Environmental Impact Assessment With Respect To Ambient Air Quality in the Neighbourhood of A Typical Thermal Power Plant - A Case Study

[1]Dr. S. Mohan
Associate professor,

[2]Dr. S. Palanivelraja,
Professor
Deptofcivilengineering
,Faculty of Engineering&Technology
Annamalai University-Chidambaram
Tamilnadu,India-608002

[3] Dr. M. P. Chockalingam,
former Professor and Head,

***ABSTRACT*- A short term air quality survey was conducted for a period of about 20 days at Cuddalore , from 21.08.1987 to 10.09.1987, in the neighborhood of the proposed location of the Cuddalore Thermal power plant. Ambient air concentrations of the 3 major pollutants relevant to the Thermal power plant situation, namely, Sulphur Dioxide (SO_2), Nitrogen Dioxide(NO_2) and Suspended Particulate Matters (SPM) were measured on a continuous basis , in order to gather the baseline air quality data in the area . Nine sampling stations were operating at a time. The air concentrations of SO_2, NO_2, and SPM measured in the neighborhood of the proposed Cuddalore Thermal Power Plant site, during a 20-days experimental period in August-September 1987 were found to be well below the Ambient Air quality standard prescribed by the Government of India.**

INTRODUCTION

There are number of problems associated with use of fossil fuel, such as pollution and green house effect [1, 2]. The issue of air pollution brought into attention in fourteen century, as combustion of coal caused air pollution [3]. Dispersion of carcinogenic chemicals reported to be as major source of pollution [4, 5]. Nowadays, the fossil fuel still is the major source of energy. Combustion of fossil fuel with sulfur content generates carbon monoxide, carbon dioxide, sulfur oxides and nitrogen oxides [3-6]. In order to reduce global air pollution, industrial zone outside of civilization and residential area were established. Green belt of forest around the civilized area for protection of the environment and reduction of air pollution were suggested [7-9]. The most important sources of fuel for energy conversion in thermal power plant are mainly fossil fuels, coal and natural gas [10-13]. Combustion of fuel generates gaseous products such as CO, SOx and NOx, which are considered major air pollutants. Most power plants using fossil fuel cause tremendous amount of environmental pollution. Elimination of pollution sources by using high quality of fuel would be able to reduce air pollution and to meet the international standards for clean environment [4-6, 14-18]. In industrialized countries, demand for electrical power is rapidly developing. Along with massive power generation, tremendous amount of air pollution is also created. Therefore it is necessitate for assessing the impact of air quality on ambient environment

METHODOLOGY

High Volume Sampler (HVS) were used for the measurement of suspended particulate matter (SPM). Gravimetric method was employed for assessing the SPM concentration in ambient air.SO_2 and NO_2 were measured concurrently, employing a suitably designed bubblers technique similar to the Midget Impinger Assembly. West and Geake method was used for the analysis of SO_2. Modified Jacob & Hochheiser (J-H) method was employed for analysis of NO_2. The air concentration of SO_2 and NO_2were measured for an averaging time of 8 hours, continuously. SPM concentration were measured for an averaging time of 24 hours. The air sampling was done at the rate of 1.15 cubic meter per minute , through the HVS for the measurement of SPM, and at the 1.0 litre per minute through the midget impinge Assembly for the measurement of gaseous pollutants ,namely SO_2 and NO_2 .

Air Sampling Stations

Air sampling instrument were placed at 19 locations situated at various distance from the proposed power plant , in a such a way all the direction –sector were represented. Most of the 19 sampling station were located on the 22.5 degrees direction-sector, with respect to the Power Plant Site. The distance between the sampling station and the power plant site varied between 2.7 kilometers and the 8.8 kilometers, thus ensuring immediate neighborhood of the power plant and the distant locations within a radius of 10.0 kilometers are represent in the air quality survey.

