Impact of Air Pollution on Crops in the Vicinity Of a Power Plant: A Case Study

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"Abstract"

The impact of ambient air pollution on the crops like paddy and cotton which are the major crops in these areas surrounding Dr.NarlaTataRaoThermal Power Plant (NTTPS) area during summer and monsoon seasons is studied. The amount of tolerance on these crops towards air pollution is determined by simple and economical method APTI (Air pollution Tolerance Index) test leaf samples from the identified crop plants were collected from within 25Km radius of the NTTPS site during summer and monsoon seasons and four biochemical parameters like, relative water content, leaf pH, ascorbic acid content and total chlorophyll content are examined. The results have shown that these crops are sensitive as the APTI values are less than 11.The study indicated that ambient air pollution due to the presence of power plant has adverse impact on the growth of paddy and cotton crops in the close vicinity of 25 Km radius of this thermal power plant.

Key words: Air pollution, APTI value, NTTPS *Power plant, Paddy and Cotton crops. Summer and Monsoon seasons*.

"1. Introduction"

To meet the growing demand for electricity from the industries, agriculture and domestic needs a large number of thermal power plants are being set up by the public and private sector. These power plants emit a complex mixture of gaseous pollutants like Sulphurdioxide (SO_2), Nitogendioxide(NO_2), Hydrogenfluoride(HF), Carbon dioxide (CO_2), and particulate matter $PM_{2.5}$ and PM_{10}, and fly ash into the ambient air during the combustion of coal NTTPS power plant under study is located in the Ibrahinpatnam village of Krishna district in Andhra Pradesh. The power plant has a generation capacity of 1760 MW with its six units of 6 X 210 MW each and one unit with 500 MW which requires 35000 metric tons of coal for the generation of steam. To control air pollution from the plant electrostatic precipitators with high efficiency have been installed in these units. Inspite of implementing such measures to mitigate the impact of air pollution from this plant, vegetation in this area is effected in various levels.

The crops in the polluted area are very sensitive and are considered as the bioindicators of air pollution [1]. The present study is confined to the impact of the air pollution caused due by the thermal plant on crops like paddy and cotton during summer and monsoon There are two main types of injuries that air pollution cause on plants: acute and chronic Injuries [2]. Acute injury results from exposure to a high concentration of gas for a relatively short period and is manifested by clear visible symptoms on the foliage, often in the form of necrotic lesions..While chronic injury is much more subtle it results from prolonged exposure and results in reduction of growth and yields. Many contributors agree that the air pollutants effect plant growth adversely [3,4]Early consideration of environmental impacts in evaluating power production could help to identify the key elements responsible for environmental problems [5]. Singh et al published in 1983 the Air Pollution Index chlorophyll was analyzed following the method of Arnon [9] and ascorbic acid by Sadasivam and Balasubraminan [10].Species having APTI less than 11 are termed as sensitive species and can be used for the biomonitoring of air pollutants [11].

(APTI) value is a number which determines the tolerance of plant towards air pollution [6] and has been undertaken in the present study. Plants play a major role in monitoring and maintaining the ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide, oxygen and also provide enormous leaf area for impingement, absorption and accumulation of air [**7**]. The present study finds the amount of tolerance towards air pollution on the major crops like paddy and cotton in the villages surrounding NTTPS in 5 Km, 10, Km, 15Km, 20Km and 25Km radius. The impact in summer and monsoon seasons is studied for determining Air Pollution Tolerance Index (APTI) four different biochemical parameters i.e. leaf extract pH, ascorbic acid, total chlorophyll and relative water contents are determined. In the present study paddy and cotton are found to be sensitive to air pollution caused by power plant.

