Modeling impacts of industrial park activity on air quality of surrounding area for identifying isolation distance: A case of Tan Tao Industrial Park, Ho Chi Minh City, Viet Nam

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Abstract. Industrial factories have been addressed as the main contributor to the amount of air pollution in many urban areas around the world. The emissions of air pollutants from factories, combined with exhausted gases from automobile and domestic cooking activities, have placed enormous adverse effects on human health. Recently, air quality models, which usually figure out for industrial emission with representative indicators such as CO, NO\textsubscript{2}, SO\textsubscript{2}, and TSP, have triggered an application to identify a suitable isolation distance that could lessen affection on public health. Concerning to develop an air emission inventory for Tan Tao Industrial Park (IP) for three sources of points, line and area sources by using top-down and bottom-up approaches, this study aim to: (i) apply a system model of TAPM – AERMOD model to study the air pollution dispersion from the IP to the surrounding area, and (ii) identify a hygiene isolation distance for sensitive objects around industrial park, especially zones of community, based on their separating demand from contamination. Results show that the point sources are the dominant air emission sources of Tan Tao IP. Total emissions of Tan Tao IP in 2019 estimated at 413.15 tons of TSP/year, 280.9 tons of NO\textsubscript{2}/year, 621.99 tons of SO\textsubscript{2}/year, and 2720.21 tons of CO/year. Modeling results show that 1-hour maximum concentration of TSP, NO\textsubscript{2}, SO\textsubscript{2}, and CO in the simulation area is 581µg/m\textsuperscript{3}, 4.069µg/m\textsuperscript{3}, 5.478µg/m\textsuperscript{3}, 40.695µg/m\textsuperscript{3}, respectively, exceeding the standards. Especially, the pollution levels of NO\textsubscript{2} were 20 times higher than the limit value, similar trends for SO\textsubscript{2} (15 times higher). The hygiene isolation distance was suggested a widely ranged from 2910 meters in the North-West and in the rest directions of Ho Chi Minh City. Some sensitive objects such as residential areas, hospitals and kindergartens recently are inside the affected zone should be reckoned to have suitable solutions that keep their health safe. The method for calculation of hygiene isolation distances from industrial activities has a significant guiding not only for environmental safety action but also for public health protection.

Keywords: Tan Tao Industry park; Atmospheric pollution; Isolation distance; TAPM-AERMOD model; Ho Chi Minh City.
1. Introduction

Industrialization is one of the reasons that worse the quality of life, in the meaning of the air [1]. The air pollutants, releasing into the air from factories, combined with those added by automobiles on the road and cooking activities for workers. So that, demand for distances and additional technical measures should be implemented so as to diminish the risk to people [2]. The air pollution will impact public health such as increasing risk of developing the chronic respiratory disease, lung cancer, heart disease, and many other illnesses, diseases [34]. Whilst a deterministic approach for fixing appropriate distances is done probabilistically or at least using probabilistic elements in some developed countries [2], it just might be pursued in the developing countries.

Ho Chi Minh (HCMC) is the largest commercial industrial city in Viet Nam. Currently, HCMC concentrates 19 industrial zones and numerous small manufactures that could release amount of pollutants affecting on the residential area inside, as simulating results show that the concentration of some classic ambient air (CO, NO2, O3 and SO2) exceeds exposure limits according to national regulation [3]. The running growth of industrialization and the emission scenarios in 2030 represent some drawbacks of implementing the separation distances between industrial activities and residential areas, which base on polluting isolation and health protection demand. These are the lack for regarding on appropriate isolation distances in the planning period and the deficiency of adequate basis on the decision. This boosts the ideas to research finding a technique which could calculate approximately hygiene distances between industrial activities and sensitive objects surrounding. The hygiene distance is an aid that minimizes the impacts of polluting emissions from locating industry to sensitive land uses.

