurdle and an opportunity to contribute meaningful insights to waste and air quality management in Nigeria.



Figure 2: Awotan dumpsite in Ido LGA (Source: Authors field work 2025)

2.2 Mission inventory estimation

The emission estimation techniques (EETs) were used in this work to calculate the amount of PM and SO₂ emissions resulting from the waste's open burning. The emission factor approach was used to calculate the amount of air pollutants released from the open burning of solid waste at the Awotan dumpsite in Ibadan, Nigeria. Using eqn (1,2 and 3)) reported by Orhoro and Omole. The open burning of solid waste was used to calculate the emission rates of air pollutants (PM and SO₂). The annual emissions for each pollutant were computed by multiplying the waste quantity of each type by its respective emission factor, then summing across types, and converting to tons. The amount of solid waste burned and the equivalent emission factors for each pollutant were used to estimate daily, weekly, monthly, and yearly emissions. Different forms of solid waste and combustion conditions may result in varying emission factors between countries. However, these emission factors for different air pollutants are taken as the same internationally, irrespective of the country.

The emission factor for PM and SO₂ emissions from municipal solid waste combustion was derived from the United States Environmental Protection Agency. According to the United States Environmental Protection Agency's (USEPA) AP-42 compilation of air pollutant emissions, the emission factors of PM and SO₂ for burning municipal solid waste are 8 kg Mg⁻¹ and 0.5 kg Mg⁻¹, respectively. Tailoring them to the local context with data from Odediran and Adewoyin (2018), who monitored emissions at Awotan. The factors were assigned based on waste type: for combustibles (plastics, paper, textiles, rubber), 0.44 kg/ton for SO₂ was used, 15 kg/ton for PM was used. It simply implies that for municipal solid waste combustion, the estimated amount of particulate matter emission is 15 kg Mg⁻¹ of the quantity of solid waste combusted. Also, to estimate the quantity of SO₂ emitted, an emission factor of 0.44 kg of SO₂/ton of the quantity of municipal solid waste combusted was considered.

Criteria air pollutant emitted in ton per year

$$E_{\text{pollutant}} = W_{\text{type}} \times EF_{\text{pollutant}} \quad (\text{i})$$

Total emissions were summed in Equation $E_{\text{Total}} = \sum(W_{\text{type}} \times EF_{\text{Pollutant}})$ (ii)

$$E_{\text{daily}} = \frac{E_{\text{Total}}}{365}, E_{\text{weekly}} = \frac{E_{\text{Total}}}{52}, E_{\text{monthly}} = \frac{E_{\text{Total}}}{12} \quad (\text{iii})$$

2.3 Dispersion modelling

According to Mohd and Siti (2024) the spatial dispersion was modeled with the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD). It employs two preprocessors (AERMET and AERMAP), which combine terrain and meteorological data to generate sufficient input data for AERMOD. Air quality modeling is a fundamental tool for determining the spatial distribution of overall pollutant concentrations. AERMOD was used to estimate the ground level concentrations of each identified CAP and to predict the change in ground level air quality within a 19 kilometer radius of the pollutant source. It bases its functional organization on the pathways that comprise the run stream file. The modelling procedure was as follows:

- A. The meteorological pathway. The atmospheric conditions of the modelled area were set to determine the distribution of air pollution consequences.
- B. The control pathway. The modeling scenario and run control, including pollutants and average periods, were specified.
- C. The source pathway. The source pathway is the sources of pollutant emissions being modeled and provides information on the number of emission sources and contaminants specified.
- D. Receptor pathway. This involves specifying receptors in specific locations to mitigate the influence on air quality.
- E. Terrain grid pathway. This section specifies the grid-based topography data for calculating dry depletion in elevated or complex terrain.
- F. Output pathway. The output results required for the air quality modeling analysis were determined. The output was the modeled ground-level concentration of pollutants. The receptor pathway was taken into consideration using a consistent Cartesian coordinate. The location's scaled map (length, width, and scale length of the map measured) was imported into the site domain, where the X and Y coordinates for the two points, the southwest (SW) point (min.) and the northwest (NW) point (max.) of the domain were used to specify the domain's size. The receptor locations acquired from the map, emission sources, emission rates and meteorological data were inputted into the source dialog box. Then, the dispersion model was run to obtain the ground level concentration of emission on the host environments in 1h, 8h, 24h and annual averaging time.

3 RESULTS AND DISCUSSION

The results obtained in this research include determination of solid waste generated, estimation of emission inventory between 2018-2024 and modelling of the air pollutants using AERMOD

3.1 Emission inventory estimation

The emission inventory of the PM and SO₂ emissions due to open burning of waste from 2018–2024 is presented in this section. According to Odediran and Adewoyin (2018) the emission factors of PM and SO₂ for municipal solid waste combustion were given to be 15 kg Mg⁻¹ and 0.44 kg Mg⁻¹ respectively. The daily/weekly/ monthly/annual emissions were estimated based on the amount of solid waste burnt and equivalent emission factors for PM and SO₂.

