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BRICK KILN INDUCED AIR POLLUTION: ASSESSMENT THROUGH APTI OF PLANT SPECIES

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ABSTRACT

Plants purify the atmosphere by absorbing pollutants on their leaf surfaces. As a result, the accumulated pollutants have a negative impact on the leaves. It affects the plant's air pollution tolerance index (APTI), leaf extract pH (pH), relative water content (RWC), total chlorophyll content (TC), and ascorbic acid content (AA). These negative repercussions serve as indications of the pollution levels in the area. The current study assesses air pollution by measuring biochemical properties of trees as indicators (bioindicators), which are then used to estimate seasonal variations in air quality in that location. Several bio-chemical leaf parameters such as pH, relative water content, total chlorophyll and ascorbic acid were measured in seven different plants placed near brick kilns throughout the winter, summer, and post-monsoon seasons. Study carried out near brick kilns of Bundia village, Brajrajnagar Tehsil, Jharsuguda, Odisha. Plants selected for analysis are *Azadirachta indica, Buchanania lanzan, Butea monosperma, Calotropis gigantea, Holarrhena pubescens*, *Lantana Camara* and *Ziziphus jujuba*. Their air pollution tolerance index values (APTI) were calculated and considered as a measure of air pollution levels of that area. The pollution level around brick kiln locations was found to be higher during the summer and winter seasons as compared to that of the post-monsoon season. This may be due to precipitation effect of rain. In different studies SPM, SO_2 and NO_2 levels were found to be less as compared to winter and summer. The overall amount of air pollution was found to be higher during the winter season than during the summer season.

KEY WORDS: Air-pollution, APTI, Biochemical parameters, Bioindicator, Relative water content, Ascorbic acid

INTRODUCTION

Air pollution is the result of presence of hazardous compounds caused by human activities. When plants are exposed to contaminants in the air, they go through physiological changes before showing observable harm to their leaves (Liu and Ding, 2008). Pollutants impact leaf injury, stomatal damage, decrease photosynthetic activities, reduction in growth, decreased production, premature senescence and disrupt membrane permeability (Tiwari *et al*., 2006; Skinder *et al*., 2015). In addition to visual alterations, it also changes values of different biochemical parameters like leaf extract pH (pH), relative water content (RWC), total chlorophyll content (TC) and ascorbic acid content (AA) and ultimately the air pollution tolerance index (APTI) of the plant (Liu and Ding, *et al.,* 2008).

Acidic pollutants like SO_2 and NO_X lower the leaf extract pH, causing them to become more acidic. RWC of leaves is measured in terms of its full turgid state. Air pollutants affect transpiration rate in leaves (Chouhan *et al.,* 2012) lowering RWC value in plants, indicating a polluted environment (Swami and Joshi, 2004). Leaves that develop in polluted areas have lower photosynthetic activity, hence have lower chlorophyll concentration. The decline in TC is primarily due to particulate matter accumulation on the leaf surface. The ascorbic acid (AA) is a potent reductant (anti-oxidant) that is abundant in growing plant parts and acts as a plant's resistance to harsh environmental conditions. Plants release a considerable amount of it during stressful situations. As a result, the AA content of samples from the polluted environment will be higher compared to those from the non-polluted environment (Rai *et al.,* 2013). Hence AA is widely regarded as an effective biomonitoring strategy for pollution-affected plants.

The APTI is important to determine plant species resistance and also susceptibility to pollution levels. Variance in pH, RWC, AA, and chlorophyll content leads to modification in APTI values. Plants with greater APTI values are resistant to pollution, whilst those having lower APTI values are more susceptible (Lohe *et al.,* 2015). In the current study, seven different plant species *Azadirachta indica, Buchanania lanzan, Butea monosperma, Calotropis gigantea, Holarrhena pubescens, Lantana Camara and Ziziphus jujube* were selected as experimental plants present nearbrick kilns. For accessing seasonal variation of air pollution in that area, the investigation was conducted in three different seasons namely winter, summer and post monsoon.

METHODOLOGY

Area of Study

The current research was conducted in areas near the brick kilns of Bundia village, Brajrajnagar Tehsil, Jharsuguda, Odisha, which is located at 83° 54′ 50" E longitude and 21° 46′ 49" N latitude in the Jharsuguda district, Odisha, India, at an average elevation of 235 metres (771 feet) above mean sea level. This area is famous for supply of clay brick. The surrounding of this village contains more than 20 number of clay brick kilns operating presently. Large amount of coal is burnt in the kilns during production of bricks which generates huge amount of SO_2 and NO_X (George *et al.,* 2015. In addition to that, much amount of dust is also released into environment during loading and transport of bricks at the final stage.

