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2014 International Conference on Natural Science and Environment (ICNSE 2014)

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# Natural Science and Environment

Edited by

Miss Du Li

# PREFACE

Dear Distinguished Delegates and Guests,

The Organizing Committee warmly welcomes our distinguished delegates and guests to the 2014 International Conference on Natural Science and Environment (ICNSE 2014) held on April 4-5, 2014 in Dubai, UAE.

ICNSE 2014 are sponsored by Asia-Pacific Chemical, Biological & Environmental Engineering Society (APCBEES), and supported by APCBEES Members and scholars from universities all round the world. If you have attended a conference sponsored by APCBEES before, you are aware that the conferences together report the results of research efforts in a broad range of Natural Science and Environment. These conferences are aimed at discussing with all of you the wide range of problems encountered in present and future high technologies. ICNSE 2014 are organized to gather members of our international community scientists so that researchers from around the world can present their leading-edge work, expanding our community's knowledge and insight into the significant challenges currently being addressed in that research. The conference Program Committee is itself quite diverse and truly international, with membership from the Americas, Europe, Asia, Africa and Oceania.

This proceeding records the fully refereed papers presented at the conference. The main conference themes and tracks are Natural Science and Environment. The main goal of these events is to provide international scientific forums for exchange of new ideas in a number of fields that interact in-depth through discussions with their peers from around the world. Both inward research; core areas of Natural Science and Environment and outward research; multi-disciplinary, inter-disciplinary, and applications will be covered during these events.

The conference has solicited and gathered technical research submissions related to all aspects of major conference themes and tracks. All the submitted papers in the proceeding have been peer reviewed by the reviewers drawn from the scientific committee, external reviewers and editorial board depending on the subject matter of the paper. Reviewing and initial selection were undertaken electronically. After the rigorous peer-review process, the submitted papers were selected on the basis of originality, significance, and clarity for the purpose of the conference. The selected papers and additional late-breaking contributions to be presented as lectures will make an existing technical program. The conference program is extremely rich, featuring high-impact presentations.

The high quality of the program – guaranteed by the presence of an unparalleled number of internationally recognized top experts – can be assessed when reading the contents of the program. The conference will therefore be a unique event, where attendees will be able to appreciate the latest results in their field of expertise, and to acquire additional knowledge in other fields. The program has been structured to favor interactions among attendees coming from many diverse horizons, scientifically, geographically, from academia and from industry. Included in this will to favor interactions are social events at prestigious sites.

We would like to thank the program chairs, organization staff, and the members of the program committees for their work. Thanks also go to Editor Miss Du Li, Asia-Pacific Chemical, Biological & Environmental Engineering Society, for their wonderful editorial service to this proceeding.

We are grateful to all those who have contributed to the success of ICNSE 2014. We hope that all participants and other interested readers benefit scientifically from the proceedings and also find it stimulating in the process. Finally, we would like to wish you success in your technical presentations and social networking.

We hope you have a unique, rewarding and enjoyable week at ICNSE 2014 in Dubai, UAE.

With our warmest regards,

The Organizing Committees
April 4-5, 2014
Dubai, UAE.

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2014 International Conference on Natural Science and Environment (ICNSE 2014)

# Airborne Pollutants Emitted from Flaring, Their Dispersion and Impacts on Ambient Air

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**Abstract**

Airborne primary pollutants, i.e. sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$) and carbon monoxide (CO) generated by waste gas flaring and their dispersion in ambient air were assessed. The calculated amount of the generated pollutants was based on input of the flared waste gases and emission factors according to standards compiled by United State Environmental Protection Agency (US-EPA). The dispersion of the emitted pollutants in ambient air was developed by using Gaussian Dispersion Model and supported by wind speed data compiled by Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG). Result of the assessment indicated that all airborne primary pollutant concentrations in ambient air comply with the national standard i.e. PP No. 41/1999 pertaining on Air Pollution Control.