Table 1 shows the PM and SO₂ pollutants emitted between 2018 and 2024. In 2018, the daily PM and SO₂ emitted were calculated to be 7.00 tons and 0.18 tons respectively. The weekly values were 49.11 tons and 1.27 tons respectively. The monthly values were 212.83 tons and 5.51 tons respectively. The yearly values were calculated to be 2553.91 tons and 66.10 tons respectively. In 2019, the daily PM and SO₂ emitted were calculated to be 7.14 tons and 0.18 tons, respectively. The weekly values were 50.15 tons and 1.30 tons respectively. The monthly values were 277.332 tons and 5.62 tons respectively. The yearly values were calculated to be 2607.79 and 67.46 respectively. In 2020, the daily PM and SO₂ emitted were calculated to be 12.77 tons and 0.33 tons, respectively. The weekly values were 89.97 tons and 2.32 tons, respectively. The monthly values were 388.59 tons and 10.06 tons, respectively. The yearly values were calculated to be 4663.03 tons and 120.69 tons, respectively. In 2021, the daily PM and SO₂ emitted were calculated to be 13.01 and 0.34 tons, respectively. The weekly values were 91.37 tons and 2.36 tons respectively. The monthly values were 395.95 tons and 10.25 tons respectively. The yearly values were calculated to be 4751.43 tons and 122.99 tons, respectively. In 2022, the daily PM and SO₂ emitted were calculated to be 13.26 tons and 0.34 tons, respectively. The weekly values were 93.10 tons and 2.41 tons, respectively. The monthly values were 403.44 tons and 10.44 tons,

respectively. The yearly values were calculated to be 4841.31 tons and 125.30, respectively. In 2023, the daily PM and SO₂ emitted were calculated to be 13.56 tons and 0.35 tons, respectively. The weekly values were 94.87 tons and 2.45 tons, respectively. The monthly values were 411.09 tons and 10.64 tons, respectively. The yearly values were calculated to be 4933.09 tons and 127.68, respectively. In 2024, the daily PM and SO₂ emitted were calculated to be 20.99 tons and 0.54 tons, respectively. The weekly values were 147.19 tons and 3.81 tons, respectively. The monthly values were 637.84 tons and 16.51 tons, respectively. The yearly values were calculated to be 7654.10 tons and 198.11, respectively. in Table 1. Likewise, the result revealed that the emission of PM, which is the third highest of all the criteria air pollutants results from the combustion of solid waste. There is an increase in the PM emission from 2018 to 2024 due to the increase in the generation of solid waste. From 2018 to 2024, PM increases from 7.0 to 20.97 tons per day, from 49.1 to 147.19 tons per week, from 212.83 to 637.84 tons per month and 2553.91 to 7654.10 tons per year. Wheezing, aggravation of asthma, shortness of breath, coughing and chest pain are some of the short-term effects of particulate matter inhalation. Long-term exposure to particulate matter can result in heart failure, respiratory disease and lung cancer. Children, the aged, and people with pre-existing respiratory conditions are mostly vulnerable to PM health impacts. Furthermore, pregnant mothers and their babies are at serious risk for mortality and health problems because of PM exposure. The emission of PM from the combustion of solid waste must be attenuated. Table 1 also shows that the emission of SO₂, which is the fourth highest of all the criteria air pollutants resulting from the combustion of solid waste. There is an increase in the SO₂ emission from 2018 to 2024 due to the increase in the generation of solid waste. From 2018 to 2024, SO₂ increase from 0.18 to 0.35 tons per day, from 1.30 to 2.45 tons per week, from 5.62 to 10.64 tons per month and 122.99 to 127.68 tons per year. Long-term exposure to SO₂ can result in respiratory disease, eye irritation and lung cancer. Children, the aged, and people with pre-existing respiratory conditions are mostly vulnerable to SO₂ health impacts.

Table 1: The PM and SO₂ pollutants emitted between 2018 and 2024

	2018		2019		2020		2021		2022		2023		2024	
	PM ₁₀ (t)	SO ₂ (t)	PM ₁₀ (t)	SO ₂ (t)	PM ₁₀ (t)	SO ₂ (t)	PM ₁₀ (t)	SO ₂ (t)	PM ₁₀ (t)	SO ₂ (t)	PM ₁₀ (t)	SO ₂ (t)	PM ₁₀ (t)	SO ₂ (t)
Daily	7.00	0.18	7.14	0.18	12.77	0.33	13.01	0.34	13.26	0.34	13.51	0.35	20.97	0.54
Weekly	49.11	1.27	50.15	1.30	89.67	2.32	91.37	2.36	93.10	2.41	94.87	2.45	147.19	3.81
Monthly	212.83	5.51	217.32	5.62	388.59	10.06	395.95	10.25	403.44	10.44	411.09	10.64	637.84	16.51
Yearly	2553.91	66.10	2607.79	67.46	4663.03	120.69	4751.43	122.99	4841.31	125.30	4933.09	127.68	7654.10	198.11

3.2 Dispersion modelling study

This section presents the results of the ISC-AERMORD modeling of ground level concentrations for PM and SO₂ emissions during the study. The available averaging period standards for the simulated air pollutants serve as a guide for these. The impact of open solid waste burning on air quality are also discussed. The emission sources acquired in the investigation were estimated in table 2 to the appropriate unit before being entered into the dispersion protocol.

