Research Article

Impact of Air Pollution from a Coal Fired Thermal Power Station on Brinjal and Tomato Crops

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Abstract

Air pollutants not only affect human health adversely but also have serious consequences on agriculture and horticultural crops. The impact of ambient air pollution in the vicinity of a thermal plant on the vegetable crops like Brinjal and Tomato, the major vegetable crops in the study area after paddy and cotton during summer, monsoon and winter 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 within 25Km radius of the NTTPS thermal power station site during summer monsoon and winter 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 11up to 20km radius and Tolerant after 20km.This study indicated that ambient air pollution levels are unfavorable and has impact on the yield of Brinjal and Tomato crops.

Keywords: Air pollution, APTI value, NTTPS Power plant, Brinjal and Tomato crops, Summer and Monsoon seasons

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Introduction

The necessity of electricity for domestic as well as industrial use has been increasing exponentially. Electricity is an important commodity for industries and agriculture sector of any state.To meet the demand and supply for electricity a large number of thermal power plants are being set up by the public and private sector. Power plants emit a complex mixture of gaseous pollutants like Sulphurdioxide (SO2), Nitogendioxide (NO2), Hydrogenfluoride (HF), Carbon dioxide (CO2), and particulate matter PM2.5 and PM10, and fly ash into the ambient air due to the combustion of coal. Dr NTTPS thermal power station situated in the study area is a coal based thermal power station and is located in the Ibrahinpatnam village of Krishna district in Andhra Pradesh. This power plant consists of six units of 6 X 210 MW each and one unit with 500 MW and requires a huge quantity of about 35000 metric tons of coal for the production of steam to rotate the turbine and generate 1760 MW power. Due to the combustion of coal large amount of uncondensed gases, fly ash and particulate matter will be generated causing air pollution in the ambient air. The impact of air pollution from the power plant on the vegetation of this area is studied. After the major crops like paddy and cotton vegetable crops are cultivated greatly in the study area. The crops in the polluted area are very sensitive and are considered as the bioindicators of air pollution [1,2]. The present study is focused on the impact of the air pollution caused by the thermal plant on vegetable crops like Brinjal and Tomato during summer monsoon and winter seasons. Air pollution generally causes two main types of injuries on plants: acute and chronic Injuries [3]. Acute injury takes place due to the 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. Chronic injury is much more subtle it results from prolonged exposure and results in the reduction of growth and yields. Many contributors agree that the air pollutants effect plant growth adversely [4, 5] Early consideration of environmental impacts in evaluating power production could help to identify the key elements responsible for environmental problems Singh et al published in 1983 the Air Pollution Index [6]. chlorophyll was analyzed following the method of Arnon[7] and ascorbic acid by Sadasivam and Balasubraminan [8]. Species having APTI less than 11 are termed as sensitive species and can be used for the biomonitoring of air pollutants [9, 10].Air pollution Tolerance Index (APTI) value is an indicator which determines the tolerance level of plants towards air pollution, hence has been undertaken in the present study. Vegetable crops or common plants play a major role in monitoring and maintaining the ecological balance in the environment 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 pollution. This paper determines the effect of air pollution tolerance on the major crops like Brinjal and Tomato in the villages surrounding NTTPS thermal power station in and a distance of 5Km, 10Km, 15Km, 20Km and 25Km radius. Seasonal variation of air

pollution on crops is studied and Air Pollution Tolerance Index (APTI) values are calculated by measuring four different biochemical parameters i.e. leaf extract pH, ascorbic acid, total chlorophyll and relative water contents are determined.

Dr NTTPS thermal power station

Methodology

Ministry of Environment and Forests (1983) has introduced a tool named Air Pollution Tolerance Index (APTI). to determine the effects of air pollutants on vegetation by computing the bio-chemical parameters. Plant species responses to air pollution vary from species to species. Active and passive biomonitoring are the two methods according to Tripathi [11] which can be applied to evaluate the applicability of the biochemical parameters of plants as indicators of air pollution. The sensitive species help in indicating air pollution while the tolerant species help in abatement of air pollution. The tolerant species of plants function as pollution sink [12] and therefore a number of environmental benefits can be desired by planting tolerant species in polluted areas.

