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Case Study on Odour Measurements in India

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In India, there are no systematic odour measurement methods in use at this moment. Yet, odour causes several complaints and also court cases. CPCB, India and VTT Technical Research Centre of Finland have started year 2011 a project called “Capacity building for emission measurements in India”. One focus area in this project was odours and the objective was to find the most suitable method to be used to assess odours nuisance in Indian circumstances. Therefore, different odour measurement methods were introduced to Indian experts and priority was set to methods which do not need a lot of technical facilities or expertise. It was observed that the most feasible option to carry out an odour survey in India is to use Field Investigation Method. Applied field investigation method was modified to fit India’s need to measure different odour intensities based on the experience that clearly recognizable odour is observed as an annoyance. The modified method is partly based on the Guideline VDI 3940 part 3 (2008) and partly based on prEN 264086:2008 part 1. Modified field investigation method can be used to measure odour frequency and to estimate an intensity of existing odour. Results are presented as relative odour frequencies. Odour frequency results are indicatively comparable with results from mentioned guidelines. Two Field Investigation case studies were performed in India and these studies were the first odour determinations performed in India ever. First study was performed in Industrial Hazardous Waste Disposal area on February 2013 and the second one in Pharmaceutical Industry on May 2013. Both sites are categorised as critical polluted areas in India. These studies indicated that there existed remarkable odour frequencies, such as 100 percentile of observation time. Clearly recognizable odour intensities were sensed in the range from 25 to 93 percentile of observed time in the vicinity of the studied facilities. This article focuses on presenting modified field investigation method and the results of these two case studies in India.

1. Introduction

Odour pollution has distinctly different characteristics and is undoubtedly the most complex of all the air pollution problems. The land-use in India is complicated, as residential areas develop close to industrial regions the impacts from odorous substances generated from industrial activities (e.g. pulp & paper, distillery, sugar, bulk drug, pharmaceuticals, petrochemical and pesticides) result in increasing public complaints. Besides industrial activities unpleasant odour is generated from open sewer, polluted rivers and municipal solid waste landfills.

2. Odour legislation in India

In India, there are industry specific guidelines which mandate odour removal only for fermentation and natural rubber industries. There are some Emission Limit Values for few industrial sectors which include emission which may be odorous but limit values are not set based on their odour potential. There are for example emission limit values for hydrogen sulphide 5-150 mg/m^3_n, ammonia 5 mg/m^3_n, total organic carbon 0.1-20 mg/m^3_n and carbon sulphide 125-225 kg/t of produced rayon fibre. Mentioned industrial sectors are large pulp & paper industry, pesticide industry, petroleum and oil refineries, rayon industry and other petrochemical industry. It is mentioned in the Environment Act (1986) that all efforts shall be made to remove unpleasant odour as far as practicable. Odour removal techniques and overview of measurement

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techniques are presented in the guidance for reducing odour emissions (CPCB 2008). The guidance document is a review of the basics of odour pollution, its sources, measurements, control technologies, and international regulations and legislation. In India, there are no common requirements for removal efficiencies of odour removal techniques.

Indian environmental authority system has many organisations with different functions. The main authority is Central Pollution Control Board (CPCB) which works under the supervision of Ministry of Environment and Forest (MoEF). CPCB main functions are to advise the Central Government on any matters related to pollutions and to coordinate activities, provide technical assistance and plans for local authorities. Local authorities in states are State Pollution Control Boards (SPCB) and in union territories Pollution Control Committees (PCC).

3. Modified field investigation method

The modified method is partly based on the Guideline VDI 3940 part 3 (2008) and partly based on prEN 264086:2008 part 1. Group of trained assessors (minimum 4 persons) assess the odour from ambient air in the vicinity of the odour source at the same time. Observations are performed during 26 days, including varying meteorological circumstances. Typically, the duration of field investigation is from 3- 6 months and it is recommended that the observations days are distributed evenly during this time. Total duration of the investigation depends on the stability of ambient temperature in the current area. Each observation lasts 10 minutes and perceptions are written every 10 seconds. Modified field investigation method can be used to measure odour frequency and to estimate an intensity of existing odour. The main modifications were made for recording of odour intensity scales. As well the calculations were modified to define proportion of odour frequencies of different odour intensities. Results are presented as relative odour frequency. Odour frequency results are indicatively comparable with results from mentioned guidelines.