3.2.1 The receptor locations

The communities identified and considered receptors to air pollutants by open burning of solid waste on the dumpsites include Mokola Hill, Bodija, Old Quarter, Ibadan Airport, Erumu, Jericho, Moniya, Ojoo, Apata Eleyele, Ajia, and Oluwo, all of which were found to be within the designated kilometer locations shown in figure 1.

3.2.2 Predicted ground level concentration of CAPs

This section presents the ground level concentrations for all CAPs modeled during the study.

3.2.2.1 PM emissions around the receptor locations

The 1h predicted concentrations of particulate matter have values in the range 2685–268475µgm–3. As shown Fig.3. The 8h predicted concentrations are in the range 451–45065µgm–3 as shown in Fig. 4. The 24h predicted concentrations have values in the range 152–15155µgm–3 as shown in Fig.5. Fig.6 depicts the annual predicted concentrations, which range from 6 to 614µgm–3. The maximum concentrations of particulate matter in the 1h, 8h, 24h and annual averaging periods are 268475µgm–3, 45065µgm–3, 15155µgm–3 and 614µgm–3 respectively.

3.2.2.2 SO₂ emissions around the receptor locations

The 1h predicted concentrations of SO₂ have values in the range 69–6049µgm–3 as shown in Fig. 7. The 8h predicted concentrations are in the range 12–1166µgm–3 as shown in Fig.8. The 24h predicted concentrations have values in the

range $4\text{--}392\mu\text{g}/\text{m}^3$ as shown in Fig. 9. The annual predicted concentrations have values in the range $0.2\text{--}15.9\mu\text{g}/\text{m}^3$ as shown in Fig.10. The maximum concentrations of SO_2 in the 1h, 8h, 24h and annual averaging period are $6049\mu\text{g}/\text{m}^3$ – $1166\mu\text{g}/\text{m}^3$ – $392\mu\text{g}/\text{m}^3$ and $15.9\mu\text{g}/\text{m}^3$, respectively.