Site selection

Villages located in the 25 km radius from the power station under study are selected. Leaf samples from the Brinjal and Tomato plants cultivated in the village, 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. The Air pollution tolerance Index (APTI) of a species is calculated by the method of Singh and Rao 1983.

$$APTI = A\ (T+P) + R$$

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

APTI value helps to assess the impact of air pollution on plant species in the industrial areas

Estimation of Ascorbic acid

Ascorbic acid is measured by means of its reducing property. Ascorbicacid (A.A) is important in cell wall synthesis, photosynthetic carbon fixation and cell division [13].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,10 ml 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,

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

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,

$$RWC = (Wf - Wd) \text{ x } 100/(Wt - Wd)$$

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 60o C for 3 hrs and reweighed to get dry weight (Wd).

Total Chlorophyll content

About one gram of the green leaves of the Brinjal and Tomato plants were selected at random and cleaned thoroughly with water and dried at room temperature. By adding a pinch of magnesium carbonate to the leaves separately 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

$$\text{Total Chlorophyll} = 20.2 \text{ XA645} + 8.02 \text{ X A663 (mg/g)y}$$

The decrease in chlorophyll content is directly related to the increasing pollution load. Similar observations are reported by Speeding and Thomas [15-16].

Leaf extract pH

About 4 g of the fresh leaves of the Brinjal and Tomato plants were selected at random and mixed separately in 40 ml of deionized water and centrifuged. pH of the solution was measured with a pH meter at 25^0C.High pH value may increase the efficiency of conversion from hexose sugar to ascorbic acid, while low leaf pH value of the extract shows good correlation with sensitivity to air pollution and also reduce photosynthesis process in plants.

Relative Leaf water content (RWC)

Fresh leaves of the Brinjal and Tomato plants were selected at random and RWC was determined and calculated with the formula

$$RWC = (Wf - Wd) \text{ x } 100 / (Wt - Wd)$$

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 600 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].

Results and Discussion

Plants have been classified according to their degree of sensitivity and tolerance towards air pollution is suggested to act as bio-indicators of air pollution.

In 0-5 km radius of NTTPS Brinjal and Tomato plant leaf samples are collected in summer, monsoon and winter seasons from the villages Keleswarapuram, Paiderupadu, Guntupalli, Kondapally, Surayapalem and the APTI values calculated as shown in the **Table 1**.

In the vicinity of 5-10 km radius of Dr. NTTPS, leaf samples of Brinjal and Tomato are collected from crops grown in villages like Tulluru, Dondapadu, Nelapadu, Mulapadu, Gaddemanugu, ketanakonda and Jupidi. APTI values calculated in all these villages are shown in the **Table 2**.

Table 1 APTI values of Brinjal and Tomato crops in 0-5 km radius of Dr. NTTPS power station

S. No	Village Name	Crops	APTI Value			Mean	Impact of air pollution
			Summer	Monsoon	Winter		
1	Keleswarapuram	Brinjal	9.24	9.31	9.56	9.37	Sensitive
		Tomato	8.67	9.62	9.12	9.13	Sensitive
2	Paiderupadu	Brinjal	8.73	9.62	10.62	9.65	Sensitive
		Tomato	9.35	9.80	9.89	9.68	Sensitive
3	Guntupalli	Brinjal	8.43	8.50	8.85	8.59	Sensitive
		Tomato	9.21	9.12	9.23	9.18	Sensitive
4	Kondapally	Brinjal	9.26	8.33	8.43	8.67	Sensitive
		Tomato	9.35	9.25	9.67	9.42	Sensitive
5	Surayapalem	Brinjal	8.70	8.43	9.98	9.03	Sensitive
		Tomato	8.10	8.56	9.20	8.62	Sensitive

Table 2 APTI values of Brinjal and Tomato crops in 0-5 km radius of Dr. NTTPS power station