According to the above approaching, there are guidelines to determine the isolation distances applying to stakeholders who are interested in industry development in some countries such as Australia, Germany, Europeans, Malaysia, Singapore and South Africa [4 - 10]. Regarding industrialization, there are three standards to setting up the separation distances depending on the planning policies, and general damaging phenomena in the process plant. In detail, these are distances for an explosion, fire, or release of toxic materials (1); transportation needs (2), and isolated pollution respectively (3) [11]. While determining separation distances in the response of the standard (1) and (2) is applying in European countries, Malaysia and South Africa [4, 5, 8, 10 - 11], the standard (3) have been related by Singapore and Australia [6, 9, 12]. Viet Nam also established the regulation of isolation distance, following the first and second standard, for industrial process in the item of National technical regulation on construction planning (QCVN 01:2009/BXD) [13] and the Decision 3733/2002/QĐ-BYT promulgating 21 Occupational Hygiene Standards, 05 Principles and 07 Occupational Hygiene Measurements [14]. However, these regulations do not be practiced effectively by industrial investors, typically in Ho Chi Minh City (HCMC). Tan Tao IP, being one of the large industrial zones in HCMC, is near the residential areas and consists of different types of processes like electricity and mechanic (18.4%), plastic (15.8%) and textile and garment (14.8%) [15]. There are many sensitive objects surrounding such as hospitals.
residential zones, kindergarten and small house might be affected by emission from exhaled sources in IP. This gap provokes a study to find an appropriate distance that could protect sensitive land uses from pollution, which could be supported by model dispersion [11, 16, 17]. The study is aimed to simulate of represented industrial pollutants (NO\(_2\), SO\(_2\), CO and total suspended particular) that are emitted from Tan Tao IP by EMISEN-TAMP-AERMOD system model. The simulating results were used to develop the isolation distances for sensitive land uses surrounding.

2. Materials and Methods

The framework of the study was followed by the Figure 1, including survey steps for collecting data to emission calculation and pollutants dispersion modeling, preparing for determining a suitable distances in the local scope.

![Figure 1. Research diagram](image)

- **Survey, data collection**
- **Process data and analysis**
- **Emission calculation**
- **TAPM-AERMOD model**
- **Model Calibration and Validation**
- **Propose of hygiene isolation distances**

2.1. Data collecting for emission calculation:

Data was collected from three central agencies namely Ho Chi Minh Export Processing Zone and Industrial Park Authority (HEPZA), Tan Tao Investment and Industry Corporation (ITACO), and enterprises of Tan Tao Industrial Park. There are four data collection methods applying on research survey, in details:

i. **Historical method** was used to collect the information on situation of Tan Tao IP, the number of active enterprises, and the distribution of production facilities. All suitable documents were recorded from HEPZA and ITACO.

ii. **Questionnaire method** was applied to get the information about operation process, being supported to the emission calculation process, which includes the source of emissions, the exhaust treatment systems, emission distributions, the amount of raw materials, and the way that fuels were used. These data was collated by survey fulfillments questionnaires at 196 enterprises in Tan Tao IP.

iii. **Observation method** was settled by counting and classifying the types vehicles transmit on 13 main roads representative in the Tan Tao IP. The vehicle type, number of vehicles in circulation, and distance traveled by vehicles supported to the air emissions calculation step.

iv. **Experiment method** was addressed to monitor the ambient air parameters, including TSP, NO\(_2\), SO\(_2\), and CO at four locations in the North, South, West, and East direction of the industrial part. All samples were taken at the same time for later model calibration and validation steps.
2.2. Methodology

To calculate emission for the activities of Tan Tao IP, the research used the emission calculation method based on the emission factor. This method is suitable for Vietnamese conditions [18]. Emission factors for industrial activities in Vietnam are almost nonexistent and not standard. Therefore, the research team applied the emission factor proposed by MONRE in combination with the US EPA AP42 [19] emission factor dataset. Emission calculation formula for production activities in Tan Tao IP is as follows:

$$E = AR \times EF \times \left(\frac{100-ER}{100}\right) \quad (1)$$

Where: $E$: emission rate (kilograms/year); $AR$: operating capacity of the emission source (tons/year) $EF$: emission factor (kilograms/ton); $ER$: emission reduction efficiency (%).