Nine sampling station were operating at the time in such a way that the entire land area around power plant site is represented , within 5.0 kilometer radius in the first

setting and within 10.0 kilometer radius in the second setting. Figure -1 represent the detail of the relative location of these sampling stations with represent to proposed power plant site and gives the details of distance and direction sector, for each station, with respect to the power plantsite

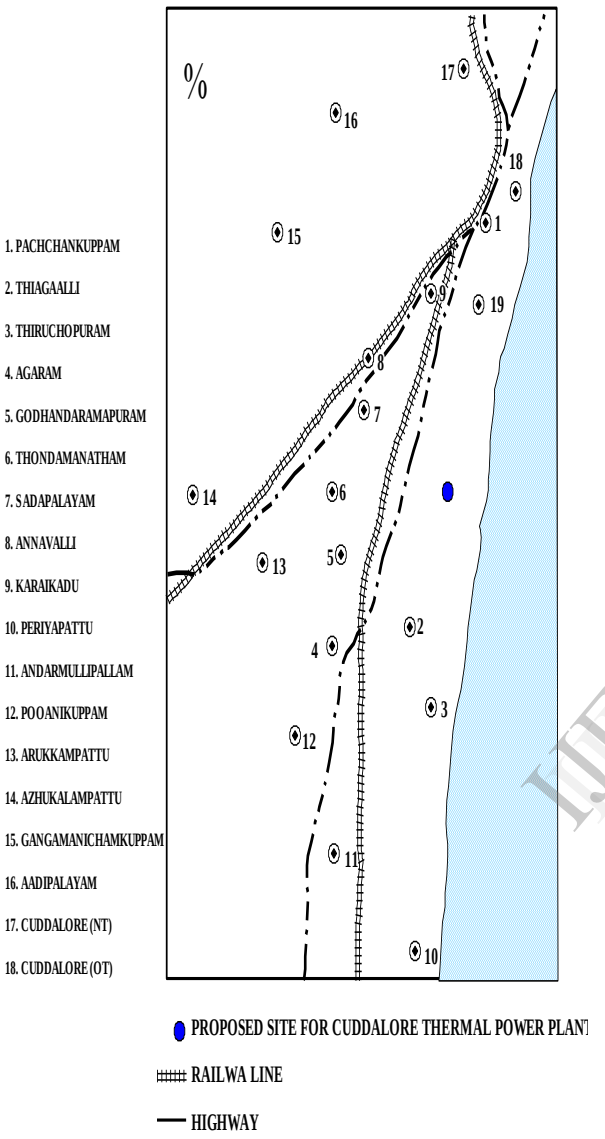

Figure – 1: location of the sampling stations with represent to proposed power plant site

RESULTS:

The summary of the baseline data of air quality prevailing in the neighborhood of the site proposed for the Cuddalore Thermal Power Plant is presented in table -1 indicating the maximum and the minimum of 8 hours SO_2 concentration, 8-hour NO_2 concentration and 24 –hour SPM concentration as measured in all the 19 sampling station. The following trends are indicates in the base line data gathered during August –September 1987

1. The maximum 8-hour SO_2 concentration (21.0 µg/m3) was measured at station 10 (Periyapattu village, located at about 8.8 kilometer south of the power plant site).

2. The maximum 8-hour NO_2concentration (16.5 µg/m3) was measured at station 19 (neighborhood of Vanavil Dyes & Chemicals) located at about 3.6 kilometers North of the power plant site. This sampling station can be considered to represent the middle location of the SIPCOT Industrial Estates at Cuddalore

3. The maximum 24-hour SPM concentration (60.0 µg/m3) was measured at station 17 (cuddalore New Town ,Hotel Dwaraka location) situated at about 8.0 kilometers North of the power plant site. The higher concentration of SPM (60.0 µg/m3) measured at this particular station ,in contrast to the other sampling station , can be remembered in the light of the fact that some construction work was in progress in the neighborhood during the period of air sampling.

