Derivation of Cumulative Annual Average NO_x to NO_2 Conversion Equation using Jenkin Method

Jenkin Method for Long-term Cumulative NO_2 Assessment

With reference to the *Review of Methods for NO to NO_2 Conversion in plumes at short ranges*[1], Jenkin method was adopted for the conversion of cumulative annual average NO_x to NO_2 by using the functional form of annual mean of NO2-to-NOx. The mentioned functional form is referenced from Jenkin, 2004a[2] and is presented below:

$$[NO2] = \frac{\left([\mathrm{NOx}] + [\mathrm{OX}] + \frac{\mathrm{J}}{\mathrm{k}}\right) - \sqrt{([NOx] + [OX] + \frac{J}{k})^2 - 4[NOx][OX]}}{2}$$

where

$[NO_2]$	is the NO_2 concentration
$[NO_x]$	is the NOx concentration
[OX]	is the sum of NO_2 concentration and O_3 concentration (i.e. [OX] = $[NO_2] + [O_3]$)
J	is the photolysis rate of NO_2
k	is the rate coefficient for reaction between NO and O_3

The above functional form was used to analyze the annual mean data obtained from relevant EPD's air quality monitoring stations (AQMS) including Sha Tin general station, Tap Mun general station and three roadside stations (i.e. Causeway Bay, Central and Mong Kok roadside stations). The recent five years annual mean data are extracted and presented in Annex A. Scattered plot for recent 5 years annual means NO_2 versus NO_x concentrations obtained from relevant AQMS was created. The functional form curve would fit the annual mean data when [OX] = 106.2 $\mu g/m^3$ and J/k = 17.3 $\mu g/m^3$. The value of [OX] and J/k are considered reasonable as they are within typical value range for Hong Kong. The range of annual average [OX] from the selected air quality monitoring stations is 80 – 116 $\mu g/m^3$. The obtained functional form curve was adopted for the cumulative annual average NO_x to NO_2 conversion. The curve is slightly higher than all the annual mean data obtained from AQMS, the calculated annual average NO_2 concentration using the obtained functional form curve based on the measured annual average NO_x obtained from AQMS are presented in Annex A, the calculated annual average NO_2 concentration are higher than the measured annual average NO_2 concentration, no underestimation of the annual average NO_2 concentration is expected.