2.2.1. EMISENS Model

EMISENS model is used to emission calculate loads due to traffic activities, developed in 2006 – 2010 at the Laboratory of Air and Soil Pollution (LPAS), Lausanne Federal Polytechnic University (EPFL), Switzerland [20]. The theory of EMISENS bases on emissions calculating methods of CORINAIR (European Environment Agency). EMISENS helps users to shorten the calculation time and calculate the errors through the Monte Carlo simulation technique [21]. The input data of the EMISENS model requires: the number of each type of vehicle, the length of each kind of road, the traffic volume of each type of vehicle corresponding to each type of road, the emission factor calculated according to the vehicle system in circulation, etc. Emissions calculation for traffic activities according to the EMISENS model is classified into three types of emissions: hot emissions, $E_{\text{hot}}$; cold emissions, $E_{\text{cold}}$; evaporation emissions, $E_{\text{Evap}}$ as follows:

$$E_{\text{Total}} = E_{\text{Cold}} + E_{\text{Hot}} + E_{\text{Evap}} \quad (2)$$

Where: $E_{\text{hot}}$: hot emissions; $E_{\text{cold}}$: cold emissions; $E_{\text{Evap}}$: evaporation emissions; $E_{\text{Total}}$: Total emission. Each type of emission follows a general formula in EMISENS model, which is:

$$E_{ip;ie} = e_{ip;ie} \times A_{ie} \quad (3)$$

Where: $E$: total emission; $ip$: type of pollutant; $ie$: range of vehicle; $e$: emission factor; $A$: traffic activities.

2.2.2. TAPM Model

The TAPM Model is developed by the Commonwealth Scientific and Industrial Research Organization of Australia (CSIRO). This model is used to simulate meteorological conditions and air pollution concentrations in the 3D space environment. This principle function is suitable for supporting meteorological simulation for Tan Tao Industrial Park, where the input data of the model could downscale from the global observed meteorological data, have implemented the detailed meteorological simulations for the whole year 2019. The output meteorological data is the input file for the AERMOD model [22].
2.2.3. AERMOD Model

The AMS/EPA Regulatory Model (AERMOD Model) is designed to support the management program of the United States Environmental Protection Agency (US-EPA). The model consists of 3 parts: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD Terrain Tool), and AERMET (AERMOD Meteorological Instrument). Since 1991, The AERMOD model was firstly known in 1991 and officially used on December 9, 2005 after 14 years of research and perfection. AERMOD is the commercial software that uses Gaussian theory to calculate the dispersion of pollutants and is a suitable tool to simulate the dispersion of pollutant concentrations such as TSP, NO$_2$, SO$_2$, CO in the atmosphere due to industrial emission activities. Input data, steps, and content to implement the AERMOD model are shown in the following diagram (Figure 2). The meteorological file includes two types: (i) surface meteorological data (*.sam). This file must be the observed data recorded per hour, represented by wind direction, wind speed, air temperature gas, humidity, barometric pressure, precipitation, cloud cover, solar radiation; and (ii) spatial meteorological data (*.ua). This information consists of data, monitoring twice a day at 0 GMT (7:00 LST) and 12 GMT (19:00 LST), and altitude disturbance data. AERMOD would produce simulation results in the form of two-dimensional or three-dimensional images when all data was ready. The grid domain was set 40 km by 40 km with 81 cells x 81 cells, and the grid resolution was 0.5 km x 0.5 km, covering the study areas with Tan Tao IP is in the middle of the simulated topographic map for study area (Figure 2). The output of AERMOD can be imaged on Google Earth platform, making it easily see the impacts of emissions on the survey area [23].