3.1 Selection of assessors

Selection of assessors is done mostly according to EN13725. In Standard EN13725, the acceptable sensitivity of sense of smell is defined using n-butanol as a reference compound, which should be observed between concentrations 62 µg/m^3 and 246 µg/m^3 by using dynamic dilution. Due to the fact, that there is not yet olfactometer available in India, the Sense of Smell of assessors was decided to be tested using static dilutions of n-butanol. The modified reference test method for Indian purposes was introduced to Indian experts. With modified n-butanol test method India can perform required odour assessor tests. The modified method is performed with static dilutions to receive three bags having following n-butanol concentrations; 16 ppb (part per billion), 79 ppb and 90 ppb. Accepted assessor must detect odour from two bags having 79 and 90 ppb of n-butanol. Modified n-butanol test is based on static dilutions, thus uncertainty is higher than in the case of dynamic dilution e.g. olfactometer.

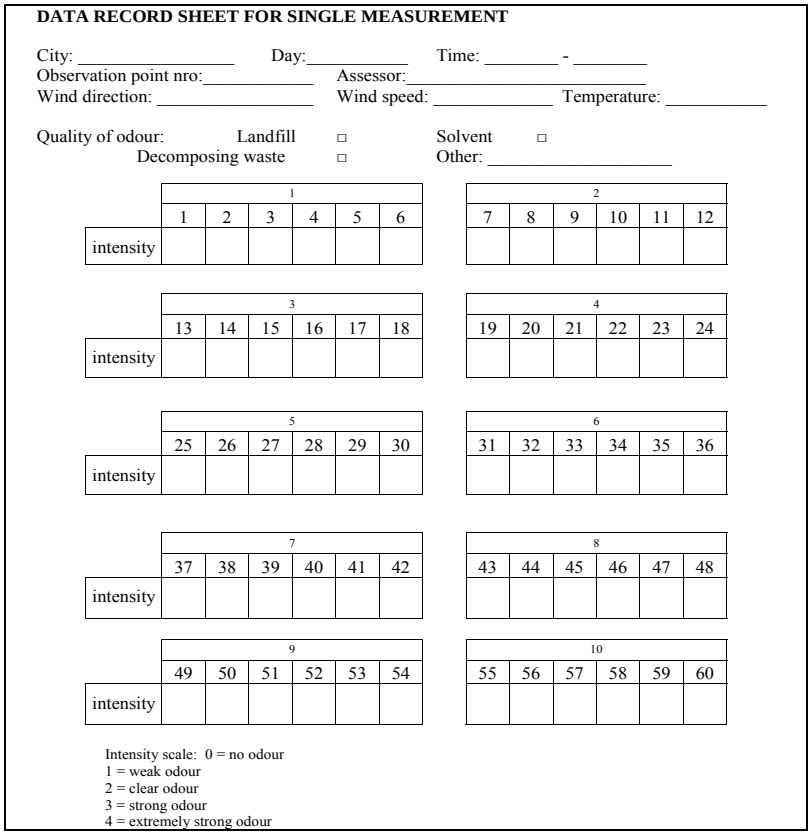
3.2 Assessment area and measurement point selection

In order to select the assessment area there should be some preliminary information how far odour is dispersed. Assessment area and measurement points are fixed depending on the dispersion distance. According to prEN 264086:2008, part 1 an assessment square size of 250 m should initially be chosen. Depending on the needs in the particular case, larger (500 m maximum) and smaller squares (e.g. 125, 100 or 50 m) are possible. In some cases an assessment square can be replaced by an individual measurement point. In this modified method assessment squares are replaced with individual measurement points to get indicative odour exposure results. Locations of measurement points are selected in advance from at least four different distances and from at least four breadths from odour source. Total number of field investigation days is set to be 26 times in different days during 3-6 months depending on weather variations. Measured wind directions should be compared with long time mean wind direction distribution.

3.3 Recorded data

Odour intensity of observed odour quality is written into data record sheet every 10 seconds. Total time of measurement is 10 minutes, which equals 60 times of 10 second periods. However, if odour exists clearly all the time in first 5 minutes the assessment can be finished in that point. Odour intensity is recorded using five step scale which is modified from VDI 3940 part 3 (2008). Recorded odour intensity scale is “0 = no odour”,”1 = weak odour”, “2 = clear odour”, “3= strong odour” and “4 = extremely strong odour”. Data

record sheet includes also data of measurement point identification, assessor, time, wind direction, air temperature and humidity. An example of data record sheet is shown in Figure 1.



