Developing an Effective Exposure Assessment Tool for Estimating Odour Annoyance from Point Sources of Air Pollution

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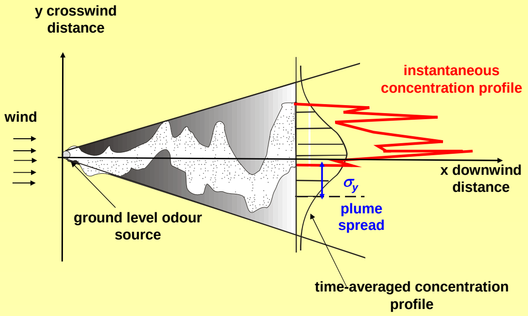
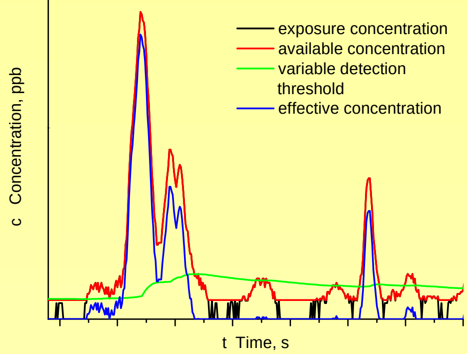
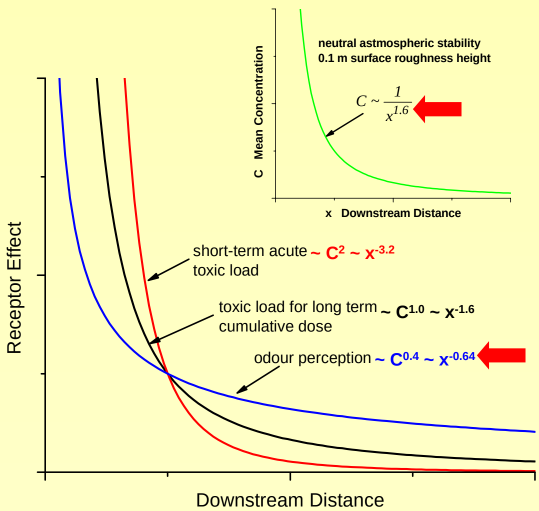
Odour annoyance is an air quality issue that usually receives little attention in the planning stages of an industrial or agricultural development project. But, once a new development is in place its most obvious effect on the population is from the noxious or unfamiliar odours that it creates. These odours can significantly reduce quality of life, and often affect local property values. Because the human nose has a highly non-linear sensitivity that allows people to detect even tiny concentrations of an unfamiliar odour, efforts to reduce odour emissions to socially acceptable levels are often doomed to failure once a new facility is in operation. Avoiding the social and political problems that odours can cause requires an effective method to assess the odour annoyance potential of new industrial and agricultural developments (refineries, livestock feedlots, fish farms etc.) Current methods for assessing the likely effect of odours are inadequate because they use only the time-averaged concentration of odourous compounds in a pollution plume. This approach fails to take into account the way in which people actually respond moment-by-moment to time-varying levels of the odour concentration.



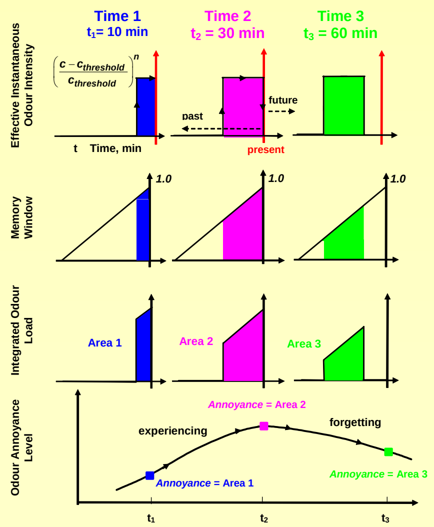
MODEL ELEMENT #1 Concentration fluctuations and intermittent periods of zero concentration are simulated using random time-series modelling, or direct water channel or wind tunnel modelling. *(Here we used direct water channel fluorescent dye plume modelling) For random time series generation methods see: Hilderman, T.L. and Wilson, D.J. (1999) Simulating Concentration Fluctuation Time Series with Intermittent Periods and Level-Dependent Derivatives, Boundary Layer Meteorology, 91, 451-482.*