S.No	Village	Crops	APTI Value			Mean	Impact of air pollution
			Summer	Monsoon	Winter		
1	Tulluru	Brinjal	7.39	7.41	8.22	7.67	Sensitive
		Tomato	7.52	7.47	7.90	7.63	Sensitive
2	Dondapadu	Brinjal	8.73	7.1	7.56	7.79	Sensitive
		Tomato	7.35	7.69	8.42	7.82	Sensitive
3	Nelapadu	Brinjal	7.81	9.00	9.22	8.67	Sensitive
		Tomato	8.83	9.15	10.22	9.4	Sensitive
4	Mulapadu	Brinjal	7.61	7.82	8.30	7.91	Sensitive
		Tomato	8.59	8.50	8.60	8.56	Sensitive
5	Gaddemanugu	Brinjal	8.10	8.01	8.21	8.10	Sensitive
		Tomato	8.80	8.02	8.5	8.44	Sensitive
6	Ketanakonda	Brinjal	9.32	9.72	10.93	9.99	Sensitive
		Tomato	9.73	9.85	10.11	9.89	Sensitive
7	Jupidi	Brinjal	9.86	9.34	7.98	9.06	Sensitive
		Tomato	10.76	9.91	8.89	9.85	Sensitive

In the vicinity of 10-15 km radius of NTTPS leaf samples of paddy and cotton crops are collected from villages like Donabanda, G.Konduru Chevitikallu, Paritala, Kuntamukkala, Kotikalapudi and Paritala APTI values calculated in all these villages are shown in **Table 3**.

In the vicinity of 15-20 km radius of NTTPS crop samples of cotton and paddy are collected from villages like Narukallapadu, Endrayi Shermohamedpeta, and Chandrellapadu. APTI values calculated in all these villages are shown in **Table 4**.

In the vicinity of 20-25 km radius of NTTPS crop samples of cotton and paddy were collected from villages like Tadikonda, Ponnekallu, Gorantla, lam, Errapalem, Kanteru. APTI values calculated in these villages are shown in **Table 5**.

From the results obtained and shown in Tables 1 to 5 it is found that both Brinjal and Tomato crops are sensitive towards air pollution up to 20 km radius from the power plant and are little tolerant from 20 to 25Km.

Table 3 APTI values of Brinjal and Tomato crops in 10-15 km radius of Dr. NTTPS power station

S.No	Village Name	Crops	APTI Value			Mean	Impact of air pollution
			Summerr	Monsoon	Winter		
1	Donabanda	Brinjal	9.11	9.22	9.31	9.21	Sensitive
		Tomato	8.22	9.87	9.33	9.14	Sensitive
2	G.Konduru	Brinjal	9.21	9.31	9.45	9.32	Sensitive
		Tomato	9.35	9.43	9.46	9.41	Sensitive
3.	Chevitimukkala	Brinjal	9.21	9.41	9.32	9.31	Sensitive
		Tomato	8.32	8.33	8.55	8.4	Sensitive
4	Kuntamukkala	Brinjal	9.22	9.23	8.22	8.89	Sensitive
		Tomato	8.21	8.83	8.70	8.58	Sensitive
5	Kotikalapadu	Brinjal	8.22	8.29	8.24	8.25	Sensitive
		Tomato	9.48	7.82	7.77	8.35	Sensitive
6	Paritala	Brinjal	9.33	9.10	9.33	9.25	Sensitive
		Tomato	9.20	9.23	9.62	9.35	Sensitive

Table 4 APTI values of Brinjal and Tomato crops in 15-20 km radius of Dr. NTTPS power station

S.No	Village Name	Crops	APTI Value			Mean	Impact of air pollution e Index
			Summer	Monsoon	Winter		
1	Narukalapadu	Brinjal	9.57	9.90	9.62	9.69	Sensitive
		Tomato	8.34	9.30	9.42	9.02	Sensitive
2	Endrayi	Brinjal	9.23	9.29	9.34	9.28	Sensitive
		Tomato	9.12	9.61	9.21	9.31	Sensitive
3	Sher mohamedpeta	Brinjal	9.68	9.12	10.78	9.86	Sensitive
		Tomato	9.34	9.38	10.45	9.72	Sensitive
4	Nandigama	Brinjal	9.78	9.11	10.82	9.90	Sensitive
		Tomato	9.89	9.67	10.98	10.18	Sensitive
5	Chanadrallapadu	Brinjal	9.68	9.80	10.83	10.10	Sensitive
		Tomato	9.59	9.67	10.66	9.97	Sensitive

Table: 5 APTI values of Brinjal and Tomato crops in 20-25 km radius of Dr. NTTPS power station