*Keywords:* airborne primary pollutant, ambient air, dispersion, emission, flaring

## 1. Introduction

Generally defined, flaring is gas combustion practiced in petroleum refineries, chemical plants, natural gas processing as well as at oil or gas production sites having oil wells, gas wells, offshore oil and gas rigs and landfills. Waste gas is generated thereof and subsequently emitted into ambient air as a consequence of oil or

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gas combustion during flaring process. The quantity and quality of the emitted airborne pollutants were strongly depends on the combustion process input, i.e. oil or gas. The most important environmental impact issue of flaring is ambient air quality change due to the emitted waste gases into the atmosphere. Hence, prudent design and monitoring of flaring process is very critical in order to ensure that the process is environmentally safe and comply with the pertinent national as well as local (provincial or municipal) standards. The objective of the paper is firstly to predict the emitted primary airborne pollutants resulted from flaring, and secondly, to predict their dispersion in the ambient air surrounding the flaring site. This is a study case of waste gas flaring in an oil and gas company located in Natuna Islands, Republic of Indonesia.

## 2. Methods

Airborne pollutants in this study case were limited on three (3) main airborne parameters, i.e. sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$) and carbon monoxide (CO). The threshold limits of the relevant parameters of ambient air gas concentration refer to national regulation namely PP No. 41/1999 pertaining on Air Pollution Control. The quantity of the emitted pollutants released into the ambient air was calculated that was based on the definitions and assumptions as follows:

- Gas combustion rate used to determine pollutants generation during flaring process was 0.3 MMSCFD (million standard cubic feet per day) [Ref. Company X]
- Emission factors for $SO_2$, $NO_2$ and CO refer to US-EPA (United States Environmental Protection Agency) Standard, AP-42 Chapter 5, Petroleum Refineries
- Average monthly wind speed (i.e. 1.9 m/s), used to support pollutant dispersion simulation was based on climatology data compiled during 12 years by National Agency for Meteorology, Climatology and Geophysics (BMKG) of Indonesia.
- Stack height as pollutant point source was 30 m above ground level.

Pollutant dispersion in the ambient air was simulated by using Gaussian dispersion model (Equation 1) as follows [1]-[4]:

$$C_{(x,y,z)} = \frac{Q}{2\pi\sigma_y\sigma_z U}\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right]+\exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\} \quad (1)$$

On the ground level, however, the above mentioned expression of the pollutant concentration where the plume height is H, y = 0 and z = 0 becomes simpler (Equation 2) as follows:

$$C_{(x,y,z)} = \frac{Q}{\pi\sigma_y\sigma_z U}\exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right] \quad (2)$$

Where $C_{(x,y,z)}$ is concentration of gas at any point coordinate (x,y,z) [g/m$^3$]; Q is stack emission rate [g/s]; $\sigma_y$ and $\sigma_z$ are dispersion coefficient according to Pasquill-Gifford curve [m]; U is wind speed [m/s]; y is distance of any point along the y-axis to the centre line [m]; z is vertical distance along z-axis from centre line [m], and H is plume height from the ground level [m].

## 3. Results and Discussion

The amount of generated waste gas from flaring is presented in form of calculation sheet as shown in Table 1. Dispersions of the waste gases, i.e. $SO_2$, $NO_2$ and CO in the ambient air are presented in Fig. 1, Fig. 2 and Fig. 3. These figures were produced by using Gaussian dispersion model. Fig. 1 shows that the highest concentration of $SO_2$ in the ambient air was reached at a radius of about 150 metres from the source. At this point the ambient concentration of $SO_2$ was 285 μg/Nm$^3$ whereas the threshold limit for this parameter according to PP No. 41/1999 pertaining on Air Pollution Control is 365 μg/Nm$^3$. The calculation result indicated therefore that ambient concentration of sulphur dioxide ($SO_2$) was lower than that the prescribed limit and hence comply with the regulation.