MODEL ELEMENT #3 Loss of odour detection sensitivity by high peak concentration that desensitize the nose, followed by slow recovery of sensitivity during periods of low concentration. *For time constants of these processes see Cain, W.S., 1974. Perception of odor intensity and the time-course of olfactory adaptation. ASHRAE Trans., 80, 53-75. See also Berglund, U., 1974. Dynamic properties of the olfactory system, Ann. N.Y. Acad. Sci., 237, pp. 17-27. Adaptation is discussed in: Wang, L., Walker, V. E., Sardi, H., Fraser, C., and Jacob, T. J. C., 2002. The correlation between physiological and psychological responses to odour stimulation in human subjects, Clinical Neurophysiology, 113, pp. 542-551*

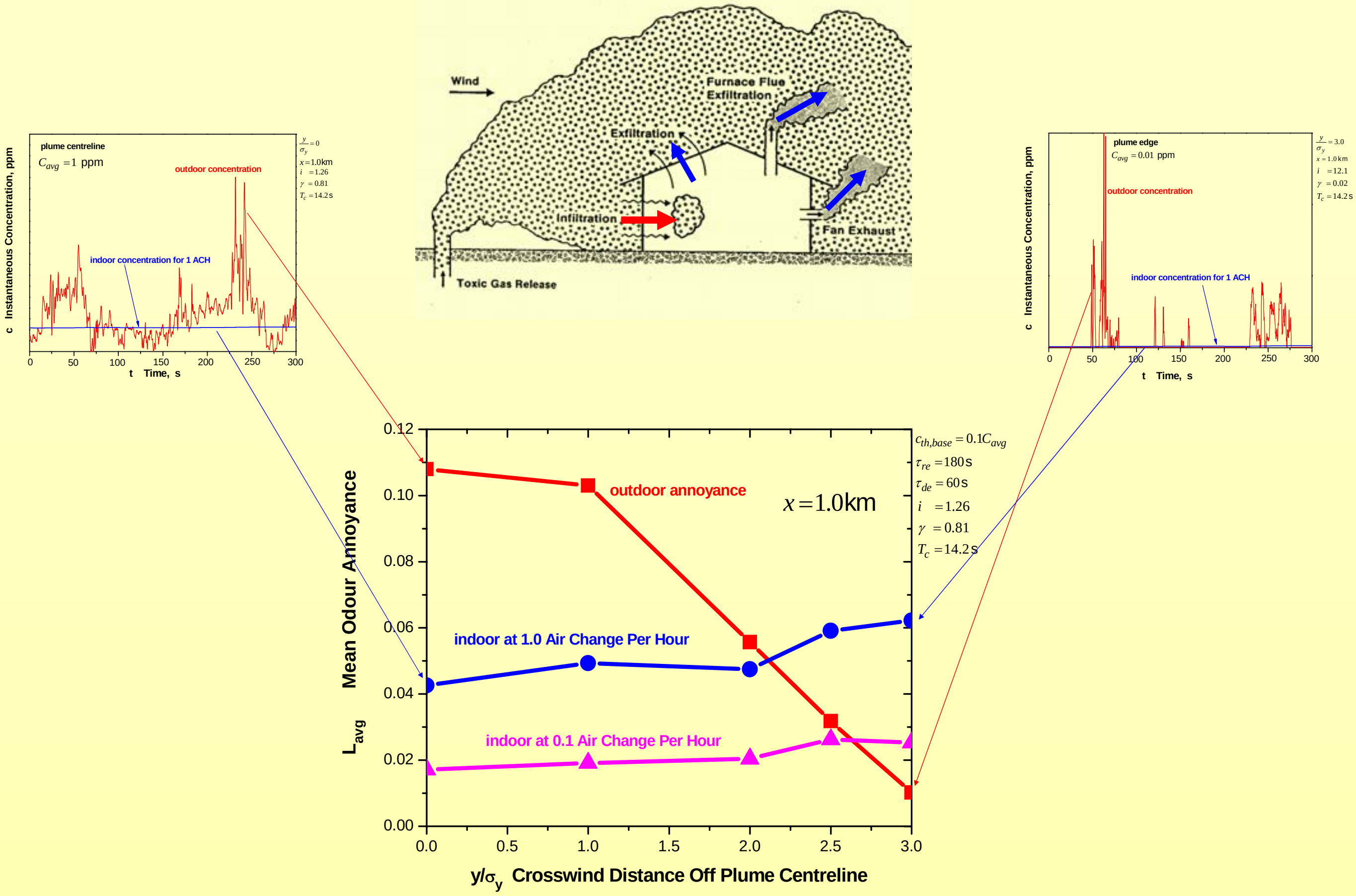


MODEL ELEMENT #2 Non-linear sensitivity of perceived odour intensity I to concentration. *We chose Steven's a power-law model, rather than the logarithmic response model. The two models give very similar results. In our model* ***$I = kC^n$*** *is the perceived odour intensity (5=very strong, 4=strong, 3=easily recognizable 2=perceptible, 1=faint), k is a constant for each chemical, and C is the instantaneous concentration, n is the Stevens' exponent (n~0.2 to 0.8, with n=0.4 shown on the figures here. See Stevens, S.S., 1960. The psychophysics of sensory function. American Scientist 48, pp 226-253.*



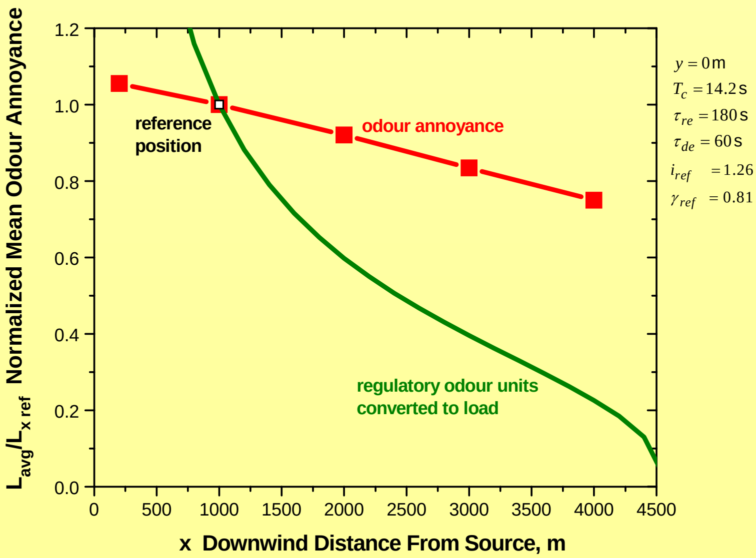