4. the trend of the variation of individual readings of8-hour SO_2, 8-hour NO_2 and 24-hour SPM shown that the present air quality prevailing in the neighborhood of the proposed Cuddalore Thermal Power Plant site is in the compliance with the National Ambient Air Quality Standards prescribed by the Government Of India

5. The meteorological data available for the period of experimentation during August – September 1987 indicates that the wind speed varied from calm (no-wind) situation to a maximum of 7.22m/sec (26.0 kmph), the ambient air temperature varied from 24.2° C to 37.4° C and the Relative Humidity varied from 42.0 percent to 100.0 percent, and the winds have been blowing from almost all directions-sectors (expecting the direction-sectors : North, North-North East, North-East and East).the prevalence of these wind directions would imply that the pollutants emitted from the industrial sources existing in the cuddalore SIPCOT Industrial Estate would have exerted an impact over the ambient air quality measured during the experimental period of 20 days in August – September , 1987, as the sampling station were located all around, and

the baseline air quality measured in the area during this period could reflect the impact due to emission from the existing industrial source. Even under the influence of the existing industrial emissions, the background air quality presently prevailing in the cuddalore area seem to be in compliance with the ambient air Quality Standards prescribed by the Government of the India

Prediction of Future Air Quality

When the proposed 3*210 MW coal-fired power plant is commissioned at cuddalore , during stage-1 of the project, the emission rate will be 9.98X10*8 µg/sec of SO_2,9.95X10*8 µg/sec of NO_2, and 1.77 X 10*8 µg/sec of particulate matter (assuming ESP'S dust removal efficiency @ 99.5 percent).

Computer simulation modeling calculation indicate that the SO_2 , NO2 and particulate matter emitted from the proposed 630 MW Thermal Power Plant at cuddalore would not exert any significant impact on the ambient air quality in the area around the power plant, considering downwind distances up-to 50.0 kilometers(please see Table-2). The physical stack height to be the provided for in the design is 275.0 meter which is in accordance with the recommendation of the Government of India , as per their revised guidelines.

In the Gaussian diffusion model employed in this study, for the purpose of prediction future air quality in cuddalore area, both long-term and short term meteorological data have been used .Mathematical modeling procedures have examined the worst air pollution situation that might arise under various combinations of atmospheric stability categories , wind speeds and other pertinent meteorological parameters. The possibilities of surface inversion occurrence and subsidence inversion occurrences have been considered, from the view point of air pollutant dispersion. Mean Mixing Depth were decided, depending upon the height at which the plume loses its ability to penetrate the cap of inversion, due to decreasing rate of buoyancy and momentum forces during its upward travel. In this approach, Mean Mixing Depth of 300.0 meter to 3000.0 meters have been considered while assessing the influence of mixing height over the dispersion of pollutants. Any mixing height less than the stack height (275.0 meters, in the present case) would be only help keeping the plume above the inversion layer, and the dispersion will be favorable.

Referring to Table -2, it can be seen that the maximum concentrations of pollutants would occur at a downwind location of 4.5 kilometers from the power plant, when a wind speed of 4.17 m/sec (15.0 kmph) prevails under the atmospheric stability class D (neutral atmosphere), in which case , the maximum 1- hour SO2concentration would be 23.0 µg/m^3, the maximum 1-hour NO_2 concentration would be 22.9 µg/m^3, and the 1-hour maximum SPM concentration would be 4.08 µg/m^3. These 1-hour maximum concentration would correspond to a maximum 8-hour concentration of 10.0 µg/m^3 in the case of SO_2, 9.8 µg/m^3 in the case of NO_2, and 24-hour maximum SPM concentration of 1.47 µg/m3 likely to occur at various sampling station chosen for the study , due to emissions from the initial units of 3*210 MW, on completion of stage -1.