Table 1. Calculation sheet of waste gas generated by flaring

| Aspect | Unit | Quantity | | |
|---|---|---|---|---|
| Amount of flared gas | [MMSCFD] | 0.3 | | |
| | [litre/day] | $8.5*10^6$ | | |
| | | $SO_2$ | $NO_2$ | CO |
| Emission factor [a] | [kg/$10^3$ litre] | 0.077 | 0.054 | 0.012 |
| Stack emission rate | [kg/day] | 653.7 | 458.5 | 101.9 |
| | [μg/s] | $7.6*10^6$ | $5.3*10^6$ | $1.2*10^6$ |

[a] = US-EPA Standard, AP-42. Chapter 5, Petroleum Refineries [5]

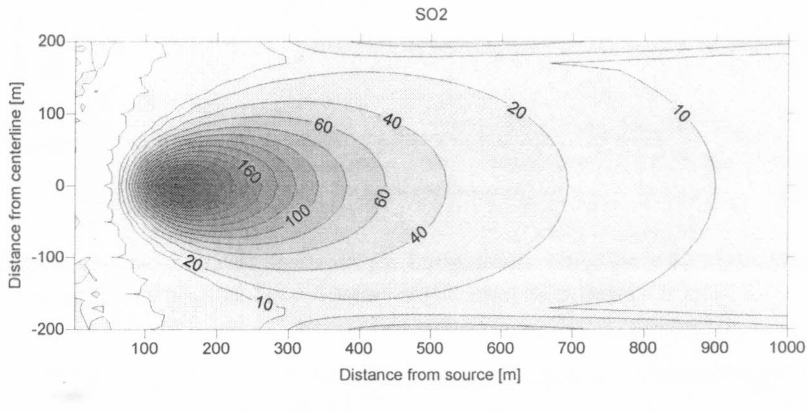


Fig. 1. Dispersion of $SO_2$ in ambient air resulted from waste gas flaring. (Notes: Flared gas = 0.3 MMSCFD; Stack emission rate = $7.6*10^6$ μg/s; Average wind speed = 1.9 m/s [Ref. Tarempa Meteorology Station]; Stack height = 30 m).

In the environment $SO_2$ is known as one of primary air pollutants in ambient air. The gas in the air originates from a number of sources such as coal and oil fired power plants and a lot of industrial processes involving fossil fuel combustion [6]. Coal-fired power plants are the worst $SO_2$ polluters [7]. $SO_2$ is also known as corrosive and poisonous gas. If the gas is released in the atmosphere then it could be converted chemically into sulphate which is then deposited as acid rain. At high concentrations, $SO_2$ affects breathing and produces respiratory illness, alterations in the defences of the lungs and aggravation of exiting respiratory and cardiovascular disease as well as produce foliar damage on trees and agricultural crops [8].

Fig. 2 shows the dispersion of $NO_2$ in ambient air that was resulted from waste gas flaring. The highest ambient concentration of $NO_2$ was 200 μg/Nm$^3$ which was reached at a distance of ±145 m from the source. On the other site however, the threshold limit of this parameter is 150 μg/Nm$^3$ according to PP No. 41/1999. Hence, the condition does not comply with the national standard. An appropriate solution such as stack height change is accordingly necessary to manage the environmental impact of the flaring. However, in area at a distance of more than 190 m from the source, the ambient concentration of $NO_2$ has been lower than the pertinent standard.

The environmental impact of $NO_2$ release in the ambient air [8] showed that if the gas is inhaled, it can irritate the lungs and lower resistance to respiratory infections such as influenza. Secondly, continued or frequent exposure to high concentrations causes increased incidence of acute respiratory disease in children. $NO_2$ is also an important precursor of both ozone and acidic precipitation and may affect both terrestrial and aquatic ecosystem. Another research finding [9] showed that decrement in lung function indices associated with increasing concentrations of particulate matter and $NO_2$.

Fig. 3 shows the carbon monoxide (CO) dispersion in the ambient air as caused by waste gas flaring. It indicates that the highest ambient concentration takes place at a distance of about 150 m from the source at a concentration level merely 44 μg/Nm$^3$. If the standard for the relevant parameter according to PP No. 41/1999 is 10,000 μg/Nm$^3$, then the whole surrounding areas of the flare comply with the pertinent national standard.