Sample Collection

Mature and healthy leaves were collected from plants in good condition, with little or no disease or pests (Table 1). Leaves of the same plants were collected during three different seasons, winter season (December 2021), summer season (May, 2022) and post monsoon (September, 2022). Leaf extract pH (Varshney, 1992), RWC (Yan-ju and Hui, 2008), TC (Arnon, 1949) and AA (Pradhan *et al.,* 2016) were all measured in fresh leaves and the APTI values were calculated adopting the formula as per Liu and Ding, (2008) and Singh and Rao, (1983).

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

Where A is ascorbic acid content in mg/g, P is pH of the leaf extract, T is total chlorophyll content in mg/g and R is relative leaf water content in percentage.

Statistical Analysis

The correlation coefficients were calculated between independent variables such as, TC, pH, RWC, AA and dependent variable such as APTI. Analysis Tool Pack in Excel was used for this calculation.

RESULTS AND DISCUSSION

In this investigation seven plant species were identified in area near brick kilns around Gudiali village of Jharsuguda District. The findings in different seasons are as mentioned in Table 2. APTI values are attributed to the different responses of the trees to the 4 biochemical parameters of their leaves, namely pH, RWC, TC and AA.

Table 1. Details of plant species under experiment

Species No.	Name of species	Common Name	Local Name	Family	Type	Average Plant height
1	*Azadirachta indica*	Neem	Neem	Meliaceae	Tree	15 to 20m
2	*Buchananialanzan*	Chironji	Char	Fissurellidae	Tree	10 to 15m
3	*Butea monosperma*	Palas	Palas	Fabaceae	Tree	10 to12m
4	*Calotropis gigantea*	Aak	Arakh	Apocynaceae	Shurb	2 to 3m
5	*Holarrhenapubescens*	Kurchi	Kure	Apocynaceae	Shurb	2 to 3m
6	*Lantana Camara*	Lantana	Putus	Verbenaceae	Shurb	2 to 3m
7	*Ziziphus jujuba*	Bair	Barakoli	Rhamnaceae	Tree	10 to 12m

Table 2. Biochemical parameters and APTI of selected plant species in different seasons

Species No.	Name ofspecies	Season	pH	RWC	AA	Chl	APTI	Average APTI
1	*Azadirachta indica*	Winter	6.62	79.95	12.55	5.23	22.87	20.90
		Summer	6.70	73.39	11.59	4.98	20.88	
		Post Monsoon	6.87	82.77	8.46	5.76	18.96	
2	*Buchananialanzan*	Winter	6.91	78.10	7.63	3.23	15.55	14.58
		Summer	6.97	76.72	6.74	3.97	15.05	
		Post Monsoon	7.05	83.08	4.52	3.64	13.14	
3	*Butea monosperma*	Winter	6.09	70.45	7.25	5.14	15.19	14.10
		Summer	5.99	64.53	6.99	4.72	13.94	
		Post Monsoon	6.21	73.17	5.18	5.08	13.17	
4	*Calotropis gigantea*	Winter	7.14	82.63	12.70	4.34	22.84	21.56
		Summer	7.19	77.62	12.25	4.41	21.97	
		Post Monsoon	7.39	90.51	8.98	4.65	19.86	
5	*Holarrhenapubescens*	Winter	6.49	80.12	6.64	3.52	14.66	13.48
		Summer	6.52	78.49	6.21	3.13	13.84	
		Post Monsoon	6.54	83.12	3.72	3.18	11.93	
6	*Lantana camara*	Winter	7.76	75.70	9.83	5.25	20.36	19.17
		Summer	7.85	67.31	9.69	5.01	19.19	
		Post Monsoon	7.09	81.32	7.56	5.92	17.97	
7	*Ziziphus jujuba*	Winter	5.98	50.89	8.95	3.17	13.28	12.95
		Summer	6.11	45.56	8.66	4.29	13.56	
		Post Monsoon	6.19	58.94	6.14	3.79	12.02	

For the study of air quality such as SPM, SO_2, NO_X were done by a high volume air sampler manufactured by Envirotech APM 460BL. Pre-weighted glass micro fiber filter were used and concentrations were computed as per standard method prescribed by BIS. The obtained results are shown in Table 3.