![Figure 2. The simulated topographic map](image.png)

2.2.4. Model calibration and validation
Meteorological data used to calibrate the model were collected from Da Phuoc meteorological station for 2019. The meteorological data input to the TAPM model is downloaded at the same time from the CSIRO website, which is the global meteorological observation provided by the Australian Meteorological Agency for the world. When TAMP model had been calibrated, it would be run for the area by the AERMOD model. The output of the AERMOD model would be validated by relative error coefficients (MAGE, and R²) [24],[25] with the relating data of the actual monitoring results at the point (X=674623.69; Y=1187253.90). This is signed by the crossroad of Street No 2 and Street D10 inside IP.

The simulating and adjusting parameters will be calibrated by comparing to monitoring results based on the correlation coefficient and the relative error of the model. The correlation coefficient R² (4) and the relative error of the model MNBE (5) will be calculated using the equations as following and must be meet the standard requirement in Table 1 to strengthen the reliability of dispersion results [19].

**Correlation coefficient:**

\[ R = \frac{\sum (P_i - \bar{P}) (O_i - \bar{O})}{\sqrt{\sum (P_i - \bar{P})^2 \sum (O_i - \bar{O})^2}} \]  

Where: Pi: Simulation data, Oi: Monitoring data, N (n) quantity of data.

**Mean Normalized Bias Error (MNBE):**

\[ MNBE = \frac{1}{N} \sum_{i=1}^{N} \left( \frac{C_{mod}(x_{i,t}) - C_{obs}(x_{i,t})}{C_{obs}(x_{i,t})} \right) \times 100 \]  

Where:

- \( C_{mod}(x_{i,t}) \): modeling value at site i, time t
- \( C_{obs}(x_{i,t}) \): observed value at site i, time t

**Table 1. Standard of evaluation indicator**

| Indicator | Standard |
|-----------|----------|
| Correlation coefficient(R²) | ≥ 0.7 |
| Mean Normalized Bias Error (MNBE) | ± 15% |

### 2.3. Steps to determine sanitary buffer/isolation zone

Step 1: Identify sensitive objects around the IP and permissible standards/regulations for concentration of pollutants.

Step 2: After validating the dispersion results of the AERMOD model, the AERMOD model was simulated for 8760 hours/year of 2019. The polluted area was determined based on the air pollution dispersion map of NO₂, SO₂, CO and TSP that exceeds the permissible guideline for ambient air quality. The isolation distance was determined for Tan Tao IP based on Vietnam’s technical regulation for ambient air quality limits and the influence of local meteorological parameters. In this study, the allowed threshold guideline for ambient air quality is the National technical regulation in ambient air quality (QCVN 05:2013/BTNMT). The hygiene isolation distance is limited from the border point of the industrial zone boundary to the point, where the polluted area exceeds the QCVN 05:2013/BTNMT determined from the simulation results.

### 3. Results
Tan Tao IP has two main parks with 232 enterprises that release air emission into the atmosphere. The pointed sources are related to the using of DO oil with total a total consumption volume of above 7 million liters per year. There are 63/196 enterprises with exhaust gas treatment systems at the time of survey and the most commonly technology is the absorption tower. There are also 13 main roads, being inside The Tan Tao IP, are road sources emissions from transportation activities.

3.1. Air emission inventory

Air emissions for point source and area source, according to the formula (1) were calculated by excel tool, and emissions for traffic activities (road source) in the IP were estimated by the EMISEN model. The results show that point sources, being the chimneys, are the main emission source of Tan Tao IP. The emission of each air pollutant from three emission sources is obtained in Table 2. These results are the input data for the AERMOD air pollution dispersion model, in terms of emission loads by gram per second per square meter (usually uses: g/s/m²).

| Parameter | TSP (Tons/ year) | NO₂ (Tons/ year) | SO₂ (Tons/ year) | CO (Tons/ year) |
|-----------|------------------|------------------|------------------|-----------------|
| Point sources | 140.47 | 262.97 | 619.28 | 1918.9 |
| Area sources | 270.18 | 0.53 | 0.20 | 0.07 |
| Line sources | 2.50 | 17.40 | 2.51 | 801.1 |

3.2. Developing the hygiene isolation distances from modeling results

3.2.1. Calibration and validation models

![Figure 3. Correlation between simulated temperature and observed temperature on January, 2019](image)