"2. Experimental Methodology"

Active and passive biomonitoring are the two methods according to Tripati [8] which can be applied to evaluate the applicability of the biochemical parameters of plants as indicators of air pollution. In the present study APTI values are determined by taking the four biochemical parameters into consideration. The methodology adopted to determine the impact of air pollution on paddy and cotton crops is as follows:

Leaf samples from the paddy and cotton crop plants cultivated in the village areas within 5 km, 5-10Km 10-15Km, 15-20Km, 20-25Km radius of the NTTPS site during summer and monsoon seasons were collected and quickly transported to the laboratory in a heat proof container. Leaf fresh weight was taken immediately upon returning to the laboratory. Air pollution tolerance Index (APTI) was calculated to know the impact of air pollution on the crops. This will denote whether the plant is sensitive, intermediate or tolerant. Total

2.1 Air pollution Tolerance Index

The Air pollution tolerance Index (APTI) of a species is calculated by the method of Singh and Rao 1983

$$APTI = \frac{A\,(T+P) + R}{10}$$

Where A = Ascorbic acid content of leaf mg/g, P = pH of leaf material, T = Total Chlorophyll content mg/g, R + Relative water content of leaf tissues.

Standard APTI values
Less than 11 –sensitive
Between 12-16 – Intermediate
Above 17 - Tolerant

This helps to assess the extent of impact on plant species in the industrial areas [12].

2.2 Estimation of Ascorbic acid

Ascorbicacid(A.A) is important in cell wall synthesis, photosynthetic carbon fixation and cell division[13] .Ascorbic acid can be measured by means of its reducing property .it is oxidized in the presence of colored dye 2, 6 dichlorophenol-indophenol to dehydro Ascorbic acid.10 ml of standard Ascorbic acid solution is taken and titrated with 2,6 dichlorophenol indophenols dye [14] .The appearance of pink colour indicates the end point.Similarily,10ml of unknown solution is taken and titrated with the dye. For the blank 10ml of 5% oxalic acid is taken and titrated with the dye. The Ascorbic acid present in the unknown sample is calculated as follows,

$$A.A = \frac{UT - BT}{ST - BT} \text{ X 1mg X100/10…… mg/100m}$$

Where,
UT = Titer value of unknown solution, ST = Titer value of standard Ascorbic acid solution,
BI = Titer value of Oxalic acid solution.
Relative Leaf Water Content (RWC)
Leaf RWC was determined and calculated with the formula
RWC = (Wf – Wd) x 100/(Wt –Wd)
Fresh weight Wf was gained by weighing the fresh leaf pieces on a 4- digit balance. To get the turbid weight wet Leaf pieces were weighed after immersing in water overnight. Next leaf pieces were blotted to dryness in drier at 60^{o} C for 3 hrs and reweighed to get dry weight (Wd).

2.3 Total Chlorophyll content

One gram of the greenest leaves of the plants were selected and cleaned thoroughly with water and dried in room temperature. By adding a pinch of magnesium carbonate leaves are mashed and 20-25 ml of 80% acetone is added. After centrifuging for 15 mts the extract is transferred into a 100 ml volumetric flask and made up to volume of 50ml using 80% acetone. A green solution is obtained like Arnon The optical density of the green solution obtained is read at 663nm, and the total chlorophyll content in it is calculated with the formula
Total Chlorophyll = 20.2 XA_{645} +8.02 X A_{663}(mg/g)y
The decrease in chlorophyll content is directly related to the increasing pollution load. Similar observations are reported by Speeding and Thomas [15].

2.4 Leaf extract pH

About 4 g of fresh leaves was homogenized in 40 ml deionized water and centrifuged and its pH was measured with a pH meter at 25^{o}C.High pH may increase the efficiency of conversion from hexose sugar to ascorbic acid [16] while low leaf pH extract showed good correlation with sensitivity to air pollution and also reduce photosynthesis process in plants.

2.5. Relative Leaf water content (RWC)

Leaf RWC was determined and calculated with the formula
RWC = (Wf –Wd) x 100 / (Wt – Wd)
Fresh leaf weight Wf, was obtained by weighing the fresh leaf pieces on a 4-digit balance and immersed in water overnight to get Wt, which is the turbid weight. Next, leaf pieces were blotted to dryness and placed in a drier at 60^{0} C for 3 hrs and reweighed to get dry weight Wd High-water content within plant body helps to maintain its physiological balance under stress conditions such as exposure to air pollution when the transpiration rates are usually high. It also serves as an indicator of drought resistance in plants as suggested by Dedio [17].

