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Odour Pollution and Its Measurement

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Abstract—Odour is an environmental component that can contribute to its changes. Odour pollution is an indicator of environmental change that impact health and human-being. Among sources of Odour pollution are animal rearing, landfills, sewage treatment plants, oil palm and rubber mills, industries and dumpsites. This study is attempted to relate odour pollution and its effect in concentration due to various meteorological factors. Different times of day (morning, evening and night) and weather conditions (normal days and after rains) affects the odour concentration. Odour concentration was measured by Odour Concentration Meter. In this study it was found that, meteorological factors also influence odour concentration. The stations further from the site were recorded highest odour concentration.
Keywords— Odour Pollution, Odour Concentration, Landfill, Atmosphere factor, Distance factor, RDF

I. INTRODUCTION

Odour is an environmental component that can contribute to its changes. Odour pollution is an indicator of environmental change that impact health and human well-being.The Department of Environmental Protection (DEP) must deal with odour complaints which are impacting on the amenity of the community. The Environmental Protection Act 1986 protects against “unreasonable emissions” – emissions of noise, odour or electromagnetic radiation which unreasonably interfere with the health, welfare, convenience, comfort or amenity of any person. Criteria for what is considered “unreasonable” must be determined on a case by case basis. Odour is likely to become an issue in situations where conflicting land uses result in sensitive receptors locating close to odour sources.

Odour measurement may be used for assessment of a range of situations including:

Proposals for a new and expansion of an existing odorous facility;

Proposals for sensitive land use near an existing odorous facility;

Investigation of complaints to the DEP of odour from existing facilities;

Setting of licence conditions;

Buffer definition studies where surrounding land is not yet zoned for urban use;

Assessing odour during contaminated site remediation;

Determination of odour emission rates before and after a plant upgrade in order to quantify emission reduction.

The study was attempted to measure odour pollution generated by Refuse Derived Fuel (RDF) operation. In that study the analysis was conducted at different times of day (morning,evening and night) and weather conditions (normal days and after rains). 10 sampling stations were selected for observations using the Odour Concentration Meter XP-329 III.

A. Sources of Odour

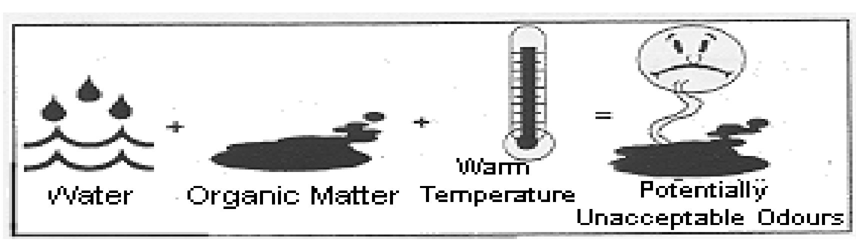

Fig. 1 Conditions for Potential Foul Odour

Odour sources can be classified as:

Point Sources: Point sources are confined emissions from vents, stacks and exhausts.

Area Sources: Area sources may be unconfined like sewage treatment plant, waste water treatment plant, solid waste landfill, composting, household manure spreading, settling lagoons etc.

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Building Sources: Building sources of odour like pig sheds and hog confinement chicken. Fugitive Sources: In this source of odour, emissions are of fugitive nature like odour emissions from soil bed or bio-filter surface.

TABLE I

Indicates the various odorous chemicals emitted from industrial operations

Sr. No.	Industry	Odorous Material
1.	Pulp & Paper	Mercaptans, hydrogen sulfide
2.	Tanneries	Hides, flesh
3.	Fertilizers	Ammonia, nitrogen compounds
4.	Petroleum	Sulphur compounds from crude oil, mercaptans
5.	Chemical	Ammonia, phenols, mercaptans, hydrogen sulfide, chlorine, organic products
6.	Foundries	Quenching oils
7.	Pharmaceuticals	Biological extracts and wastes, spent fermentation liquors
8.	Food	Cannery waste, dairy waste, meat products, packing house wastes, fish cooking odours, coffee roaster effluents
9.	Detergent	Animal fats
10.	General	Burning rubber, solvents, incinerator, smoke
11.	Swine Operations	Hydrogen sulfide and ammonia
12.	WasteWater Treatment Plant	Hydrogen sulphide

B. Effects & Its Importance

Odour affects human beings in a number of ways. Strong, unpleasant or offensive smells can interfere with a person’s enjoyment of life especially if they are frequent and / or persistent. Major factors relevant to perceived odour nuisance are:

Offensiveness

Duration of exposure to odour

Frequency of odour occurrence

Tolerance and expectation of the receptor

II. METHODOLOGY

The study was conducted on the RDF operation located in Semenyih, Kajang in the state of Selangor. The RDF was operated by Recycle Energy Sendirian Berhad (RESB) under the Kajang District Council. The RDF operation was capable to convert solid wastes into electric power.