Table 3. The calculating relative error of AERMOD model on April 16th, 2019

| Parameter | Results of simulation (µg/m³) | Results of monitoring (µg/m³) | MNBE (%) |
|-----------|-------------------------------|-------------------------------|----------|
| TSP       | 35.98                         | 40                            | +10.1    |
| NO₂       | 67.3                          | 60                            | -12.2    |
| SO₂       | 57.1                          | 50                            | -14.2    |
| CO        | 3950                          | 4600                          | +14.1    |

The reliability of simulating values is carried out by the model calibration and validation steps. To test the TAMP simulation results, value R² was used to validate meteorological TAPM model. The correlation coefficient (R² = 0.7857 > 0.7) shows a high correlation of TAMP model and monitoring results. This correlation coefficient R², being close to 1, means that the results of simulated temperature is very close to results of observed temperature in January 2019 (Figure 3) and the TAPM has good
performance/quality to simulate meteorological for the study area. When AERMOD model was validated, in case of a small domain as Tan Tao industrial park and the wind direction in North-West could blow air plumb to South East, only one monitoring result at the South location was utilized to validate the model. The relative error between simulated concentrations of CO, SO₂, NO₂, and TSP and their monitoring results on 16th April 2019 is shown in Table 3. The values of MNBE belong to chosen pollutants is from -14.2% to 10.1% proved that the outcome of the AERMOD model is qualify for this study.

3.2.2. Simulation results for wind directions in study area

The calibration values had indicated that the AERMOD model is fully capable of simulating the dispersion of air pollution by the region. So, the model could apply this wind rose to simulate air pollution for different scenarios. The wind rose chart displays the frequency of wind directions and wind speed which has strongly affect dispersion pictures of pollutants in the study area (Figure 4).

![Wind rose in the study area](image)

It is clear to show that the main wind directions of Tan Tao IP are Southwest, Northeast and Southeast.

3.2.3. Simulation results for representing pollutants in Tan Tao Industrial Park

The outcomes of the simulation process are concerning pollutants like CO, SO₂, NO₂, and total suspended particular (TSP), defining in 1-hour maximum, 8-hour mean, 24-hours mean and annual average concentration. Simulation outputs were compared with the air quality in ambient environment standards, regulating on QCVN 05:2013/BTNMT. So that, pollution map results had been extracted from the AERMOD model, including (i) 1-hour maximum concentrations (CO, SO₂, NO₂ and TSP); (ii) 8-hours mean concentration of CO; (iii) 24-hours mean concentrations (SO₂, NO₂ and TSP); and (iv) annual average concentrations (SO₂, NO₂ and TSP). Noticeable outcomes involve 1-hour maximum concentration of NO₂, 8-hours mean concentration of CO, of 24-hours mean concentration and annual average concentration of SO₂, being the highest values, which would be described on Figure 5, 6, 7, and 8.

A quick review of the simulation results (2019) indicated that several pollutants had pollution levels higher than the standards (QCVN 05:2013/BTNMT), but only occurred in the industrial zone areas. This includes CO 8-hours average (12.662 µg/m³), NO₂ 24-hours average (472.4 µg/m³), SO₂ 24-hours average (636 µg/m³), annual average of NO₂ (80.1 µg/m³), and annual of SO₂ (108 µg/m³).
Concerning the results on 1-hour maximum type, the average maximum concentration of TSP, NO$_2$, SO$_2$, and CO in the simulation area is 581 µg/m$^3$, 4.069 µg/m$^3$, 5.478 µg/m$^3$, and 40.695 µg/m$^3$, respectively, exceeding the standards. Especially, the pollution levels of NO$_2$ were 20 times higher than the limit value, similar trends for SO$_2$ (15 times higher). The isolation distances were determined from the center of pollution to the farthest radius where the levels meet the standard. As this circumstance, the suggesting space was 1.75 km for TSP, 2.91 km for NO$_2$, and 2.15 km for SO$_2$ toward the northwest direction.