Superimposing the estimated maximum concentration over the measured maximums, in respect of every sampling station, the future maximum concentrations likely to occur at these 19 locations , when `the 3*210 MW units come into the operation , are shown in Table- 4, based on data show in Table-3 on the completion of stage-1 of the project, or in other word, when the initial electric generation capacity of 630 MW is achieved , the emission from the power plant might cause to occur a maximum 8-hour SO_2 concentration of 28.8 µg/m3 , and a maximum 8-hour NO2 concentration of 25.3 µg/m3 at station 19. The estimated future maximum 24-hour SPM concentration of (61.0 µg/m3) would occur at station 17(Cuddalore New Town, Hotel Dwaraka location).These future maximum concentrations of SO_2, NO_2 and SPM would be individually well below the National Ambient Air Quality Standard prescribed by the Government of India.

CONCLUSIONS

1.The air concentrations of SO_2, NO_2, and SPM measured in the neighborhood of the proposed Cuddalore Thermal Power Plant site, during a 20-days experimental period in August- September 1987 were found to be well below the Ambient Air quality standard prescribed by the Government of India.

2. The results of a mathematical diffusion model, based on computer- aided simulation technique, indicate that the maximum estimated concentration of 8-hour SO_2, 8-hour NO_2, and 24 –hour SPM when superimposed over the measured maximum of respective pollutants will be well below the prescribed Ambient Air Quality Standards, during all the stages of the Cuddalore Thermal Power Plant Project when the electric generation capacity reaches 630 MW.