The RESB output of this source of renewable energy was to a maximum of 9 Megawatt (MW) through conversion of 700 tons of solid wastes daily. The RDF location is at latititude 03°00’3.1’’ and longitude E 101°52’56.6’’, with an altitude of 70 meters from sea level.

The study was also conducted at landfill site in Malaysia.

The equipment used for measuring the odour concentration was Odour Concentration Meter (OCM)XP-329 III. This equipment was also used to measure odour threshold and the measuring unit was stated in odour concentration per cubic meter or ou/m^3. The OCM has the capacity to measure odour concentration from a minimum concentration of 0 to a maximum of 2000 ou/m^3.

Malaysian Standards on Odour Pollution and Gas:

There have not been specific standards established for regulatory and enforcement guidelines on odour pollution and of gas components. Existing Malaysian guidelines such as the Recommended Malaysian Air Quality Guidelines (RMAQG) have been limited to those pertaining to several gas types: O_3, CO, NO_2 and SO_2 .

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Fig. 2 Odour Concentration Meter (OCM)XP-329 III

III. RESULTS AND DISCUSSION

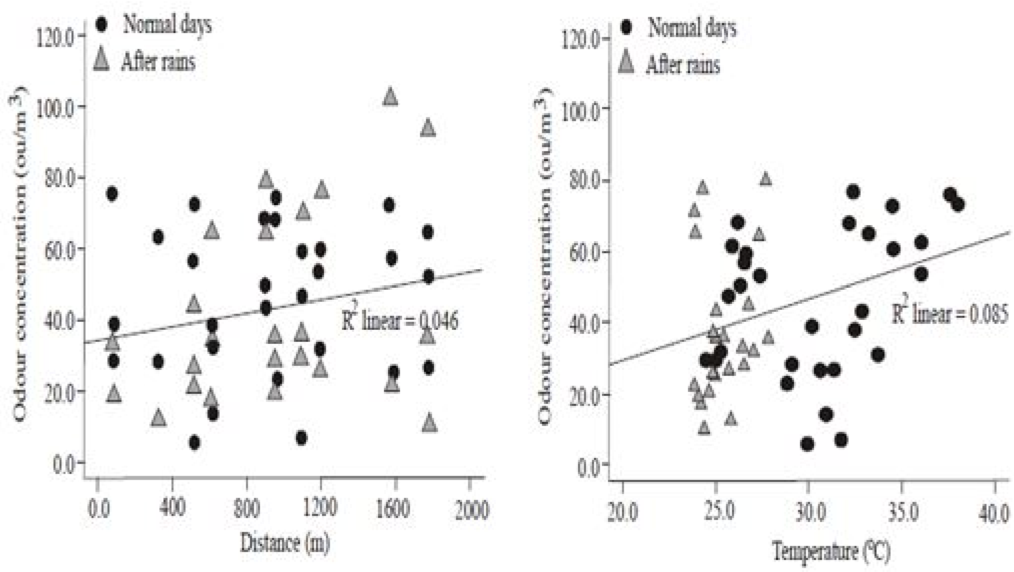

Fig. 3 Relationship between distance, Temperature and odour concentration

Distance factor

Fig. 3 indicates relationship between distance and odour concentration. Relationship of distance per odour intensity whereby the farther the distance from the RDF higher the distribution. Commonly, higher odour concentration was often detected at areas nearer to the source such as sewage treatment plants and dumpsites. However the findings of that study indicated positive relationship between distance and odour, whereby the farther the distance, higher the odour were concentrated. Based on the analysis conducted at Malaysia, the distribution of odour was higher at stations farther from the RDF.