DATA RECORD SHEET FOR SINGLE MEASUREMENT

City: _____ Day:_____ Time: _____ - _____
Observation point nro:_____ Assessor:_____
Wind direction: _____ Wind speed: _____ Temperature: _____

Quality of odour: Landfill □ Solvent □
Decomposing waste □ Other: _____

	1						2					
	1	2	3	4	5	6	7	8	9	10	11	12
intensity												

	3						4					
	13	14	15	16	17	18	19	20	21	22	23	24
intensity												

	5						6					
	25	26	27	28	29	30	31	32	33	34	35	36
intensity												

	7						8					
	37	38	39	40	41	42	43	44	45	46	47	48
intensity												

	9						10					
	49	50	51	52	53	54	55	56	57	58	59	60
intensity												

Intensity scale: 0 = no odour
1 = weak odour
2 = clear odour
3 = strong odour
4 = extremely strong odour

Figure 1. An example of data record sheet in modified field investigation method for India.

3.4 Result calculation

Principle of the result calculation is that frequency of odorous observations are calculated. According to prEN 264086:2008 part 1, observation is calculated to be odorous observation if at least 10 % of the single measurement records are odorous. Number of odorous observations are divided with number of observations and multiplied with 100. Total odour frequency (relative frequency) is calculated using all odour intensity records (intensity scale from 1 to 4). Frequency of at least clear odour is calculated using intensities from clear to extremely strong odour (intensity scale from 2 to 4). If needed, frequency of extremely strong odour can be calculated using only such intensity records (intensity scale 4).

4. Case studies in India

Odour assessment case studies were performed twice with different location and participants. The first site was located in Gujarat and the second site in Uttar Pradesh. Participants were Indian environmental authorities, site managers and Finnish experts. Case studies were performed for introducing observation and calculation styles of the modified field investigation method. The Sense of Smell of participants was not tested before case studies.

4.1 Site description

The first Site was a landfill of industrial hazardous waste in Gujarat. Area includes two waste incinerators and a landfill area. Biodegradable waste is combusted in the incinerators and non-biodegradable waste is dumped onto landfill area. Landfilled industrial waste produces some times a landfill gas which may contain e.g. hydrogen sulphide or methyl mercaptane. Emitted gases may cause odours in the vicinity of the site.

The second Site was an integrated Pharmaceutical and chemical company in Uttar Pradesh. The company manufactures pyridine and picoline following bio-route using ethanol from molasses as the region is rich in sugarcane production. The plant uses several chemicals and has focused on conservation of resources (chemical usage), energy conservation (co-generation and waste heat boilers) and water conservation. Emissions of the pyridine plant included ammonia and the odour of ammonia was defined in the case study.

4.2 Site-specific adaptation of the method

In the Site 1 the odour assessment was done at two locations inside the landfill area. The first measurement point was located at 20 metres from odour source landfill area. The second measurement point was located at 200 metres distance from the source. All 20 participants were asked to independently fill the format for absence or presence of sensed odour along with its type and intensity. Odour intensity data for 10 minutes at each location were collected.

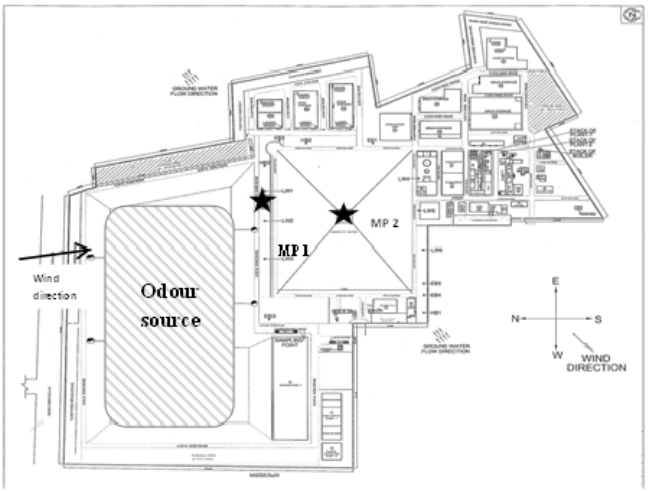


Figure 2. Site 1, landfill of industrial hazardous waste. Recorded wind direction, odour source area, odour measurement points 1 (MP 1) and 2 (MP 2). (Picture source: Gujarat State Pollution Control Board)

In the Site 2 the modified field investigation method was demonstrated inside the industrial area, near to pyridine plant number 2. Distance to plant was about 50 to 70 meters. Odour quality was solvent and sometimes mixed with ammonia. Participants observed odour intensities according to method for 10 minutes. Only one measurement point was recorded due to extremely high temperatures which made it impossible to have more measurement points.