"3. Results"

Plants have been classified according to their degree of sensitivity and tolerance towards are suggested to act as bio-indicators to

predict he extent of air pollution tolerance.Parameters that are analyzed for APTI plays a significant role in determining the resistivity and susceptibility of plant species towards air pollution. Air Pollution Tolerance Index (APTI) is calculated in crops like paddy and cotton cultivated in the vicinity of and up to 25km radius of NTTPS in **summer and monsoon** seasons and the results are tabulated below according to the various villages situated in the range of 5 km, 5-10Km, 10 -15Km, 15- 20Km, 20-25Km from NTTPS.

Table 3.1: APTI Values of paddy and cotton found in the 0-5Km radius. of NTTPS

	APTI Within 0-5 Km Radius of NTTPS				
S.No	**Village Name**	**Crops**	**APTI Value**		**Air Pollution Tolerance Index**
			Summer	**Monsoon**	
1	Keleswarapuram	Cotton1	7.24	7.31	Sensitive
		Cotton2	7.67	7.62	Sensitive
		Paddy 1	8.44	8.62	Sensitive
		Paddy2	8.60	8.91	Sensitive
2	Paiderupadu	Cotton 1	7.73	8.62	Sensitive
		Cotton 2	8.35	8.91	Sensitive
3	Guntupalli	Cotton 1	7.43	7.40	Sensitive
		Cotton 2	8.21	8.12	Sensitive
4	Kondapally	Paddy 1	8.21	8.31	Sensitive
		Paddy2	8.32	8.25	Sensitive
		Cotton 1	7.21	7.10	Sensitive
		Cotton 2	8.23	7.98	Sensitive
5	Surayapalem	Cotton 1	7.79	7.43	Sensitive
		Cotton 2	8.10	7.56	Sensitive
		Paddy 1	8.11	8.23	Sensitive
		Paddy2	8.12	8.34	Sensitive

Table 3.2: APTI values of paddy and Cotton found in the **5-10 Km** radius, **of NTTPS**

	APTI Within 5-10 Km Radius Of NTTPS				
S.No	**Village Name**	**Crops**	**APTI Value**		**Air Pollution Tolerance Index**
			Summer	**Monsoon**	
1	Tulluru	Cotton 1	6.39	6.41	Sensitive
		Cotton 2	6.52	6.37	Sensitive
2	Condapadu	Cotton 1	7.73	7.1	Sensitive
		Cotton 2	8.35	7.29	Sensitive
3	Nelapadu	Cotton 1	6.81	8.00	Sensitive
		Cotton 2	6.83	8.15	Sensitive
4	Mulapadu	Paddy 1	7.71	7.72	Sensitive
		Paddy 2	7.59	7.50	Sensitive
		Cotton 1	7.32	7.29	Sensitive
		Cotton 2	7.43	7.42	Sensitive
5	Gaddemanugu	Paddy 1	8.10	-	Sensitive
		Paddy2	8.00	-	Sensitive
		Cotton 1	7.80	7.92	Sensitive
		Cotton 2	7.92	8.32	Sensitive
6	Gaddemanugu	Paddy 1	7.80	8.12	Sensitive
		Paddy 2	7.65	7.72	Sensitive
		Cotton 1	-	7.90	Sensitive
		Cotton 2	-	7.42	Sensitive
7	Rayapudi	Cotton 1	6.38	8.79	Sensitive
		Cotton 2	6.47	8.19	Sensitive
		Paddy 1	8.12	8.42	Sensitive
		Paddy 2	8.23	7.82	Sensitive

Table 3.3: APTI Values of paddy and cotton found in the **10-15** Km radius **of NTTPS**