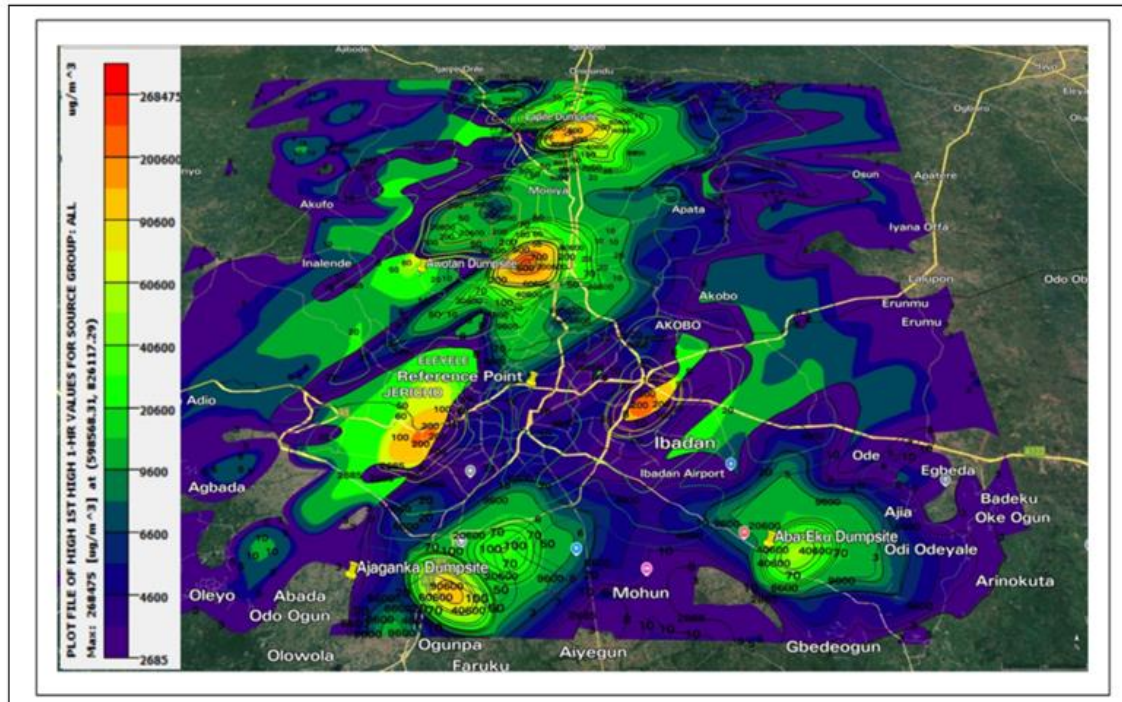


Figure 3: Hour ground level PM isopleth for the Awotan dump sites

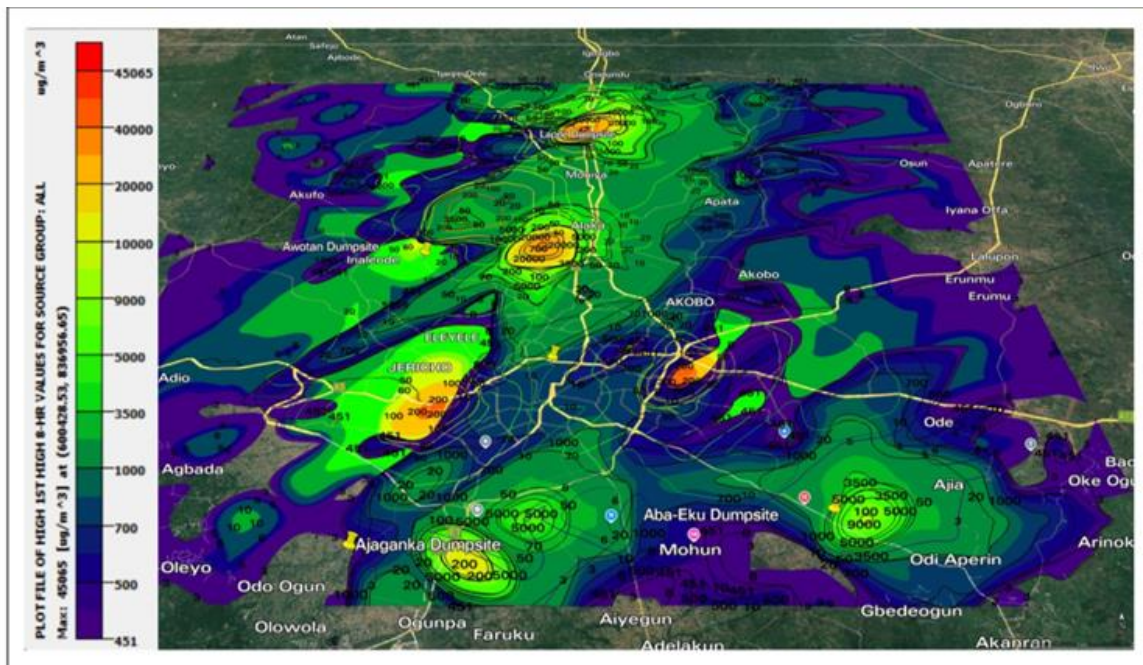


Figure 4: 8 Hour ground level PM isopleth for the Awotan dump sites

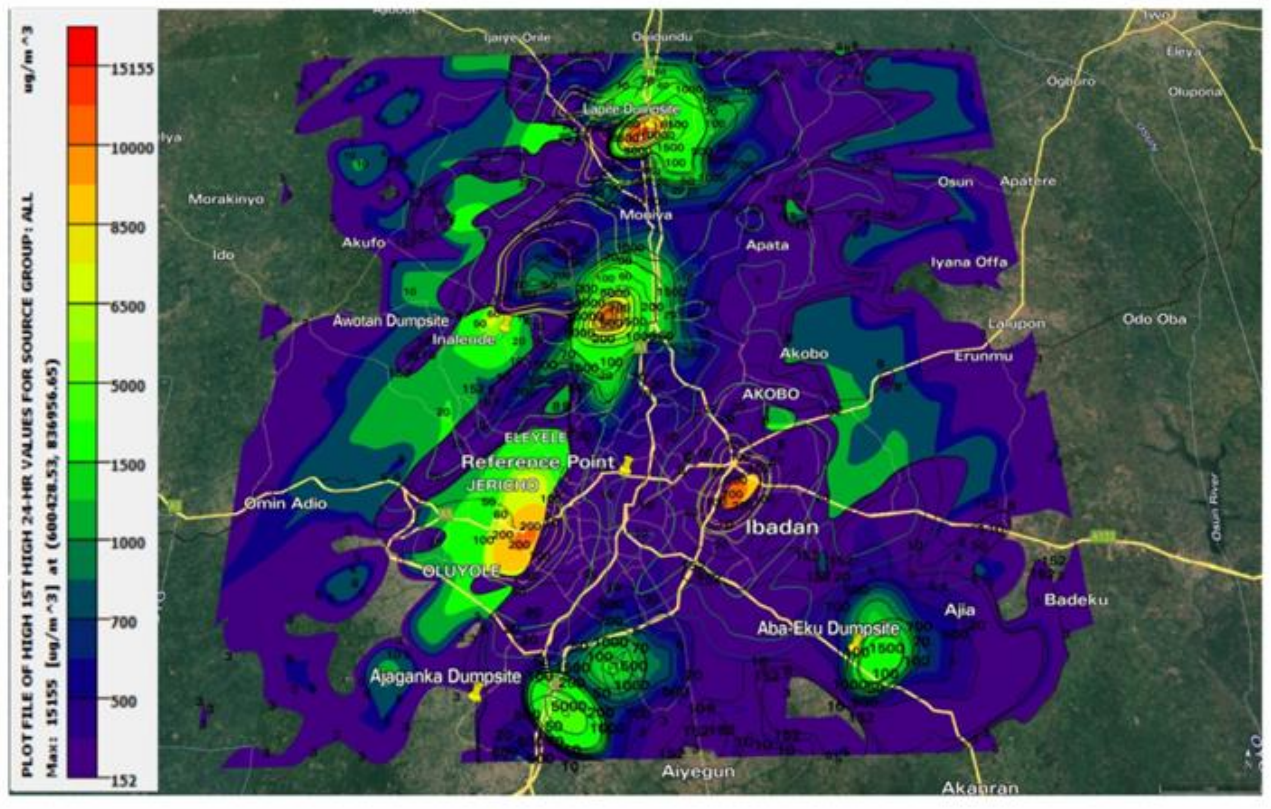