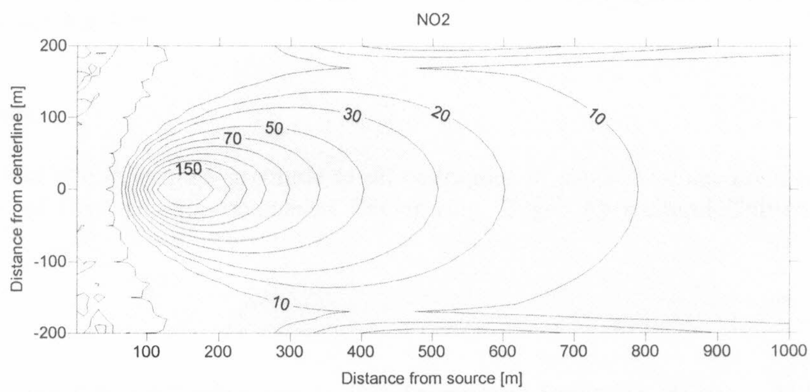


Fig. 2. Dispersion of $NO_2$ in ambient air resulted from waste gas flaring. (Notes: Flared gas = 0.3 MMSCFD; Stack emission rate = 5.3*10$^6$ μg/s; Average wind speed = 1.9 m/s [Ref. Tarempa Meteorology Station]; Stack height = 30 m).

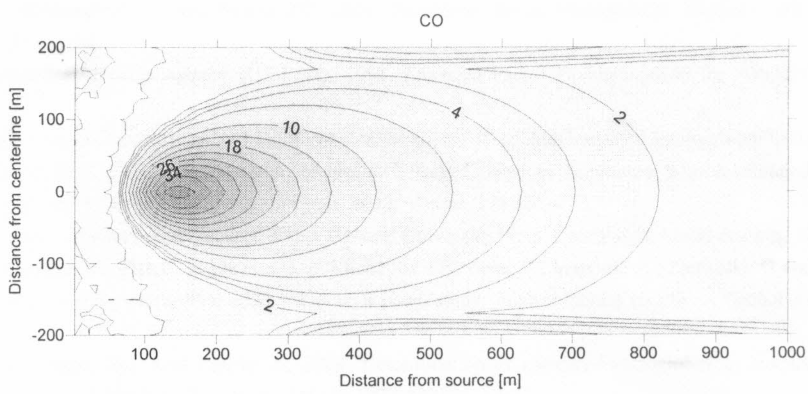

Fig. 3. Dispersion of CO in ambient air resulted from waste gas flaring. (Notes: Flared gas = 0.3 MMSCFD; Stack emission rate = $1.2*10^6$ μg/s; Average wind speed = 1.9 m/s [Ref. Tarempa Meteorology Station]; Stack height = 30 m).

It has adverse effects on human health, replacing oxygen in the bloodstream and forming carboxy-hemoglobin (CO-Hb) [10]. If the percentage of CO-Hb exceeds about 2 per cent, health is temporary impaired, and this level occurs in people engaged in heavy physical activity if the ambient CO level is greater than about 30 ppm (≈ 35,000 μg/$Nm^3$) [3]. The health threat is most serious for people who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Exposures to elevated CO concentration are associated with impairment of visual perception, work performance of complex tasks [8].

## 4. Conclusion

The conclusions that can be drawn from the study are as follows:

- The emitted primary airborne pollutants from waste gas flaring with input as much as 0.3 MMSCFD are $7.6*10^6$ μg/s ($SO_2$), $5.3*10^6$ μg/s ($NO_2$) and $1.2*10^6$ μg/s (CO).
- Airborne pollutants were dispersed in ambient air and comply with the national standard after radius of 285 m from the source for $SO_2$ parameter and after 190 m for $NO_2$. For CO parameter, all of surrounding area complies with the standard.

## Acknowledgements

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