ESTIMATION OF HAZARD ODOR DISTANCES IN AGROCHEMICAL INDUSTRIES: CASE STUDY

Pampana Anil Kumar Assistant Professor, Department of Chemical Engineering, UCEK (A), JNTUK Kakinada, Andhra Pradesh, India. anilkumarchemical801@gmail.com
Pichikala Varsha Assistant Professor, Department of Petroleum Engineering, UCEK (A), JNTUK Kakinada, Andhra Pradesh, India.
Janipelli Surya Teja Student, Department of Petroleum Engineering, UCEK (A), JNTUK Kakinada, Andhra Pradesh, India.
K. Akash Student, Department of Petroleum Engineering, UCEK (A), JNTUK Kakinada, Andhra Pradesh, India.
Sangharsh Kiran Matta Assistant Manager, Coromondal International Limited, Kakinada, Andhra Pradesh, India.
S S Srimanth Varma Student, Department of Chemical Engineering, UCEK (A), JNTUK Kakinada, Andhra Pradesh, India.
K.V. Rao Adjust Professor, Department of Petroleum Engineering, UCEK (A), JNTUK Kakinada, Andhra Pradesh, India.

ABSTRACT

Odor, is refers to the unpleasant smells and is considered as an important environmental pollution issue. Attention to Odor as an environmental nuisance has been growing as a result of increasing industrialization and the awareness of peoples need for a clean environment. The main objective of this study is to eliminate the air emissions from the pesticide manufacturing units of Dichlorvos and Profenofos (3 MT/day) and to model the emissions for calculating the Odor distances. To suggest and recommend remedial measures wherever the emissions odor pollutants that exceed the permissible exposure limits or the distances to reach odor threshold values involving residential/ populated areas.

Keywords:
Odor, Air Emission, Pollutants, Dichlorvos and Profenofos.

1. Introduction:

Odor, which refers to unpleasant smells, is considered as an important environmental pollution issue. Attention to Odor as an environmental nuisance has been growing as a result of raising industrialization and the observance of people's need for a clean terrain [1]. As a consequence, efforts to abate Odor problem is the technique for the detection of Odor emissions, Detection is an important aspect concerning compliance with environmental regulations since the detection results will be used as an evidence of the release of odorous substances to the terrain. There's a growing tendency in industriousness to develop a finding system that enables real time measures [2]. In this way, a simple and quick online monitoring system can be established and time consuming methods are avoided.

Presently, it is not easy to develop analytical procedures for multi-component pollutants in the emissions from pesticides or the bulk drug industry as such they are very complicated and not reliable. Unfortunately, the on-line monitoring systems for chemicals like Tri-methyl Phosphite (TMP), Dichloromethane, n-propyl bromide, bromine, and tri-methyl amine (TMA) are not available in India.

The main objective of this study is to eliminate the air emissions from the pesticide manufacturing units of Dichlorvos and Profenofos (3 MT/day) and to model the emissions for calculating the odor distances. To suggest and recommend remedial measures wherever the emissions odor pollutants that exceed the permissible exposure limits or the distances to reach odor threshold values involving residential/ populated areas.

2. Methodology for estimating the air emissions

Several air emission sources have been identified for the Manufacturing operations in the two units. They are as follows [3-5]:

- Storage tanks
- Process operations including solvent recovery
- Equipment leaks
- Wastewater collection and treatment.

A hybrid model comprising of emission factors, materials balance and engineering equations has been used to access the emissions from various operations of the production units. The process stages for both the units are studied and material balances are carried out. Flow streams from one stage to the other in each unit are determined. The losses of chemicals from the storage tanks, fluid transfer operations, reactors, condensers vents including the losses due to leakages through valves, flanges, and other fittings are calculated [6].

To estimate the concentration of each odor-emitting chemicals in the air as a results of emissions from the process equipment, storage tanks and other sources mentioned above, depression models (Both contained puff) are used in conjunction with Air Odor Threshold (AOT) values of the chemicals under study. The AOT values of the imported chemicals involved in the two units are given in table-1. The distances along with the wind direction are determined for each chemical to reach the odor threshold value [7,8].