Figure 5: 24 Hour ground level PM isopleth for the Awotan dump sites

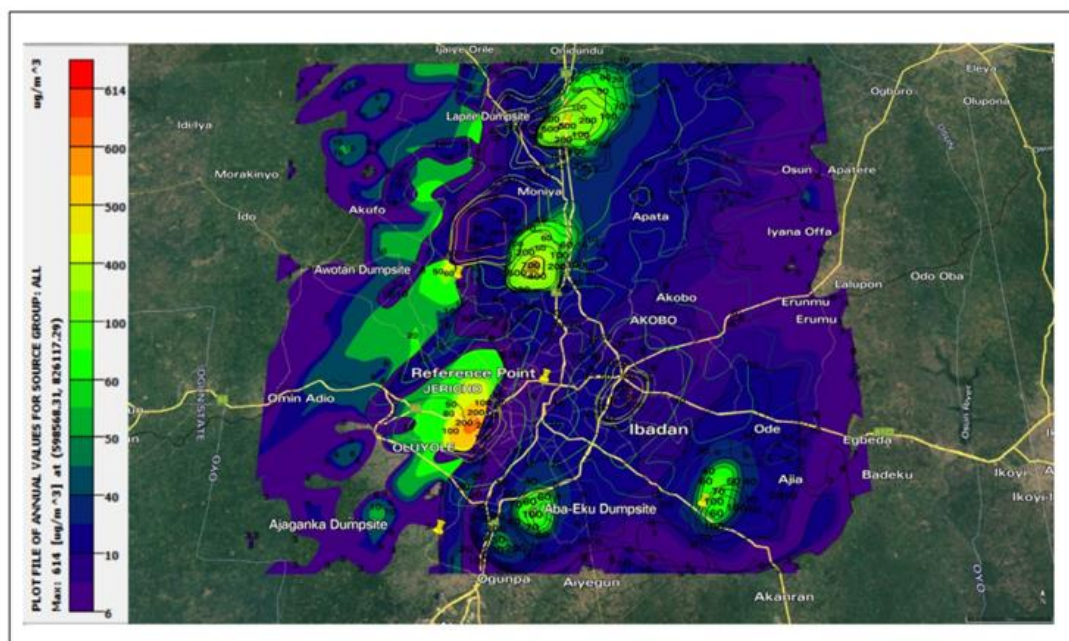


Figure 6: Annual ground level PM isopleth for Awotan dump site

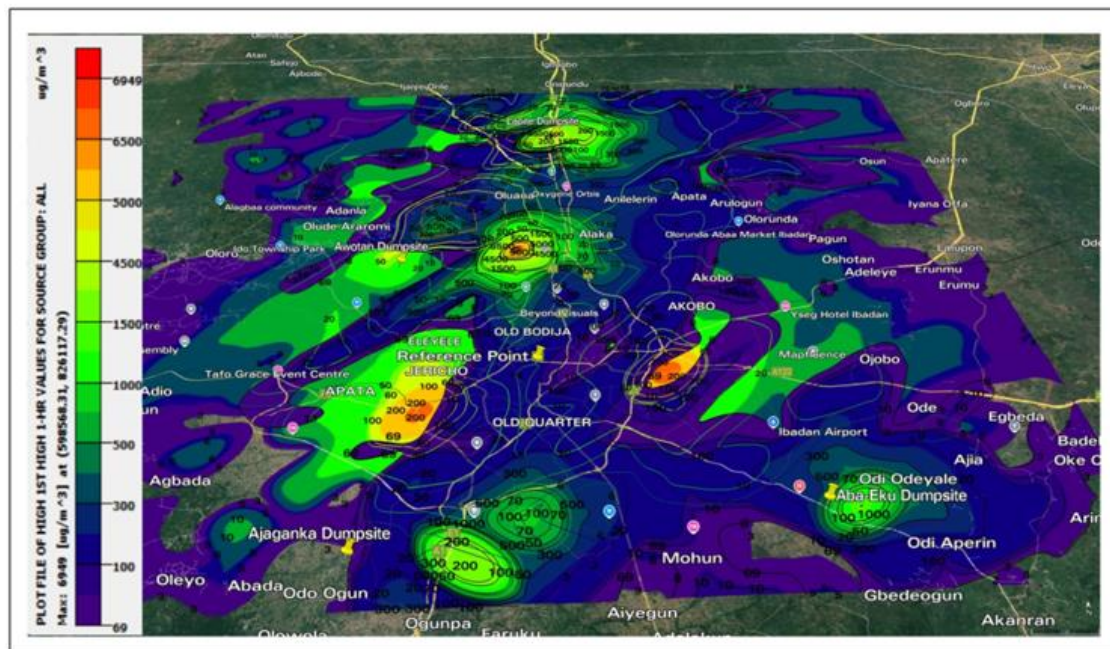


Figure 7: 1hour ground level SO₂ isopleth for Awotan dump site