MODEL ELEMENT #4 Forgetting your annoyance level with passing time. *We propose here a simple linear decay of annoyance memory that gradually decreases our annoyance "load". We also propose that the "load" is the area under the odour intensity vs time curve; and that the time-averaged value of this odour annoyance load is a good estimator of relative odour annoyance levels.*

Annoyance "Load" Predictions for a Continuous Ground Level Source of Hydrogen Sulphide



STAYING INDOORS DOES NOT PROVIDE MUCH RELIEF FROM ODOUR ANNOYANCE

Time-averaged indoor annoyance "load" remains high even at the edge of the plume where the time-averaged ground level concentration has been reduced to only 1% of the centerline concentration and non-zero concentrations are present only 2% of the time! The decreased annoyance of outdoor concentrations at the edges of the plume is due primarily to the large fraction of the time that the outdoor concentrations are zero.



ODOUR ANNOYANCE PERSISTS MUCH FURTHER DOWNWIND THAN CURRENT MODELS PREDICT

Concentration peaks produce annoyance "load" even when the mean concentration has decreased by a factor of 10 between 1 km and 4 km downwind distance from the source. At 4 km the odour load is still 80% as severe as it was at 1 km. Current regulatory models predict that the odour annoyance should decrease by a factor of 5. This suggests that odour annoyance will be severe over a much larger area than expected.