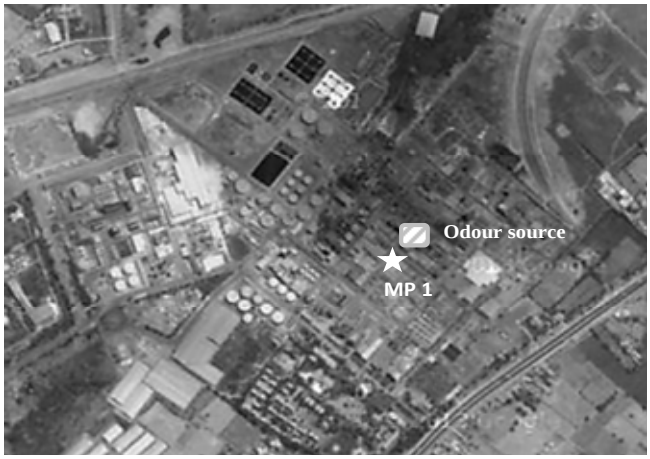


Figure 3. Site 2. Pharmaceutical and chemical industry. Odour source area and odour measurement point (MP 1).

4.3 Results and discussion

Result calculations of each measurement points are shown in Tables 1-3. Number of each intensity 'Int.' scale records were calculated for each panellists. Records were changed as odorous/not odorous data using criteria of 10% (prEN 264086:2008 part 1), thus observation was odorous if ≥ 6 records were reached at each studied intensity scale. Total amount of odorous observations were summed as a total 'Tot.'. Daily odour frequency 'F_{daily}' results were calculated as an average.

Table 1: Result calculations of Site 1 measurement point 1, distance to odour source 20 metres. Number of odour intensity observations, calculation of odorous points and daily odour frequency.

Assessor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Tot.	F_{daily}
Number of odour intensity observations																						
Int. 1-4	56	60	60	49	57	57	41	40	44	22	60	43	60	51	59	43	50	43	59	55		
Int. 2-4	27	58	44	19	37	21	10	16	17	11	26	19	22	21	16	17	22	17	16	16		
Int. 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Odorous point (Yes=1, No=0)																						
Int. 1-4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	100
Int. 2-4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	100
Int. 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2: Result calculations of Site 1 measurement point 2, distance to odour source 200 metres. Number of odour intensity observations, calculation of odorous points and daily odour frequency.

Assessor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Tot.	F_{daily}
Number of odour intensity observations																						
Int. 1-4	20	29	24	17	0	11	25	14	35	10	20	25	20	42	35	3	49	54	24	48		
Int. 2-4	1	0	0	0	0	0	4	0	7	0	4	0	4	8	0	0	7	22	3	6		
Int. 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Odorous point (Yes=1, No=0)																						
Int. 1-4	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	18	90
Int. 2-4	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	1	5	25
Int. 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3: Result calculations of Site 2 measurement point 1, distance to odour source 50-70 metres. Number of odour intensity observations, calculation of odorous points and daily odour frequency.

Assessor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Tot.	F_{daily}
Number of odour intensity observations																		
Int. 1-4	60	44	54	45	60	35	55	57	60	60	60	54	60	49	46	37		
Int. 2-4	42	15	36	24	41	9	26	35	39	42	60	20	34	12	7	2		
Int. 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Odorous point (Yes=1, No=0)																		
Int. 1-4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	100
Int. 2-4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	15	93
Int. 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The results of Site 1 having two measurement points indicate that at measurement point 1 the frequencies of total and clear odour were 100 %. At the measurement point 2, the frequency of total odour was 90% and frequency of clear odour was 25% around this site. Extremely strong odour was not observed. Variation in presence and intensity of odour was observed between two locations, which may be attributed to distance from the source and prevalent wind direction. The results of Site 2 with one measurement point were that daily frequency of total odour was 100 % and frequency of clear odour was 93 %. Extremely strong odour was not observed.

Measurement points in both cases were inside the industrial area which explains assessed high odour frequency results. Odour frequency results showed that this modified method can be used for measuring odour frequencies of total odour and at least clear odour intensities. Odour intensities of extremely strong odours were not detected during these case studies and usability of that scale couldn't be seen.

5. Conclusions

Experience on these case studies was encouraging beginning of odour measurements in India. Indian experts were delighted to have odour measurement method which can separate weak and strong odours in digital form without technical facilities or deep expertise. Indian experts will begin to use the described modified field investigation method and after few years of expertise Indian authorities can see whether the method fills their needs for ambient odour measurements or should the method be changed to meet more European field investigation methods. Operation plans for the next years in India related to odours are to share odour management and measurement knowledge between central and local authorities in order to be able to tackle existing odour issues. One proposed action was to establish an Odour Monitoring Cell which would be an odour expert group in CPCB. Issues to be processed in the near future are the adoption of methods for odour measurements (e.g. modified field investigation method and population investigation), procurement for olfactometry facility according to EN 13725 and training the assessors for field investigation methods.

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