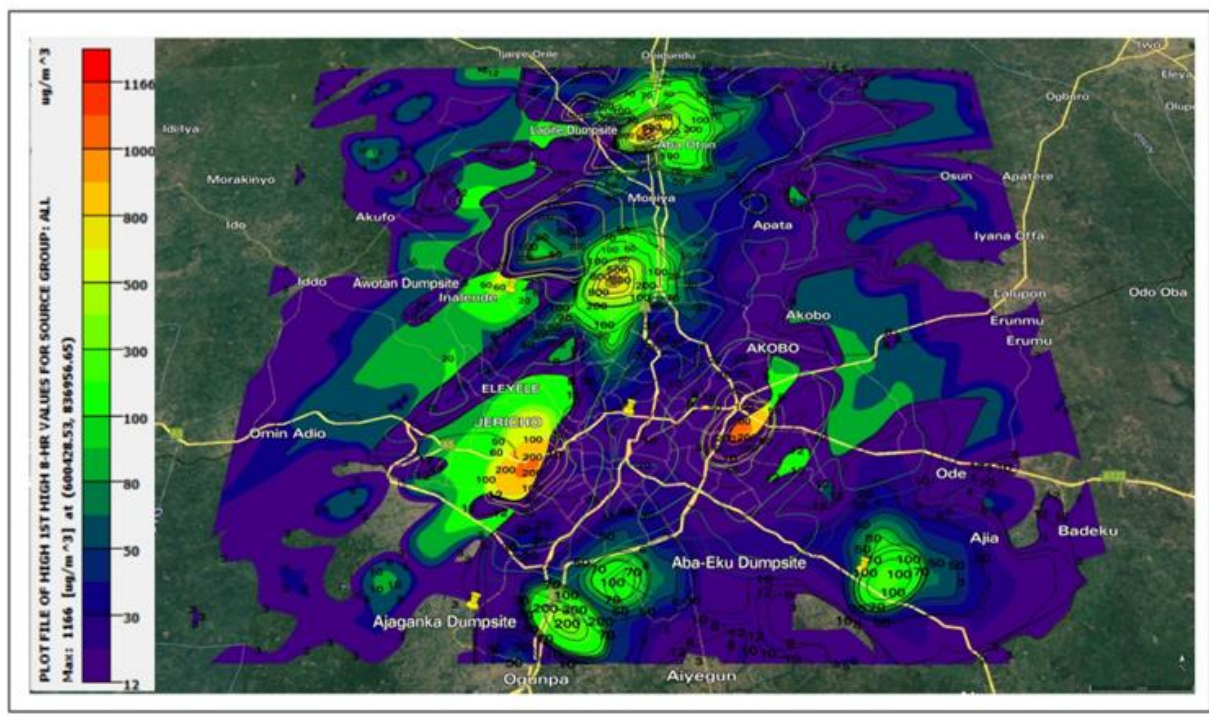


Figure 8: 8hour ground level SO₂ isopleth for Awotan dump site

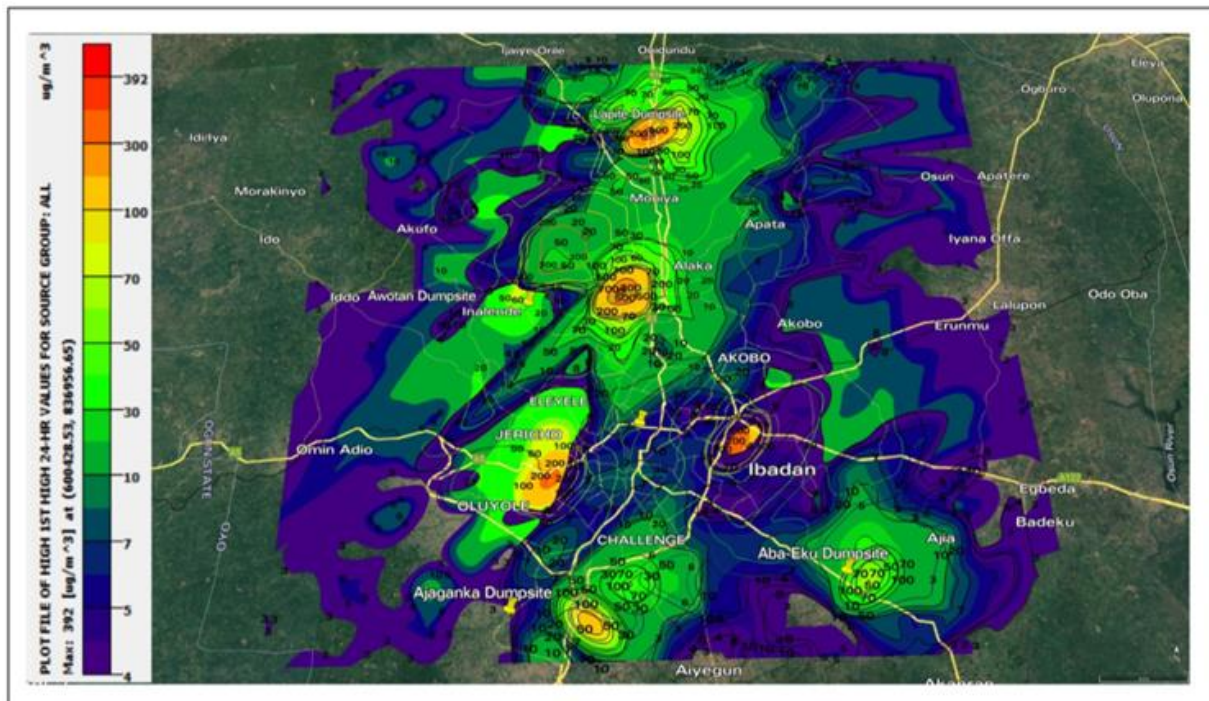


Figure 9: 24hour ground level SO₂ isopleth for Awotan dump site

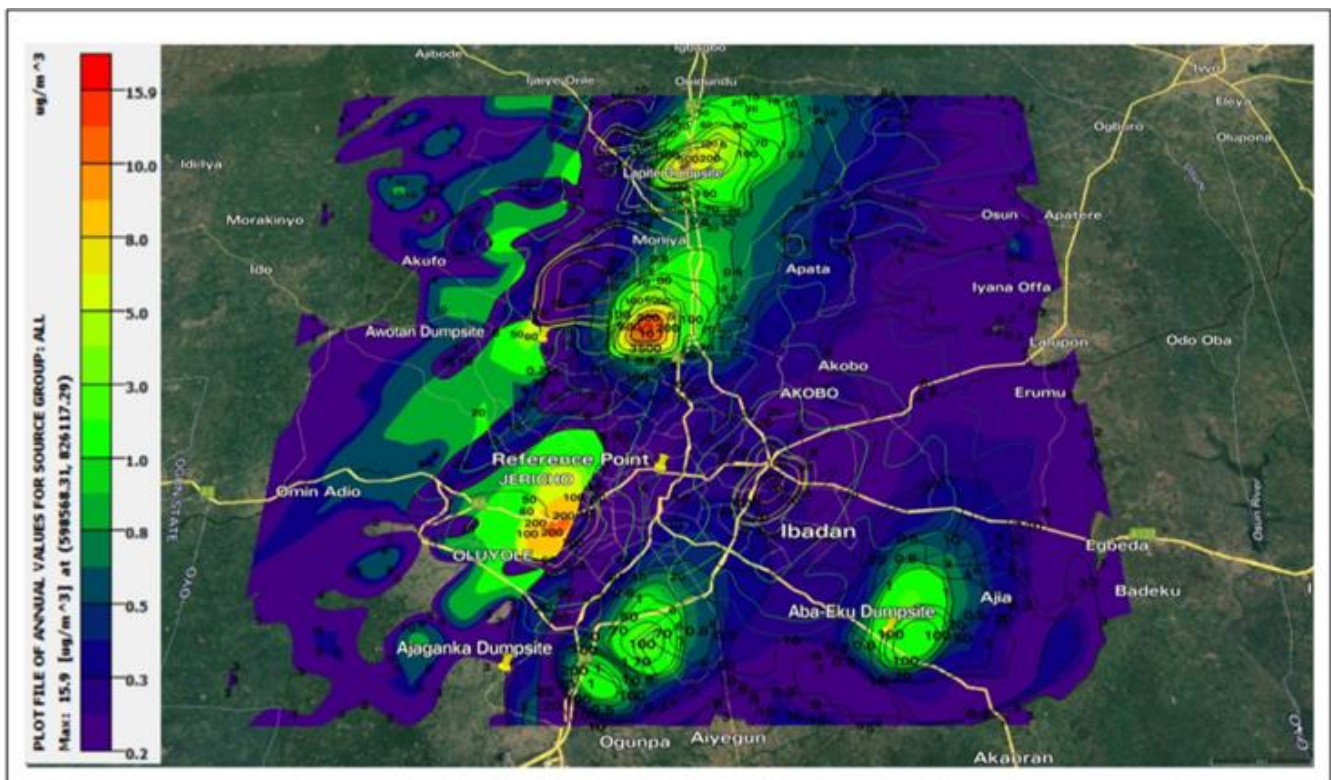


Figure 10: Annual ground level SO₂ isopleth for Awotan dump site

3.3 Impacts of modelled CAPs on air quality

The impacts of each CAP on the air quality of the host environment are herein presented. PM affect the air quality more, due to their higher predicted concentrations as contained in Tables 2 and 3.