Air Dispersion Models used in the Present Work

Plume release (continues model): For a continuous point release at the ground level, steady state is assumed. For centre-line concentration C (s, 0, 0) is in the direction of wind is given by [9,10]:

$$C(x, 0, 0) = Q/(3.14*\sigma_y*\sigma_z*u) \quad (1)$$

For release at height H:

$$C(x, 0, 0) = [Q/(3.14*\sigma_y*\sigma_z*u)]\,[\exp(-II/2\,\sigma_z^2)] \quad (2)$$

Instantaneous release (puff model): If the release of chemicals is for brief time during transfer of chemical to batch tanks/ reactors, this model is used.

The maximum concentration, $C(u_t, 0, 0, t) = 2*Q/[(2*3.14)^{3/2} *\sigma_x *\sigma_y*\sigma_z]$ (3)

Where, Q = continuous mass rate of release, kg/s and σ_x, σ_y, σ_z = Dispersion coefficients in x, y, z directions.

A computer program written in BASIC has been used to calculate the concentration profile of the chemical vs distance using the chosen dispersion model and other conditions.

3. Manufacture of Dichorovos

The process flow diagram for manufacturing of DDVP is given in figure 1.0., the raw materials used for the manufacture of DDVP are Chloral and Tri-methyl Phosphate. The odor distances for several chemical emissions from various equipment in the unit have been emitted. But, the results of the most odorous chemical in this process, Tri-methyl Phosphate (TMP) are presented in the following.

Calculations of Working Losses During Storage Tank Filling

The concentration profile of TMP along with the horizontal distance towards the wind direction is given in the table 1.

Table 1: Odor Distances for TMP (AOT: 0.0001 ppm) - M* = 7.8212 * 10^{-4} kg/s (Puff model at stable conditions)

Distance, m	100	200	300	400	500	800	1000	1400	1500
Ppm	0.11166	0.01801	0.00619	0.00291	0.00162	0.00047	0.00026	0.00011	0.00008

Calculation of breathing losses & losses from the Storage Tanks

The concentration profile of TMP along with the horizontal distance towards the wind direction is given in the following table 2.

Table 2: Odor Distances for TMP from Leakages and Breathing Losses (AOT: 0.0001 ppm); M* = 33.897 * 10^{-6} kg/s. (Continuous Model at stable condition)

S.No.	Distance, m	Air velocity, m/s	Ppm	Air velocity, m/s	Ppm
1	100	3	0.02630	1.5	0.05260
2	500	3	0.00190	1.5	0.00380
3	1000	3	0.00061	1.5	0.00123
4	1500	3	0.00031	1.5	0.00063
5	2000	3	0.00019	1.5	0.00039
6	2500	3	0.00013	1.5	0.00027
7	3000	3	0.00011	1.5	0.00020
8	4000	3	0.00006	1.5	0.00012
9	4500	3	0.00005	1.5	0.00001

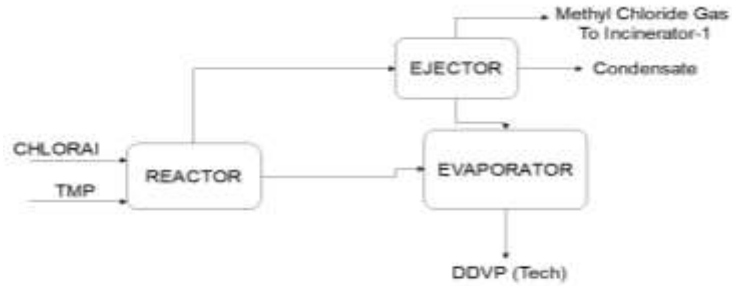

Fig 1: Process flow diagram for Dichlorovos (DDVP)

4. Manufacture of Profenofos

The process flow diagram for manufacturing of Profenofos is given in Figure 2.0. The emissions into air from the Profenofos units are mainly due to the storage, transfer in batch tanks and processing of bromine, mono-chloro benzene, 30% aqueous tri-methyl amine, n-propyl bromide, and hydro bromic acid. The losses of chemicals into air are estimated. The estimations include leakages through valves and flanges etc., of the storage tanks, batch tanks and reactors; emissions from the vents of the reactors/process equipment, process and ejector condensers. The odor distances for several chemical emissions from various equipment is the unit have been estimated. But, the results of the most odours chemical in this process, Tri-methyl Amine (TMA) are presented here. The results of emissions of TMA from the valves of storage tanks are given in table 3. and the results of emissions from surface evaporation of TMA (Ejector water condenser) are given in table 4.