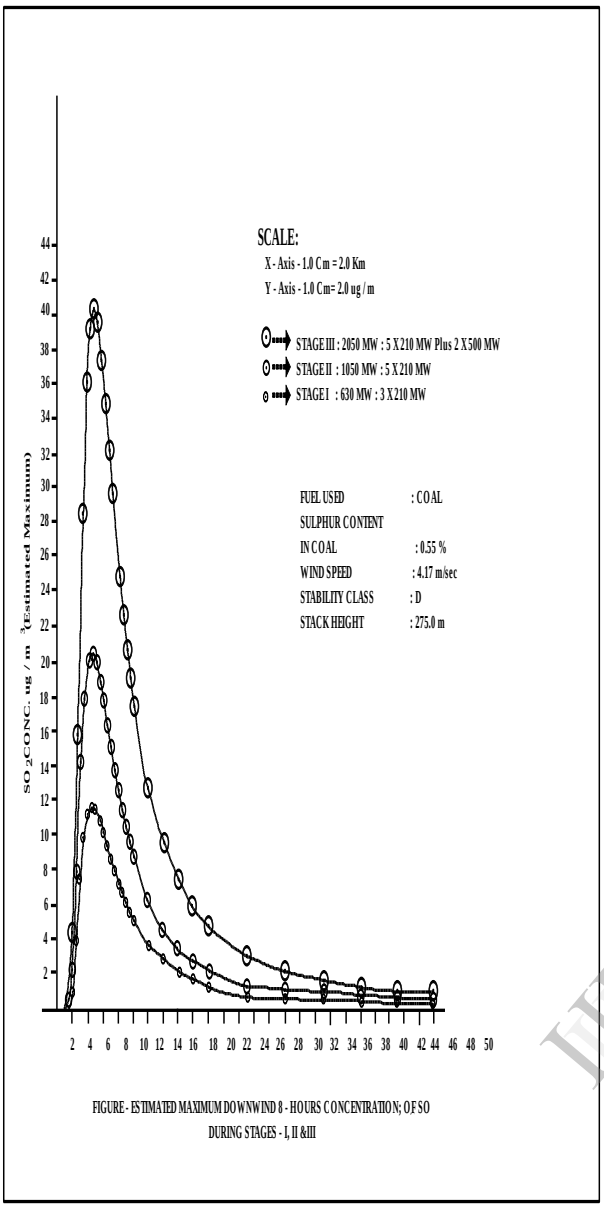

FIGURE - ESTIMATED MAXIMUM DOWNWIND 8 - HOURS CONCENTRATION; OF SO DURING STAGES - I, II &III

FIGURE 2: Estimated Maximum downwind 8-Hours Concentration of SO

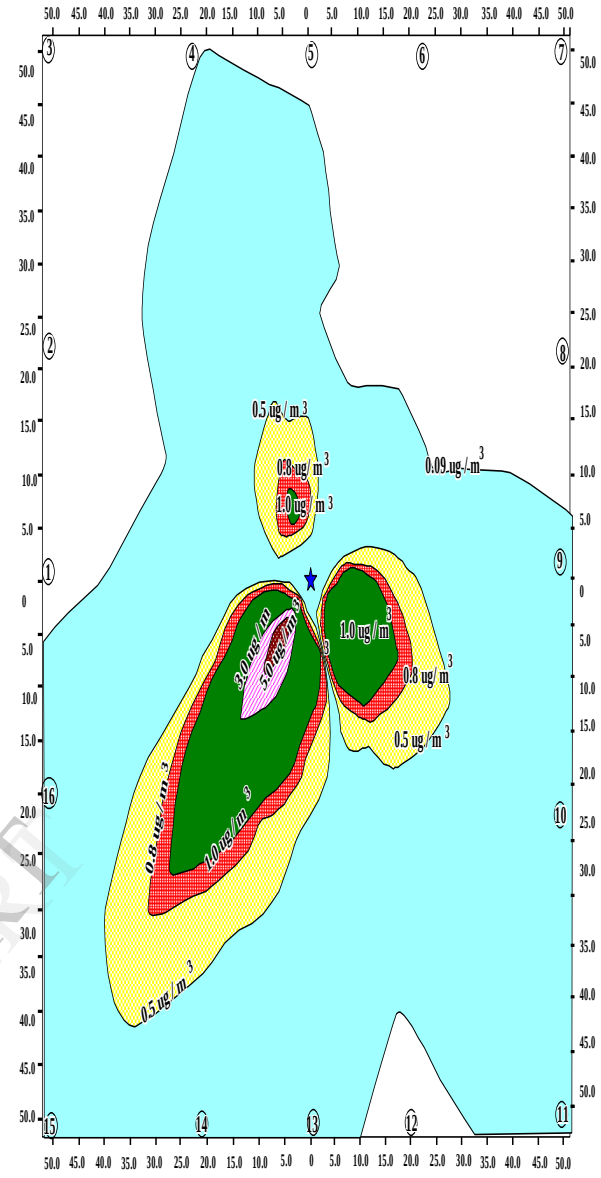

FIGURE 3: POLLUTION ROSE FOR NO_2

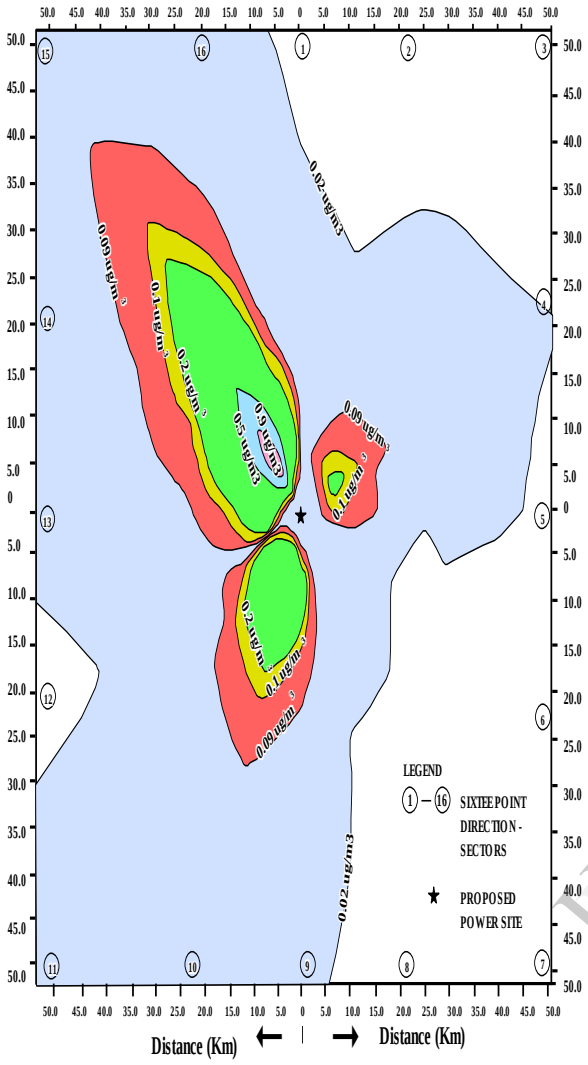

FIGURE: POLLUTION ROSE FOR SPM

FIGURE 4: POLLUTION ROSE FOR NO_2

TABLE :1
TREND OF AMBIENT AIR QUALITY VARIATIONS AT CUDDALORE
DURING AUGUST – SEPTEMBER 1987

AirSampling StationNo.& Name	8 – Hrs. Conc. SO_2 ($\mu g/m^3$)		8 – Hrs. Conc. NO_2 ($\mu g/m^3$)		8 – Hrs. Conc. SPM ($\mu g/m^3$)	
	Max.	Min.	Max.	Min.	Max.	Min.
1.Pachahankuppam	10.0	0.6	7.3	0.5	37.9	24.0
2.Thiagavalli	13.9	4.5	11.0	1.1	29.3	16.8
3.Thiruchopuram	12.7	4.9	9.6	2.9	32.1	20.4
4.Agaram	12.4	1.8	9.8	1.0	33.3	20.4
5.Gadhandaramapuram	15.7	2.3	7.0	0.8	37.2	24.3
6.Thandamanatham	14.2	2.2	7.5	1.5	31.3	19.7
7.Sedapalayam	14.1	7.9	7.2	4.1	35.5	23.7
8.Annavalli	15.8	1.2	9.7	0.9	32.4	21.
9.Karaikadu	18.6	1.6	9.2	0.7	34.3	21.7
10.Periyapattu	21.0	7.6	9.7	5.2	28.2	18.1
11.Andarmullipallam	14.4	7.1	9.2	2.7	32.9	25.5
12.Poovanikuppam	18.3	7.7	9.1	3.2	29.5	19.7
13.Arukkampattu	17.2	6.3	9.1	3.2	27.7	18.7
14.Vazhukalampattu	16.7	7.6	11.2	3.2	27.7	18.7
15.Gangamanichamkuppam	14.9	5.6	13.3	3.1	34.1	21.3