Figure 5. NO$_2$ dispersion map for 1-hour concentration scenarios

Figure 6. CO dispersion map for 8-hour mean concentration scenarios

Figure 7. SO$_2$ dispersion map for 24-hour concentration scenarios

Figure 8. SO$_2$ dispersion map for annual average concentration scenarios

3.2.4. The hygiene isolation distances for Tan Tao Industrial Park
The hygiene isolation distance is determined as the farthest distance, measuring from the edge of the industrial zone to the boundary between the exceeding and permitted standards (QCVN 05:2013/BTNMT). These exposure thresholds are suggested to ensure the health of sensitive objects safely. In the study areas, there are some sensitive objectives such as kindergartens, pagodas, residential areas, clinics and hospitals, which might be impacted by the high levels of pollution from Tan Tao IP. Therefore, the reasonable hygiene isolation distance for Tan Tao Industrial Park should be the maximum length according to the settling measure. According to the concentration levels of considered pollutants, at each time resolution, hygiene isolation distance was calculated as follows QCVN 05:2013/BTNMT and listed as Table 4. At a result, the proposed distance for Tan Tao IP is 2910 m in radius from the center point, to protect public health.

Table 4. Construction of sanitary buffer zone for Tan Tao Industrial Park

| Parameter | Scenario base on average time | Values (µg/m³) | QCVN 05:2013/BTNMT (µg/m³) | Exceeding times | Minimum hygiene isolation distance | Main direction |
|-----------|-------------------------------|----------------|---------------------------|-----------------|----------------------------------|----------------|
| TSP       | 1 h                           | 6 - 581        | 300                       | Exceeded        | 194                              | 1750           |
| NO₂       | 1 h                           | 41 - 4069      | 200                       | Exceeded        | 20                               | 2910           |
| SO₂       | 1 h                           | 55 - 5478      | 350                       | Exceeded        | 157                              | 2150           |
| CO        | 1 h                           | 407 - 40695    | 30000                     | Exceeded        | 14                               | 50             |
| CO        | 8 h                           | 127 - 12662    | 10000                     | Exceeded        | 13                               | 50             |
| TSP       | 24h                           | 0.7 - 72.4     | 200                       | Lower           | -                                | 50             |
| SO₂       | 24h                           | 6 - 636        | 125                       | Exceeded        | 51                               | 50             |
| NO₂       | 24h                           | 4.7 - 272.4    | 100                       | Exceeded        | 47                               | 50             |
| TSP       | 1 year                        | 0.09 - 8.74    | 100                       | Lower           | -                                | 50             |
| NO₂       | 1 year                        | 0.8 - 81.1     | 40                        | Exceeded        | 2                                | 50             |
| SO₂       | 1 year                        | 1 - 108        | 50                        | Exceeded        | 216                              | 50             |

4. Discussion

Total emissions of Tan Tao IP in 2019 was estimated at 413.15 tons of TSP/year, 280.9 tons of NO₂/year, 621.99 tons of SO₂/year, and 2720.21 tons of CO/year. This represents that industrial activities emitted a large number of harmful pollutants (TSP, NO₂, SO₂, and CO). The airborne diffusion of pollutants can pose a public health risk, increased risk of developing chronic respiratory disease, lung cancer, heart disease, and many other illnesses, diseases [26 - 27]. It is essential to prepare suitable isolation distance from industrial areas in planning in phases to mitigate health risks for the public surrounding.

Recently, there have been a growing concerns about the air dispersion model that helps users simulate the distribution of pollution in space, for the relating pollutants such as SO₂, NO₂, TSP, VOCs,
and CO...[28],[29],[30],[31]. Almost all these models are based on the theory of GAUSS and the turbulent dispersion theory of BERLIAND [32]. The AMS/EPA Regulatory Model (AERMOD), designing to support the US Environmental Protection Agency (EPA) management program and using the theory of GAUSS, includes a range of options for simulating air quality impacted by waste streams, building common options for many applications. The AERMOD, being assessed at high spatial resolution and medium domain extension in comparison with other models like CALPUFF, CALIOPE, and SMOKE [33], could result pollutants concentration maps in types of particular matter and gases [33]. The TAPM is the prognostic meteorological and air pollution models, being weakly nudged with a 24-hour e-folding time towards the synoptic-scale input values. The output of TAMP model can be the input of AERMOD. So that, the TAPM-AERMOD model system, being the meteorology-emission dispersion model systems, is an approach to identify the isolation and develop a sanitary buffer zone due to industrial emissions.