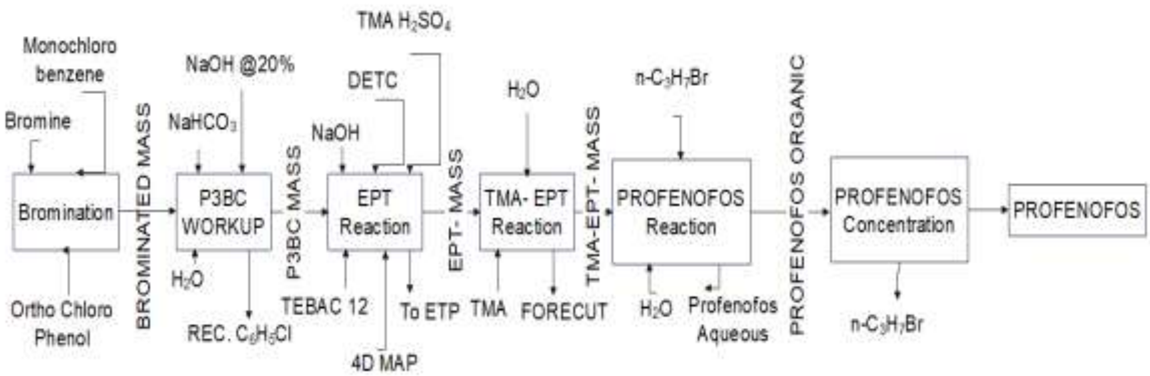

Fig: 2 Process flow diagram for Profenofos

Table 3: Odor Distances for TMA (AOT: 0.00044; M* = 5.0221 * 10^{-7} kg/s.)
(Continuous Model at stable condition)

S.No.	Distance, m	Air velocity, m/s	ppm	Distance, m	Air velocity, m/s	ppm
1	10	3	0.035110	10	1.5	0.070227
2	50	3	0.002539	50	1.5	0.005079
3	100	3	0.0008194	100	1.5	0.001638
4	200	3	0.0002644	200	1.5	0.000529
5	250	3	0.000184	250	1.5	0.000367

Table 4: Odor Distances for TMA (AOT: 0.00044; M* = 4.7375 * 10^{-4} kg/s)
(Continuous Model at stable condition)

Distance, m	50	100	1000	3000	5000	7000	9000	10000
Ppm	2.39560	0.77290	0.01800	0.00300	0.00130	0.00075	0.00049	0.00042

5. Discussions

Six Chemicals listed in table 5 have been identified as odorous substances. The AOT of each chemical is taken as criterion to evaluate the odor pollution from the two manufacturing facilities. A hybrid model is used to determine the odorous distances from the emission rates estimated for each odor compound. The results show that there is a serious odor pollution from two chemicals, Tri-methyl phosphate (TMP) in Dichlorvos unit and Tri-methyl amine (TMA) in Profenofos unit.

Table 6: AOT values of Chemicals

S.No.	Name of the Chemical	AOT (ppm)
1	Trimethyl amine	0.00044
2	Bromine	0.051
3	Chloral	0.047
4	HBr	2
5	Monochlorobenzene	0.68
6	Trimethyl Phosphate	0.00010

TMP emissions in the storage tank filling operation resulted in about 1.5 km odorous distance. Similarly, the odorous distance from emissions through leakages and breathing losses is about 3 km with the air velocity of 3 m/s and at a velocity of 1.5 m/s the value is calculated to be 4 km. For the TMA emissions due to surface evaporation from the ejector condensate seal pot, the calculations show as odorous distance of about 10 km and a distance of 25 km from the emission due to leakages. The model might have over-predicted value of the distances, even the actual valves are 50% of the theoretical predictions, odor pollution is alarming in both the cases. The variations of odor distances as shown in figure 3.0. and the figure 4.0. which depicts the odor distances for TMP from leakages and breathing losses. For TMA Both the bulk storage and batch tanks in the units need inert gas marketing to prevent emissions and thus odor. This simple measure will reduce the emissions of TMP is a harm minimum.