16.Navadipalayam	13.2	503	8.1	2.0	37.0	20.3
17.Cuddalore New Town(Hotel Dwaraka)	14.5	3.8	9.1	1.8	60.0	30.3
18.Cuddalore Old Town (ADE's office)	14.9	4.3	9.8	1.2	48.1	32.1
19.Vanavil Dyes & Chemicals	20.0	9.1	16.5	4.8	34.5	26.5

Note: the maximum and minimum concentrations of pollutants are shown underlined

TABLE: 2

Estimated Maximum Ground level concentrations of Pollutants at various
Downwind Locations, for 3 units of 210 MW each: (Stage I)

Stack Height : 275.0
Mixing Depth : 500.0m
No. of Stacks : 1
Sulphur : 0.475%

Stability Class	μ (m/sec)	x (km)	SO2 Conc. (μ/m^3)		NO2 Conc. (μ/m^3)		SPM Conc. (μ/m^3)	
			1 Hr.	8 Hr.	1 Hr.	8 Hr.	1 Hr.	8 Hr.
			(1)	(2)	(3)	(4)	(5)	(6)
A	0.25	25.0	0.03	0.01	0.03	0.01	0.005	0.002
A-B	0.25	35.0	0.07	0.03	0.07	0.03	0.01	0.004
B	0.25	45.0	0.17	0.08	0.17	0.08	0.03	0.01
A	1.00	1.0	1.2	0.5	1.2	0.5	0.21	0.08
A-B	1.00	6.0	1.6	0.7	1.6	0.7	0.28	0.10
B	1.00	7.0	1.6	0.7	1.6	0.7	0.28	0.10
A	1.75	2.5	2.8	1.2	2.8	1.2	0.50	0.18
A-B	1.75	3.0	2.5	0.9	2.5	0.9	0.44	0.16
B	1.75	3.0	4.5	2.0	4.5	2.0	0.80	0.29
A-B	3.00	1.5	4.4	1.9	4.4	1.9	0.78	0.28
B	3.00	2.0	8.1	3.5	8.1	3.5	1.43	0.52
C	3.00	2.5	12.9	5.6	12.9	5.6	2.28	0.82
E	3.00	9.0	21.0	9.1	20.9	9.1	3.72	1.34
F	3.00	14.0	19.3	8.5	19.2	8.4	3.42	1.23
D	4.17	4.5	23	10	22.9	9.8	4.08	1.47