Temperature factor

The environmental temperature was a meteorological component which influenced the concentration of an odour. Based on Fig, the results of the regression analysis indicated $R^{2.}$ values was weak at $R^2 = 0.085$. Despite the weak model to illustrate this relationship, the results of that study indicated the distribution of odour concentration was higher at stations with lower temperatures compared to those with higher ones. The distribution of odour after rains was found to be concentrated at stations with low temperatures around 25ºC .

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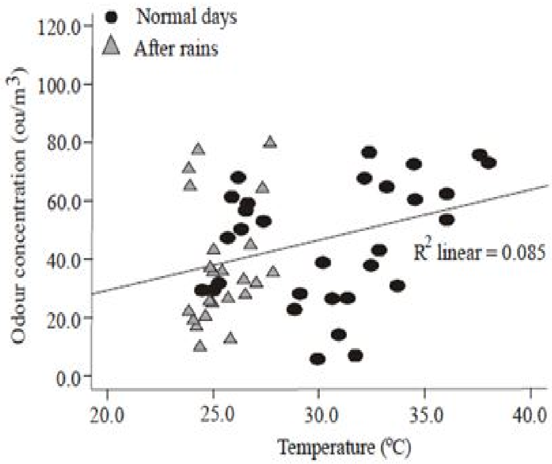

Fig. 4 Relationship of wind velocity(m/s) and odour Concentration

Wind factor

Fig. 4 indicated the concentration of odour on normal days and after rains during the slow winds. The analysis clearly indicated higher odour concentration at slower wind velocity compared to higher ones. This phenomenon occured due to the temperature of the atmosphere being stable and collected at areas with high wind velocity. These findings were similar to Laister (2002) and Zaini (2012) who found higher wind velocity to be influential in the distribution of concentrated gas and odour.

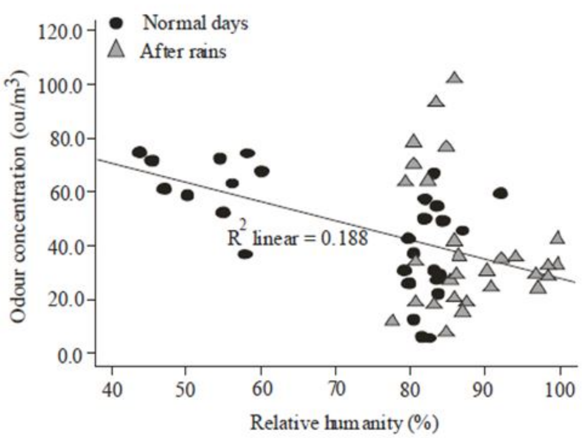

Fig. 5 Relationship between humidity and Odour Concentration

Figure 5 shows the influence of comparative humidity on distribution of odour concentration. Based on regression analysis, it was found, that there existed contrastive relationship between comparative humidity and the odour observed.

Higher distribution of odour concentration was largely at observatory stations with higher humidity exceeding 80%.between normal times and after rains.

The average of the concentrations indicated highest readings in the evening and afternoon in both weathers.

Nevertheless the average concentration of odour was found to be higher after rains.

Hence, the influence of distance and meteorological factors such as temperatures, wind and humidity were comparatively influential in the distribution of odour concentration from the RDF.

Fig. 6 shows odour concentration recorded around the RDF. Based on the figure, it shows that concentrations vary per day and time variances, with indications of the concentrations exceeded t he limit.

According to the standards, the allowable concentration was set at 10 ou/m^3.

However, the analyses showed that the average concentration of the three sessions of measurements on normal days and after rains

exceeded the limit allowable under the standards Minimum and maximum concentrations recorded on normal days was at 23.39 ou/m3(morning) than 64.29 ou/m^3 (evening) respectively.
After rains recording saw a maximum reading of 54.21ou/m^3 (evening); while minimum concentration was 31.26 ou/m^3 at (night). The high concentration could adversely affect routine outdoor activities and wellbeing of the local population.