In Vietnam, there is Decision 3733:2002/BYT and QCVN 01:2019/BXD, regulating minimum isolation distance for manufacture process [13-14]. However, these standards are only suitable for separating processes and do not consider the wind direction factor. Therefore, the application of the model in calculating the isolation distance is a solution to overcome these drawbacks in the standards of Viet Nam. The application of model system is not only an effective solution to simulating the spread of air pollution reliably, but also saves time, costs for planning policy.

The emission dispersion result (Table 4) indicated that simulating values of important ambient air pollutants such as TSP, NO₂, SO₂, and CO are exceeded limited thresholds. This also mean that the local area surrounding the IP with some sensitive objects like kindergartens, pagodas, residential, clinics, and hospitals is at health risk in general. So that, this research suggests four local-abatement strategies for controlling distribution air pollution in Ho Chi Minh region. These sector-specific policies, being based on replies by parties to general solution questions observation questionnaire, tend to improve the overall quality of life of local residential surrounding. The prior is the promoting energy efficiency, instead of using fossil fuels such as DO and coal for boilers, the enterprises should take advantages of agro material one like straw, sawdust or wood waste. The second is reducing the emission from transport sector by promotion of cycling and public transportation inside industrial park. The third one is reported on the measure of reducing emission from point source, which could be invested in efficiency exhaust gas treatment system and connected to automatic emission monitoring system of Tan Tao IP. Enlarging more green area inside each company also should be taken into account in abatement strategy of air pollution.

5. Conclusion

In this study, a simulation model system of air pollution dispersion was used to determine and propose hygiene isolation distance, aiming to protect public health. Emission calculation results from Tan Tao IP pollution sources are input data of the AERMOD model to simulate pollution spread. Point sources are the main air emission sources of Tan Tao IP. Total emissions of Tan Tao IP in 2019 estimated at 413.15 tons of TSP/year, 280.9 tons of NO₂/year, 621.99 tons of SO₂/year, and 2720.21 tons of CO/year.
Modeling results show that 1-hour maximum concentration of TSP, NO$_2$, SO$_2$, and CO in the simulation area is 581µg/m$^3$, 4.069µg/m$^3$, 5.478µg/m$^3$, 40.695µg/m$^3$, respectively, exceeding the standards. Noticeably, the pollution levels of NO$_2$ were 20 times higher than the limit value, similar trends for SO$_2$ (15 times higher). The simulation results suggest that the hygiene radius is widely about 2.910 meters in all directions, from the boundary of IP. Some sensitive objects such as residential areas, hospitals and kindergartens, now being located inside the affected zone, should be considered to relocated or other suitable solutions to protect their health. The method in this study would have driven an approach to create a reasonable hygiene buffer zone far from the concentrated industrial activities. The determination of isolation distance should be based on the hygiene protection requirements for these sensitive objects. Besides, several important elements that should be taken into account are (i) the background pollution caused by daily activities in the areas surrounding the industrial park, and (ii) high-rise constructions around the industrial park play as the obstacle of the pollution plume.

**Author Contributions:**

Nhung Pham contributes as coordinator for whole research, air quality modeling and develop abatement strategies. P.L.Vo was responsible for developing research methodology. T.T.G.N and Q.N.D collected data and process data. While H.N.K.V., T.T.N were responsible for calculating emission. H.N.K.V. is in charge of running TAPM model. B.Q.H is in charge of running AERMOD model. The manuscript was developed, revised, and edited by B.Q.H., P.L.V, Nhung Pham and H.N.K.V.

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