TABLE :3

ESTIMATED MAXIMUM POLLUTANT CONCENTRATIONS LIKELY TO OCCUR IN CUDDALORE AREA, DUE TO POWER PLANT EMISSIONS: STAGE – I

Source : 3 x210 MW
Coal – Fired Units
No.of Stacks : 1
Stack Height :275.0Meters

Sulphur : 0.475&

Sampling Station	SO2 Conc. (μ/m^3)	NO2 Conc. (μ/m^3)	SPM Conc. (μ/m^3)
	8 Hrs.	8 Hrs.	24
1.Pachahankuppam	9.7	9.6	1.4
2.Thiagavalli	4.7	4.3	0.7
3.Thiruchopuram	9.6	9.6	1.4
4.Agaram	10.0	9.4	1.5
5.Gadhandaramapuram	9.1	9.0	1.3
6.Thandamanatham	9.4	9.4	1.4
7.Sedapalayam	7.4	7.4	1.1
8.Annavalli	8.8	8.8	1.3
9.Karaikadu	9.2	9.2	1.4
10.Periyapattu	5.6	5.6	0.8
11.Andarmullipallam	6.6	6.6	0.9
12.Poovanikuppam	7.8	7.7	1.1
13.Arukkampattu	8.7	8.6	1.3
14.Vazhukalampattu	6.1	6.1	0.9
15Gangamanichamkuppam	6.6	5.6	1.0
15.Navadipalayam	6.4	6.3	0.9
16.Cuddalore New Town(Hotel Dwaraka)	6.4	6.4	0.9
17.CuddaloreOld Town (ADE's office)	8.7	8.6	1.3
18.Vanavil Dyes & Chemicals	8.8	8.8	1.3

TABLE :4

FUTURE MAXIMUM CONCENTRATIONS OF POLLUTANTS LIKELY TO OCCUR IN VARIOS DOWNWIND LOCATIONS, ON THE COMPLETION OF STAGE – I OF THE PROJECT: 3 X 210 MW

(Estimated Maximums Superimposed over the measured Maximums)

Sulphur : 0.475%

Sampling Station	SO2 Conc. (μ/m^3) 8 Hrs.	NO2 Conc. (μ/m^3) 8 Hrs.	SPM Conc. (μ/m^3) 12 Hrs.	REMARKS
1.Pachahankuppam	19.7	16.9	39.3	
2.Thiagavalli	18.6	15.3	30.0	
3.Thiruchopuram	22.3	19.2	33.5	
4.Agaram	22.4	19.2	34.8	
5.Gadhandaramapuram	24.8	16.0	38.5	
6.Thandamanatham	23.6	16.8	26.9	
7.Sedapalayam	21.5	14.6	36.6	
8.Annavalli	24.6	18.5	37.9	
9.Karaikadu	27.8	18.4	35.7	
10.Periyapattu	26.6	15.3	29.0	
11.Andarmullipallam	21.0	15.8	33.9	
12.Poovanikuppam	26.1	16.8	30.6	
13.Arukkampattu	25.9	17.7	31.4	
14.Vazhukalampattu	22.8	17.3	28.6	
15.Gangamanichamkuppam	21.5	19.8	35.1	
16.Navadipalayam	19.6	14.4	37.9	
17.Cuddalore New Town (Hotel Dwaraka)	20.9	15.5	61.0	Maximum SPM
18.Cuddalore Old Town (ADE's office)	23.6	18.4	49.4	
19.Vanavil Dyes & Chemicals	28.8	25.3	35.8	Maximum SO2& NO2