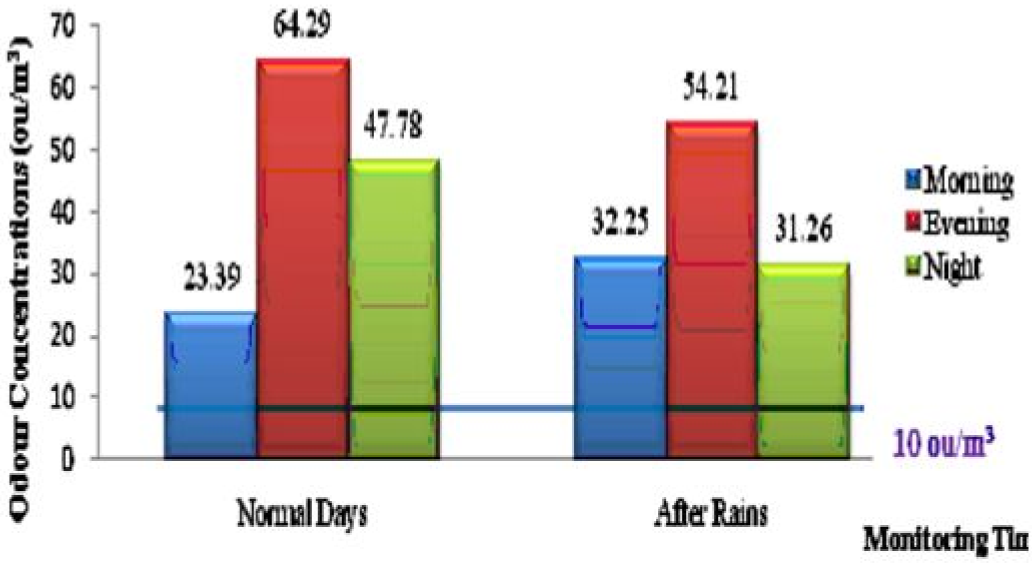

Fig. 6 Comparison of odour concentration in the morning, evening and night on normal days and after rains

Generally, based on figure 6, figure 7 and figure 8, the gas concentrations were the highest in the evening and after rains.
For example, the concentration of SO_2 and NO_2 reached highest reading after rains, whilst the H_2S registered highest concentration on normal days.

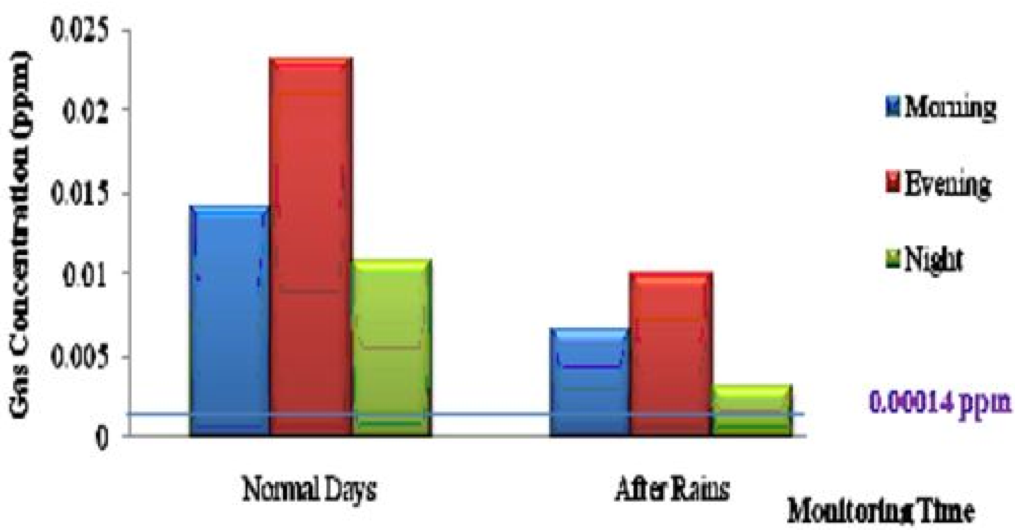

Fig. 7 Comparison of SO_2 concentrations in the morning, evening and night on normal days and after rains[2]