	APTI Within 10-15 Km Radius Of NTTPS				
S.No	**Village Name**	**Crops**	**APTI Value**		**Air Pollution Tolerance Index**
			Summer	**Monsoon**	
1	Donabandi	Cotton 1	8.11	8.32	Sensitive
		Cotton 2	8.12	7.87	Sensitive
		Paddy 1	7.82	8.74	Sensitive
		Paddy 2	7.66	8.81	Sensitive
2	G.Konduru	Cotton 1	8.21	8.31	Sensitive
		Cotton 2	8.45	8.39	Sensitive
		Paddy 1	7.81	8.00	Sensitive
		Paddy 2	7.67	7.90	Sensitive
3.	Chevitimukkala	Cotton 1	8.20	8.31	Sensitive
		Cotton 2	8.42	8.52	Sensitive
		Paddy 1	7.87	8.11	Sensitive
		Paddy 2	7.77	7.92	Sensitive
4	Kuntamukkala	Cotton 1	8.22	8.22	Sensitive
		Cotton 2	8.41	7.82	Sensitive
		Paddy 1	7.86	8.79	Sensitive
		Paddy 2	7.62	8.29	Sensitive
5	Kotikalapadu	Cotton 1	8.22	8.22	Sensitive
		Cotton 2	8.48	7.82	Sensitive
		Paddy 1	7.84	8.79	Sensitive
		Paddy 2	7.69	8.29	Sensitive
6	Jupudi	Paddy 1	8.12	8.10	Sensitive
		Paddy 2	7.94	7.43	Sensitive
		Cotton 1	7.02	7.76	Sensitive
		Cotton 2	7.11	7.45	Sensitive
7	Kavuluru	Paddy 1	8.12	7.79	Sensitive

		Cotton 1	7.28	7.41	Sensitive
		Cotton 2	7.61	7.66	Sensitive
8	Paritala	Paddy 1	8.23	8.10	Sensitive
		Paddy 2	8.10	8.23	Sensitive
		Cotton 1	7.23	7.76	Sensitive
		Cotton 2	7.81	7.75	Sensitive
9.	Kanchikacharla	Paddy 1	8.45	8.11	Sensitive
		Paddy 2	8.11	8.45	Sensitive
		Cotton 1	7.26	7.87	Sensitive
		Cotton 2	7.88	7.54	Sensitive

Table 3.4: APTI Values of paddy and cotton found in the **15-20** Km radius of NTTPS

	APTI Within 15-20 Km Radius of NTTPS				
S.No	**Village Name**	**Crops**	**APTI Value Summer Monsoon**		**Air Pollution Tolerance Index**
1	Narukalapadu	Cotton 1	7.57	7.9	Sensitive
		Cotton 2	7.34	8.1	Sensitive
2	Endrayi	Cotton 1	7,23	8.20	Sensitive
		Cotton 2	7.12	8.61	Sensitive
3	Sher mohamedpeta	Cotton 1	7.68	8.12	Sensitive
		Cotton 2	7.34	8.38	Sensitive
		Paddy 1	7.48	7.64	Sensitive
		Paddy 2	8.34	7.79	Sensitive
4	Nandigama,	Cotton 1	7.78	8.11	Sensitive
		Cotton 2	7.89	8.67	Sensitive
		Paddy 1	8.34	7.54	Sensitive
		Paddy 2	8.45	7.65	Sensitive
5	Chanadralleapadu	Cotton 1	7.68	8.00	Sensitive
		Cotton 2	7.59	6.67	Sensitive

		Paddy 1	7.14	7.54	Sensitive
		Paddy 2	8.35	8.15	Sensitive
6	Donabanda	Paddy 1	8.87	8.56	Sensitive
		Paddy 2	8.45	8.79	Sensitive
		Cotton 1	7.71	7.23	Sensitive
		Cotton 2	8.10	7.68	Sensitive
7	Duggaralapadu	Cotton 1	7.39	7.13	Sensitive
		Cotton 2	8.19	7.88	Sensitive
8	Adavinekula	Cotton 1	7.11	7.21	Sensitive
		Cotton 2	7.28	7.98	Sensitive
		Paddy 1	8.98	8.84	Sensitive
		Paddy 2	8.65	8.19	Sensitive

Table 3.5 : APTI Values of Paddy and cotton found in the **20-25** Km radius of NTTPS