3.3.1 Impact of PM₁₀ emission on ambient air quality in 2018.

The effects of ground-level PM₁₀ emissions on the host environment's ambient air quality were studied using the most stringent FMEnV and WHO /WB limits of 150µg m⁻³ for a 24hour averaging period. The predicted concentration of PM₁₀ was higher than the standard (Table 2) in the receptor communities (Jericho, Challenge and Aba Eku) where 101, 101 and 101 were predicted respectively. Also, 60µg m⁻³ (Annual averaging period) the predicted concentrations were above the standard for Bodija, Eleyele and Old Quarter with 10.2, 10.2 and 10.2 fold respectively, Similarly, using WHO/WB standards, 50µg m⁻³ (24h averaging period) the predicted ground level concentrations were above the standard with 303, 303 and 303 at Jericho, Challenge and Aba Eku respectively, Also, for 20µg m⁻³ (Annual averaging period) the predicted concentrations were above the standard for Bodija, Eleyele and Old Quarter with 30.7, 30.7 and 30.7 respectively.

3.3.2 Impact of SO₂ emission on ambient air quality in 2018.

The effects of ground-level SO₂ emissions on the host environment's ambient air quality were studied using the most stringent FMEnV and WHO /WB limits. For 100µg m⁻³(24h averaging period) FMEnV standard, the predicted ground level concentrations for all the identified Three receptors were below the limits with 0.2, 0.2 and 0.2 fold predicted respectively for Jericho, Challenge and Bodija. Also, 60µg m⁻³ (Annual averaging period) the predicted concentrations were above the standard for Bodija, Eleyele and Old Quarter with 18.3, 18.3 and 18.3 fold respectively, Similarly, using WHO/WB standards, 125µg m⁻³ (24h averaging period) the predicted ground level concentrations were below the standard (Table 3) with 0.1, 0.1 and 0.1 at Jericho, Challenge and Aba Eku respectively, Also, for 500µg m⁻³ (Annual averaging period) the predicted concentrations were above the standard for Bodija, Eleyele and Old Quarter with 13.9, 13.9 and 13.9 respectively.

Table 2: Predicted PM₁₀ cumulative impacts around the dumpsite

Receptor Location	Predicted Concentration (µg m ⁻³)				% Recommended Limit in FMEnV		% Recommended Limit in WHO/World Bank	
	1 h	8 h	24 h	Annual	24 h (150 µg m ⁻³)	Annual (60 µg m ⁻³)	24 h (50 µg m ⁻³)	Annual (20 µg m ⁻³)
Akobo	268,475	–	–	–	–	–	–	–
Jericho	268,475	–	15,155	–	101	–	303	–
Challenge	268,475	–	15,155	–	101	–	303	–
Moniya	–	45,065	–	–	–	–	–	–
Apata	–	45,065	–	–	–	–	–	–
Akinyele	–	–	–	–	–	–	–	–
Aba Eku	–	45,065	–	–	–	–	–	–
Bodija	–	–	15,155	614	101	10.2	303	30.7
Eleyele	–	–	–	614	–	10.2	–	30.7
Old Quarter	–	–	–	614	–	10.2	–	30.7

Table 3: Predicted SO₂ cumulative impacts around the dumpsite

Receptor Location	Predicted Concentration (µg m ⁻³)				% Recommended Limit in FMEnV		% Recommended Limit in WHO/World Bank	
	1 h	8 h	24 h	Annual	24 h (100 µg m ⁻³)	Annual (60 µg m ⁻³)	24 h (125 µg m ⁻³)	1 h (500 µg m ⁻³)
Akobo	6,949	–	–	–	–	–	–	13.9
Jericho	6,949	–	15.9	–	0.2	–	0.1	13.9
Challenge	6,949	–	15.9	–	0.2	–	0.1	13.9
Moniya	–	392	–	–	–	–	–	–
Apata	–	392	–	–	–	–	–	–
Akinyele	–	392	–	–	–	–	–	–
Aba Eku	–	–	–	–	–	–	–	–
Bodija	–	–	15.9	1,100	0.2	18.3	0.1	–
Eleyele	–	–	–	1,100	–	18.3	–	–
Old Quarter	–	–	–	1,100	–	18.3	–	–

4 CONCLUSION

The emissions from the open burning of solid waste at the Awotan dumpsite were studied, and the ground level concentrations of criteria air pollutants were evaluated using AERMOD. The study's findings led to the following conclusions.

The emission inventory for PM and SO₂ was in the range 2553.91–7654.10 and 66.10–198.11 tons per annum between 2018 and 2024, respectively.

The daily quality of air was within the Federal Ministry of Environment's (FMEnV), World Health Organization (WHO) and World Bank (WB) guidelines. Nevertheless, the 24 hour, and annual PM air quality for all receptor communities exceeded the FMEnV and World Bank standards.

The 24 hour SO₂ air quality for Jericho, Challenge and Bodija are below the standard while 1 hour and annual SO₂ for Bodija, eleyele, Old Quarter and Akobo are above the standard.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

Statement of informed consent

The author understands the purpose of this research and participates at every aspect of this work. The author also received consent from the Oyo State waste management authority before executing this research.

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