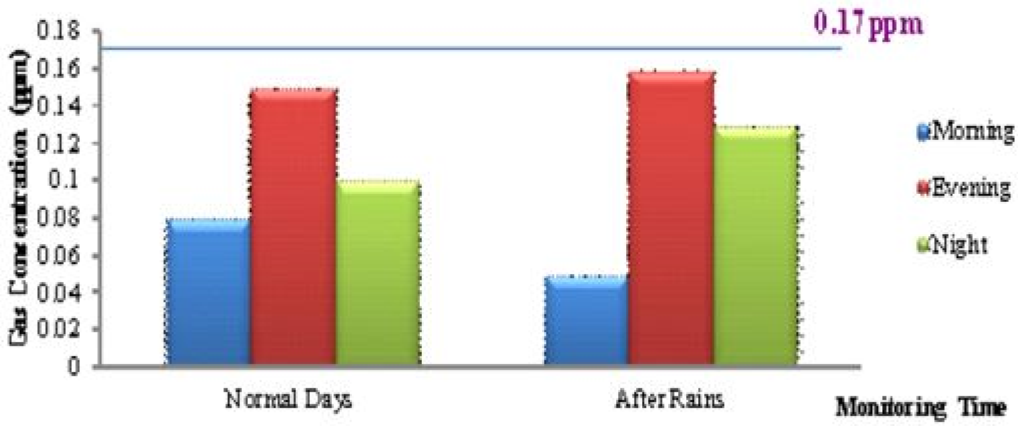

Fig. 8 Comparison of NO_2 concentrations in the morning, evening and night on normal days and after rains[2]

A. The concentration of odour in the vicinity of landfill on a regular non rainy day

1) The Concentration Of Odour In The Morning: Based on table 2, the station for the primary source indicated as the centre of the landfill AT1 recorded the highest odour concentration at 172.2 ou/m^3. This is similar to the station located at the border of the landfill which recorded the odour concentration at 95.3 ou/m^3. Observatation of odour concentratation at AT3 up to AT8 within the 2km radius, the indicated a higher concentration recorded at 48.4 ou/m^3. The reading of this slightly higher odour concentration was possibly due to the influence of the LCC oil palm mills nearby.

2) The Concentration Of Odour In The Evening: The data recorded at the station on the landfill is the highest at 407 ou/m^3. The concentration for stations within 2km showed high readings(88ou/m^3) recorded at AT3 opposite the IKHLAS institute and near the main road entering the landfill. The lowest odour concentration was recorded at AT7(ou/m^3) in LCC plantation. This condition occurred due to the influence of oil palm mill and distance of the station which is futher away from the landfill location. Odour concentration became gradually receded at stations within radius 2 to 5km. The reading at AT10 was found to occur at the highest reading of 143.7 ou/m^3. While the lowest concentration was at 9.7 ou/m^3 at station T9 near the main road to Kota Warisan. For station AT10 the concentration was high in the evening, possibly due to the construction work in the area. There were garbage trucks on road near the KW primary school during the observation.

This situation also influenced the concentration recorded by the odour concentration meter which was capable to record all types of gases in the surrounding atmosphere. Although the distance of station A10 exceeded 2km from the landfill, there were other factors in the vicinity which can influence the concentration of odour recorded.

3) The Concentration Of Odour In The Night Time: The night time odour concentration was recorded the highest at AT1 considered as primary source of odour at ou/m^3.While the highest reading of odour concentration recorded at stations within radius of 2km were recorded at AT5(65.6ou/m^3) and AT6(47.1ou/m^3). The higher odour concentration recorded stations AT5 and AT6 within 2km radius was possibly due to the existence of a nearby oil palm factory which released gaseous steams during night operations. The concentration of night time odour recorded at the sampling stations beyond the 2 to 5distance have shown readings which on average was rather low i.e. between 8.8 ou/m^3 at station AT11 and the highest only at 22.9 ou/m^3 at station AT9. The reading at station AT9 was little higher due to the main road forming the main thoroughfare of Kota Warisan. The concentration of odour recorded was also due to the presence of other gaseous elements which could be sensed but nat detectable. Although, other gases were not able to be distinctly recorded, the gases still generate smelly odour, for they were formed the odours of other sources.

B. The Concentration Of Odour In The Vicinity Of Landfill After A Rainy Day

The monitoring of post-rain odour was conducted immediately after the rain ceased. Table 2 shows the reading of after rain odour concentration recorded 13 stations on normal day. The overall reading recorded at center of landfill consistently indicated high reading compared with that of other stations, either within the 2km or between 2 to 5km radius.