S.No	Village Name	Crops	APTI Value			Mean	Impact of air pollution
			Summer	Monsoonn	Winter		
1	Tadikonda	Brinjal	11.50	11.11	12.10	11.57	Tolerant
		Tomato	12.69	12.56	12.89	12.71	Tolerant
2	Ponnekallu	Brinjal	10.22	11.42	12.41	11.35	Tolerant
		Tomato	11.71	12.75	12.10	12.18	Tolerant
3	Gorantla	Brinjal	12.20	12.45	12.53	12.39	Tolerant
		Tomato	11.32	12.43	12.39	12.04	Tolerant
4	Lam	Brinjal	11.32	12.34	12.33	11.99	Tolerant
		Tomato	11.90	12.93	12.91	12.58	Tolerant
5	Errapalem	Brinjal	11.22	12.34	12.30	11.95	Tolerant
		Tomato	12.01	12.13	12.33	12.15	Tolerant
6	Kanteru	Brinjal	13.55	14.34	14.79	14.22	Tolerant
		Tomato	14.22	13.11	13.40	13.57	Tolerant

In 0-5 km radius Brinjal and Tomato plant leaf samples were collected in the summer, monsoon and winter seasons from the villages Keleswarapuram, Paiderupadu, Guntupalli, Kondapally Surayapalem villages. The APTI values for these crops in the summer season ranged between.8.10 to 9.26, in the monsoon season APTI values ranged between 8.43 and 9.80 and in winter season from8.43 to 9.68 while the mean ranged between 8.59 and 9.68 as shown in the Table 1.

In 5-10 Km radius from the power plant leaf samples of Brinjal and Tomato were collected from the villages Tulluru, Dondapadu, Nelapadu, Mulapadu, Gaddemanugu, Ketanakonda and Jupidi. The APTI values leaf samples collected during summer season showed the minimum and maximum APTI values ranged between 7.35 and 10.76. While the crop samples collected during monsoon season showed the minimum and maximum APTI values ranged

between 7.10 and 9.91 and in winter the values ranged from 7.56 to 10.93 while the mean value ranged from 7.63 to 9.99 as shown in the Table 2.

In 10-15 Km radius of power plant leaf samples are collected from the villages Donabanda, G. Konduru, Chevitimukkala, Kuntamukkala, Kotikalapadu and Paritala. The samples collected during summer season showed the minimum and maximum APTI values ranged between 8.21 and 9.48. During monsoon season showed the minimum and maximum APTI values ranged between 8.29 and 9.87, in winter season the values are ranged between 7.77 and 9.62. While the mean values ranged from 8.25 to 9.41.

Within the radius of 15-20 Km NTTPS power station Brinjal and Tomato leaf samples were collected from the following villages like Narukalapadu, Endrayi Shermohamedpeta, Chanadralleapadu during summer, monsoon and winter seasons. The samples collected during summer season showed the minimum and maximum APTI values ranged between 8.34 to 9.89 While the crop samples collected from villages like during monsoon season showed the minimum and maximum APTI values ranged between 9.12 to 9.90 while the winter values ranged from 9.21 to 10.98, and mean value are 9.02 to 10.18 as shown in the Table 4.

In the vicinity of 20- 25 Km radius of NTTPS power station leaf samples of brinjal and Tomato were collected from the villages Tadikonda, ponekkalu, Gorantla, lam, Errapalem, Kanteru, During summer season leaf samples collected during summer season the minimum and maximum APTI values are ranged between. 10.22 and 14.22, during monsoon season the minimum and maximum APTI values are ranged between 11.11 and 14.34 while in winter season they range in between 12.10 to 14.79 with the mean values ranging between 11.35 and 14.22 as shown in the Table 5.

Vegetable crops like Brinjal and Tomato that are cultivated up to 20km are affected by the air pollution from power station and the impact is gradually declining there. From the APTI values obtained it is clearly found that these two crops are sensitive to air pollution and showed reduced yields. The impact is also found on other crops like paddy and cotton grown in this region [18-19].

Conclusion

Effect of air pollution on vegetable crops in the radius of 25 Km from NTTPS revealed that Brinjal and Tomato crops are sensitive to air pollution with their APTI values less than 11. They are tolerant after 20Km with the APTI values showing more than 12. This resulted the villagers almost to stop cultivating Brinjal and Tomato 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 Brinjal and Tomato plants are grown as double crops in the monsoon season and winter seasons. 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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