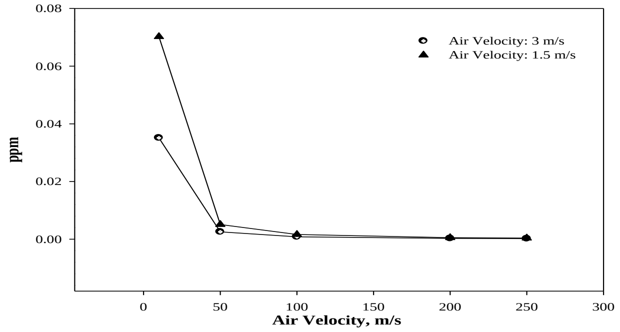

Fig. 3.0. The variations of odor distances (AOT: 0.00044; M* = 5.0221 * 10^{-7} kg/s.) (Continuous Model at stable condition)

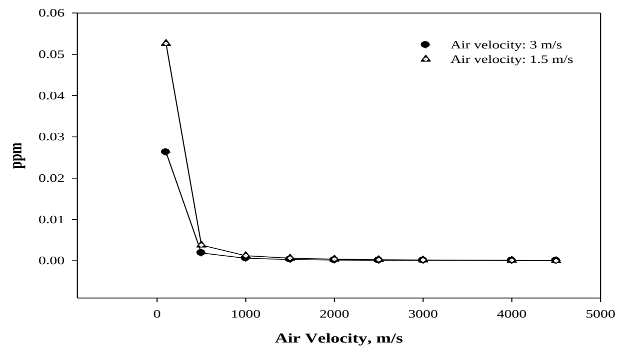

Fig. 4.0. The variations of odor distances for TMP from leakages and breathing losses (AOT: 0.0001 ppm); M* = 33.897 * 10^{-6} kg/s. (Continuous Model at stable condition)

A good TMA scrubber operating procedure should be evolved in the Profenofos unit. The following measures will certainly minimum the levels of odor concentrations of TMA,

- The concentration of sulphuric acid should be increased. Constant monitoring of the concentration of the acid required.
- Process modifications may be affected in the distillations system by providing acid traps/ scrubber to catch the escaping quantities of TMA to the ejector systems.

6. Conclusions

Odor distances are estimated from the emission data using air dispersion models and air odor threshold values.

REFERENCES

1. Shinde Raharam B., Gawande Sagar, Study and Analysis of Odour of Hydrogen Sulfide and Ammonia Gas within Kurkumbh Industrial Area, International Journal of Science and Research (IJSR), Volume 6 Issue 4, April 2017, pp 1390-1395.
2. N. G. Hansen, K. Rindel; Bioscrubbing, An effective and economic solution to odour control at wastewater treatment plants. Water Sci Technol 1 March 2000; 41 (6): 155–164. doi: https://doi.org/10.2166/wst.2000.0105
3. Card, T. R. 1998. Fundamentals: Chemistry and Characteristics of Odors and VOCs. In Odor and VOC Control Handbook, ed. H. J. Rafson, Ch.2, 2.1-2.36. McGraw Hill, New York.
4. Cheremisinoff, P. N. 1992. Industrial Odour Control. Butterworth Heinemann, Ltd. Oxford.
5. Corsi, R. L. and D. A. Olson. 1998. Emissions Model. In Odor and VOC Control Handbook, ed. H. J. Rafson, Ch.5, 5.11-5.25. McGraw Hill, New York.
6. Emission Estimation Technique Manual for Solvent Recycling, National Pollution Inventory, Australia, July 1999.
7. Pasquill, F., Atmospheric diffusion, 2nd Edition, Wiley, New York, 1974.
8. Stephenson, R. M and S. Malanowski, Handbook of the Thermodynamics of Organic Compounds, Elsevier, New York, 1987
9. Measuring odours in the environment vs. dispersion modelling: A review by Laura Capelli, Selena Sironi, Renato Del Rosso, Jean-Michel Guillot.
10. Bonanni, E. A. 1998. The Addition of Chemicals to Liquid to Control Odors. In Odor and VOC Control Handbook, ed. HJ Rafson, Ch.8, 8.2-8.17. McGraw Hill, New York, USA.