1) The Concentration Of Odour In The Morning After Rain: The odour concentration recorded in the morning after rain was also highest at station AT1(183.2 ou/m^3). The concentration data recorded on the waste dumps at 172.2 ou/m^3 at the center of the landfill was the same as the concentration recorded in the morning time. The concentration of the odour at AT12 recorded higher reading at 217.7 ou/m^3. High concentration of odour occurred due to the influence of odour originated from the waste treatement near by the sampling station.

2) The Concentration Of Odour In The Evening After Rain: Based on the table 5.2 it is clearly indicated that the highest concentration recoreded is at AT1 with 83.3 ou/m^3. While the concentration of odour for stations within 2 km radius was at an average of 23.6 ou/m^3 with the highest concentration at AT5 (25.6 ou/m^3) and the lower concentration recorded at station AT3(21.6 ou/m^3). Station such as AT11 and AT12 recorded slightly higher concentrations compared to other stations with 34.6 ou/m^3 than 47.2 ou/m^3, respectively. The increase in the odour concentration occurred due to the influence of odour contributed by the waste treatment plant near by both stations.

3) The Concentration Of Odour At Night Time After Rain: The odour concentration recorded at night time was almost at the same level with those recorded in the evening after rain with generally recorded concentration of less than ou/m^3. Only at station on the landfill recorded a concentration at 38.9 ou/m^3. For instance, the concentration for station AT12 was 18.6 ou/m^3 was higher than those stations within distance of 2 km to the landfill due to the contribution of the odour from the WTP nearby. The same was with the concentration recorded at sampling station AT7 with a reading of 17.7 ou/m^3 within distance of 2 km. This may be due to the operation of oil palm mill which emitted smoke into the air at night time after rain during the study[2].

TABLE II

The concentration of odour in the vicinity of landfill on a regular non – rainy day: odour(ou/m^3)[1]

Stations	Morning time	Evening time	Night time
AT 1	172.2	407.0	104.0
AT 2	95.3	73.0	66.0
AT 3	10.2	88.0	6.1
AT 4	18.8	26.5	11.2
AT 5	20.4	15.8	65.6
AT 6	22.7	33.0	47.1
AT 7	48.4	09.3	10.4
AT 8	13.2	13.2	18.1
AT 9	19.2	09.7	22.9
AT 10	17.2	143.7	19.9
AT 11	28.7	21.2	8.7
AT 12	26.9	29.0	8.8
AT 13	28.6	21.9	21.9

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TABLE III
The concentration of odour in the vicinity of landfill after a rainy day: odour(ou/m^3)[1]

Stations	Morning time	Evening time	Night time
AT 1	183.1	83.3	78.3
AT 2	71.9	32.5	38.9
AT 3	19.0	21.6	18.6
AT 4	26.5	24.2	13.1
AT 5	26.6	25.6	6.8
AT 6	08.8	23.5	17.7
AT 7	50.1	22.5	10.1
AT 8	23.1	24.2	9.6
AT 9	67.2	20.5	7.1
AT 10	11.7	22.0	5.8
AT 11	08.1	34.6	15.8
AT 12	217.7	47.2	18.6
AT 13	7.7	24.4	13.3

IV. CONCLUSIONS

The study done in Malaysia shown real existence of interrelations between odour concentration and the distance from the landfill. The study done in Malaysia can be used as a background to work for Indian scenario odour measurement. Various meteorological do affects the odour concentration.

Sensitive receivers who were nearer to the landfill indicated receptions of extremely strong odour.

The average of the concentrations indicated highest readings in the evening and afternoon in both weathers.

The average concentration of odour was found to be higher after rains.

Hence, the influence of distance and meteorological factors such as temperatures, wind and humidity were comparatively influential in the distribution of odour concentration from the RDF.

It also revealed the concentrations of odour generated by the RDF operation have exceeded the standard limit set bythe DEC at10ou/m3, either on normal days or after rains. It was also revealed that odour pollution also due to the release of H_2S, SO_2, and NO_2 concentrations. NO_2 and SO_2 were detected at high concentrations after rains; whilst the H_2S attained.

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NO_2 and SO_2 were detected at high concentrations after rains.

The exposure to odour concentration and the gases for an extended period may be harmful to wellbeing and quality of the environment of sensitive receptors.

Close monitoring and penalty enforcement by the authorities need to be enhanced to minimize the potential harms of odour and gas pollutions.

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