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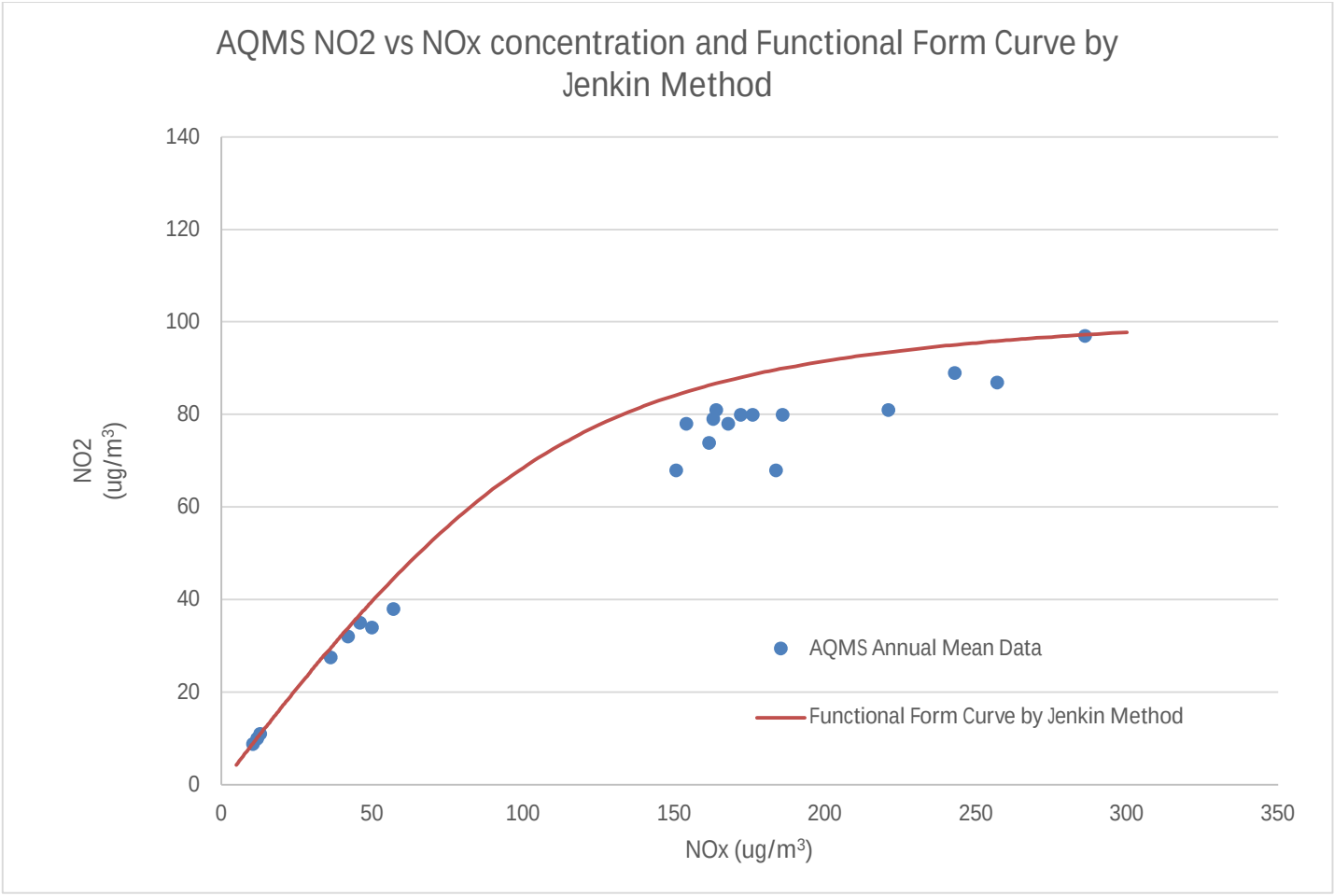
1 Environment Agency. 2007. *Review of methods for NO to NO_2 conversion in plumes at short range*. Prepared by Environmental Agency.

2 Jenkin. 2004a. *Analysis of sources and partitioning of oxidant in the UK – Part 1: The NOx-dependence of annual mean concentrations of nitrogen dioxide and ozone.* Atmospheric Environment, 38, 5117-5129.



For the long-term cumulative NO_2 assessment (i.e. predictions of annual average NO_2 concentration), cumulative annual average NO_x to NO_2 conversion equation for this assessment was calculated as follows:

$$[NO2]_c = \frac{([NOx]_c + 106.2 + 17.3) - \sqrt{([NOx]_c + 106.2 + 17.3)^2 - 4[NOx]_c \times 106.2}}{2}$$

where

$[NO_2]_c$ is the predicted cumulative NO_2 concentration

$[NO_x]_c$ is the predicted cumulative NO_x concentration

Annex A

Annual Average NO_X, NO_2 and OX concentration in Recent Five Years (Year 2016 – 2020) at Selected EPD AQMS

AQMS	Year	Measured NO_x ($\mu g/m^3$)	Measured NO_2 ($\mu g/m^3$)	Measured NO2 + O_3 ($\mu g/m^3$) Named as [OX]	Calculated NO_2 using the functional form curve based on measured NO_x ($\mu g/m^3$)
Sha Tin	2016	57	38	80	45
	2017	50	34	87	40
	2018	46	35	92	37
	2019	42	32	96	34
	2020	36	28	82	30
Tap Mun	2016	N/A	N/A	N/A	N/A
	2017	12	10	84	10
	2018	13	11	83	11
	2019	12	10	90	10
	2020	11	9	80	9
Causeway Bay	2016	243	89	105	95
	2017	286	97	115	97
	2018	257	87	108	96
	2019	221	81	110	94
	2020	184	68	98	90
Central	2016	186	78	100	90
	2017	176	80	107	89
	2018	186	80	105	90
	2019	172	80	116	88
	2020	151	68	103	84
Mong Kok	2016	168	78	96	87
	2017	164	81	105	87
	2018	163	79	106	87
	2019	154	78	110	85
	2020	162	74	104	86