	APTI Within 20-25 Km Radius of NTTPS				
S.No	**Village Name**	**Crops**	**APTI Value**		**Air Pollution Tolerance Index**
			Summer	**Monsoon**	
1	Tadikonda	Cotton 1	6.50	7.11	Sensitive
		Cotton 2	6.69	7.56	Sensitive
2	Ponekkalu	Cotton 1	8.22	8.32	Sensitive
		Cotton 2	8.71	8.75	Sensitive
		Paddy 1	7.54	7.21	Sensitive
		Paddy 2	7.41	7.57	Sensitive
3	Gorantla	Cotton 1	8.20	8.45	Sensitive
		Cotton 2	8.82	8.43	Sensitive
		Paddy 1	7.42	7.32	Sensitive
		Paddy 2	7.91	7.34	Sensitive
4	Lam	Cotton 1	8.32	8.34	Sensitive

		Cotton 2	8.90	8.43	Sensitive
		Paddy 1	7.33	8.75	Sensitive
		Paddy 2	7.87	8.99	Sensitive
5	Erripalem	Cotton 1	8.32	8.34	Sensitive
		Cotton 2	8.90	8.43	Sensitive
		Paddy 1	7.33	8.75	Sensitive
		Paddy 2	7.87	8.99	Sensitive
4	Kanteru	Cotton 1	7.75	7.54	Sensitive
		Cotton 2	7.20	7.21	Sensitive
5	Mustabad	Cotton 1	7.92	7.98	Sensitive
		Cotton 2	7.49	7.29	Sensitive
		Paddy 1	8.44	8.32	Sensitive
		Paddy 2	7.85	8.10	Sensitive
6	Surampalli	Cotton 1	7.82	7.29	Sensitive
		Cotton 2	7.69	7.45	Sensitive
		Paddy 1	8.14	8.65	Sensitive
		Paddy 2	7.95	8.43	Sensitive
7	Peddapuram	Cotton 1	8.12	7.54	Sensitive
		Cotton 2	8.13	7.43	Sensitive
		Paddy1	8.95	8.45	Sensitive
		Paddy 2	7.95	8.43	Sensitive

"4 .Discussion"

Summarizing the results from tables 3.1 to 3.5 it is found that both paddy and cotton crops are sensitive towards air pollution due to their close vicinity of thermal power plant under study.

In 0-5 km radius paddy and cotton plant samples were collected in the summer and monsoon seasons from the villages like Keleswarapuram, Paiderupadu, Guntupalli, Kondapally Surayapalem villages. The

APTI values for these crops in the summer season ranged between. 7.21-8.60, while in the monsoon season APTI values ranged between 7.10- 8.91 as shown in the table 3.1.

In the vicinity of 5-10 Km radius of NTTPS crop samples of paddy and cotton were collected from villages like Tulluru, Condapadu, Nelapadu, Mulapadu, Gaddemanugu, Rayapudi .The crop samples collected during summer season showed the minimum and maximum APTI values ranged between 6.39 -8.35 While the crop samples collected during monsoon season showed the minimum and maximum APTI values ranged between 6.37-8.79. as shown in the table 3.2.

As per the table 3.3 Paddy and cotton samples In the vicinity of 10-15 Km radius of NTTPS are collected from villages like Donabanda, G.Konduru, Chevitimukkala, Kuntamukkala, Kotikalapadu, Jupudi ,Kavuluru, Paritala, Kanchikacharla The crop samples collected during summer season showed the minimum and maximum APTI values ranged between 7.02 -8.48 . While the crop samples collected from villages like during monsoon season showed the minimum and maximum APTI values ranged between 7.41-8.81 .

Within the radius of 15-20 Km radius of NTTPS paddy and cotton Crop samples were collected from the following villages like Narukalapadu,Endrayi Shermohamedpeta, Chanadralleapadu , Nandigama, Donabanda,Duggarlapadu,Adavinekula during summer season and monsoon seasons. The crop samples collected during summer season showed the minimum and maximum APTI values ranged between 7.11 -8.98.. While the crop samples collected from villages like during monsoon season showed the minimum and maximum APTI values ranged between 7.13-8.84. as shown in the table 3.4.