REFERENCES:

1 Petkovsek S.A.S., Batic F. and Lasnik C.R., "Norway spruce needles as bioindicator of air pollution in the area of influence of the Sostanj Thermal Power Plant, Slovenia", Environmental Pollution, Vol. 151, (2008), pp. 287-291.

2 Quadrelli R. and Peterson, S., "The energy–climate challenge: Recent trends in CO2 emissions fromfuel combustion", Energy Policy, Vol. 35, (2007), pp. 5938-5952.

3 Kiely G., "Environmental Engineering", McGraw-Hill, New York (1997), pp. 334-388.
Davis L.M. and Cornwell D.A., "Introduction to Environmental Engineering", 4th Ed., McGraw-Hill,New York, (2008), 547-646.

4 Masters G.M., "Introduction to Environmental Engineering and Science", Prentice
Hall, New York,(1991), pp. 270-372.

5 Cicek A. and Koparal A.S., "Accumulation of sulfur and heavy metals in soil and tree leaves sampled from the surroundings of Tuncbilek Thermal Power Plant", Chemosphere, Vol. 57, (2004), pp. 1031-1036.

6 DeMarco A. and Poncia, G., "A model of combustion chambers, including nitrogen oxide generation, in thermal power plants", Control Engineering Practice, Vol. 7, (1999), pp. 483-492

7 Dogan O. and Kobya M., "Elemental analysis of trace elements in fly ash sample of
Yatagan thermal power plants using EDXRF", *Journal of Quantitative Spectroscopy & Radiative Transfer*, Vol. 101, (2006), pp. 146-150.

8 He B. and Chen C., "Energy ecological efficiency of coal fired plant in China", *Energy Conversion and Management*, Vol. 43, (2002), pp. 2553-2567.

9 Lopez M.T., Zuk M., Garibay V., Tzintzun G., Iniestra R. and Fernandez A., "Health impacts from power plant

10 emissions in Mexico", *Atmospheric Environment*, Vol. 39, (2005), pp. 1199-1209.

11 Matthias R., Davidsdottir B. and Amato A., "Climate change policies and capital vintage effects: the cases of US pulp and paper, iron and steel, and ethylene", *Journal of Environmental Management*, Vol. 70, (2004), pp. 235-252.

12 Mishra U.C., "Environmental impact of coal industry and thermal power plants in India", *Journal of Environmental radioactivity*, Vol. 72, (2004), pp. 35-40.

13 Mukhopadhyay K. and Forssell O., "An empirical investigation of air pollution from fossil fuel combustion and its impact on health in India during 1973–1974 to 1996–1997", *Ecological Economics*, Vol. 55, (2005), pp. 235-250.

14 Muriel M.G. and Leon H.R., "Numerical and experimental study on the SO2 pollution produced by Lerdo thermal power plant, Mexico", *Atmospheric Environment*, Vol. 33, (1999), pp. 3723-3728.

15 Nevers N.D., "Air Pollution Control Engineering", McGraw Hill, New York, 1995.

16 Peker N.S., "Lignite-fired thermal power plants and SO2 pollution in Turkey", *Energy Policy*, Vol. 34, (2006), pp. 2690-2701.

17 Karandinos A.N.R. and Karandinos M.G., "Assessment of air pollution from a lignite power plant in the plain of

18 Megalopolis (Greece) using as biomonitors three species of lichens; impacts on some biochemical parameters of lichens", *The Science of the Total Environment*, Vol.215, (1998), 167-183.

19 Sengupta I., "Regulation of suspended particulate matter (SPM) in Indian coal-based thermal power plants: A static approach", *Energy Economics*, Vol. 29, (2007), pp. 479-502.