As per the table 3.5 in the vicinity of 20- 25 Km radius of NTTPS paddy and cotton samples were collected from village like Tadikonda, ponekkalu, Gorantla, lam, Erripalem, Kanteru, Mustabad, Surampalli, Peddapuram, during summer season and monsoon seasons. The crop samples collected during summer season showed the minimum and maximum APTI values ranged between. 6.50-8.95 While the crop samples collected from villages like during monsoon season showed the minimum and maximum APTI values ranged between 7.11-8.99. The sensitive species help in indicating air pollution and tolerant species help in abatement of air pollution. The tolerant species of plants function as pollution sink [18] and therefore a number of environmental benefits can be desired by planting tolerant species in polluted areas.

"5. Conclusion"

The study of these crops in the radius of 25 Km from NTTPS revealed that these are sensitive to air pollution as their APTI values are less than 11.This resulted the villagers almost to stop cultivating paddy and cotton in the vicinity of 5 Km radius of the power plant. From this study it is also identified that mostly cotton is grown as a single crop in summer season while paddy and cotton are grown as double crops in the monsoon season. The estimation of the effect of the pollutants on the plant species should be done at regular intervals so as to ensure that they perform well under pollutant stresses.

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"References"

[1]Keller T The using of peroxidase activity for monitoring and mapping air pollution areas European Journal of Forest Pathol 4:11–19, Farmer JC, Lyon TDB (1977) Lead in Glasgow street dirt and soil. Sci Total Environ, 1974, 8:89–93.

[2] T.M.Roberts Effects of air pollutants on agriculture and forestry Atmospheric Environment, 1967, 1984 18 (3):629-652.

[3.]Sodhi GS.Fundamental concepts of Environmental chemistry. 2005 Second edition

[4] Bhatia SC.Environmental Chemistry CBS publishers and Distributors 2006.

[5]Makshoof athar, mahboob Ali, Misbahul Ali Khan Gaseous and particulate emissions from thermal power plants operating on different technologies. Environmental Monitoring and Assesment July ,2010 166(1-4) :625-639.

[6]Singh, S. K. and Rao, D. N. Evaluation of plants for their tolerance to air pollution In Proc. Symp. on Air pollution control, IIT, Delhi, (1983) :218-224.

[7] P. Suvarna lakshmi, k. Lalitha sravanti and N. Srinivas An international Biannual Journal of Environmental sciences The Ecoscan,(2008) ,2 (2):203-206.

[8]Journal of Environmental Biology Biochemical parameters of plants as indicators of air Pollution.K. Tripathi and Mukesh Gautam January 2007, 28(1): 127-132.
[9]Arnon, D.I.: Copper enzyme in isolated chloroplast. Plant Physiol, 1949, 24:1-15.
[10]Sadasivam, S and T. Balasubraminan: In: Practical manual in biochemistry. Tamil Nadu Agricultural University, Coimbatore 1987, 14.
[11]Agrawal, M., S.K. Singh, J. Singh and D.N.Rao: Bio monitoring of air pollution around urban and industrial J. Environ. Biol., 1991:12, 211.
[12]Lakshmi, P.S.; Sarawanti, K.L. and Sirinivas, N. Air pollution tolerance Index of Various plant species growing in Industrial area. Journal of Environmental Sciences.2009 2(2):203-206.
[13]Conklin, P. LRecent advances in the role and biosynthesis of ascorbic acid in plantsPlant Cell Environment. , 2001, 24:383-394
[14]Agarwal, M. Plants factors as indicators of SO2 and O3pollutants. Symp. on Bio -Monitoring state environment. New Delhi. Proceedings, 1985: 225-231.
[15] Speeding, D.J & Thomas, W.J Effect of sulphur dioxide on the metabolism of glycollic acid by barley (Hardeum vulgare) leaves.Aust. J. Biol. Sci.,1973. 6: 281-286.
[16]Scholz and Reck pH as an indicator for sensitivity to air pollution, total chlorophyll is also related to ascorbic acid productivity 1977.
[17]Dedio, W. Water relations in wheat leaves as screening test for drought resistance Canadian Journal of Plant Science.1975,55: 369-37.
[18]Subramanian, G. V., Rao, D. N., Varshney, C. K. and Biswas.D. K. (Ed). Air pollution and Plants: A state of the art report, Ministry of Environment and forests, (1985): 146-171.