Table 3. Air quality parameters measured in different seasons (in µg/m³)

	SPM	PM_{10}	SO_2	NO_X
Winter (Dec 2021)	447	105	91	61
Summer (May 2022)	453	117	84	62
Post Monsoon (Sep 2022)	403	74	63	52

pH

pH fluctuations were measured across the various species, and the results are graphically depicted in Figure 1 and Table 2. This shows the differences in response of each tree to the same pollutants from similar sources of pollution which can be ascribed to the variation in retrieved leaf pH values (Kaur and Nagpal, 2017). In this study, lowest (most acidic) pH value (5.98) was found for *Ziziphus jujuba* in winter season and the highest (7.85) for *Lantana camara* in summer season.

In the leaves extract of plants, a pH shift towards the acidic side was observed in both winter and summer seasons as compared to post monsoon season, except *Lantana camara*. The low pH level may be due to the presence of SO_2 and NO_X in the ambient air, which causes a change in the pH of the leaf sap towards the acidic side of the pH scale (Swami *et al.*, 2004).

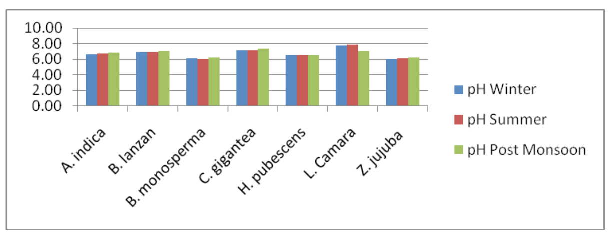

Fig. 1. Variations in pH of leaf extracts of the plant species in different seasons.

Except for *Butea monosperma*, the pH values during winter season were always lower than those during summer season of brick kiln area.It may be owing to a huge amount of SO_2 and NO_X being released due to burning of coal in the kilns and from the exhaust of diesel operated heavy vehicles operating within the site.

Relative Water Content (RWC)

RWC is plant's water balance indicators. Pollutants have an effect on leave transpiration rate, resulting in a decrease in plant RWC (Swami *et al.*, 2004). The lowest value of RWC (45.56 percent) was observed in the case of *Ziziphus jujuba* in the summer season, while the highest value (90.51 percent) was observed in the case of *Calotropis gigantea* in the Post Monsoon.

According to the current findings, RWC of all plant species was lower in summer season compared to winter and post monsoon (Table 2). The dryness of environment in summer season leads to lower RWC values. But in addition to that, higher level of dust pollution also results in low RWC values. The results (low RWC) indicate higher levels of dust from brick kilns in summer season. Figure 2 depicts the variation of RWC values of different species in different seasons.

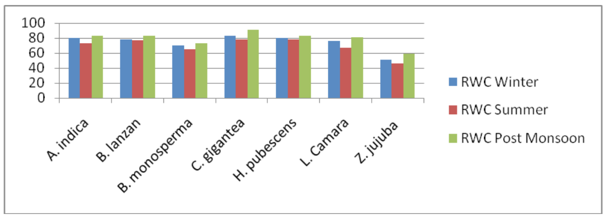

Fig. 2. Variations in relative water content of the plant species in different seasons.

Total Chlorophyll (TC)

Plant chlorophyll content indicates photosynthetic activity including biomass development. In the present study, the lowest TC value (3.13) was noted in the case of *Holarrhena pubescens* in the summer season, while the highest value (5.92) was observed in the case of *Lantana camara* in the post monsoon season. The reduction in TC content is primarily caused by particulate matter deposition on the leaf surface. Polluted and dusted leaf surfaces leads to a decrease in photosynthetic activity whichreduce chlorophyll content (Kalyani and Singaracharya, 1995). The reduction in TC may be the result of the alkaline condition caused by the chemicals present in dust particles generated by coal burning (Kuki *et al.,* 2008).

Ascorbic Acid

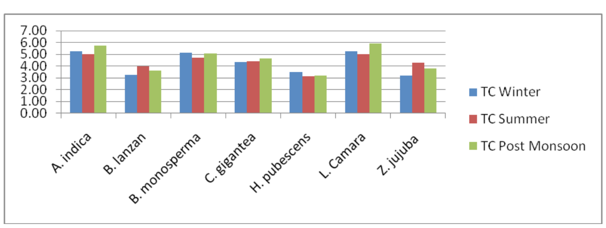

Fig. 3. Total chlorophyll content of the plant species in different seasons.

Because of the increased rate of reactive oxygen generation, the AA content of all plant species increases in polluted environments. It assesses a plant's tolerance to SO_2 contamination (Varshney and Varshney, 1984; Tripathi and Gautam, 2007). The lowest AA value (3.72) was observed in *Holarrhena pubescens* during the post-monsoon season, while the greatest value (12.7) in Calotropis gigantea during the winter. As per current data, the AA of all plant species was much less in the post monsoon season compared with summer and winter seasons (Table 2, Figure 4), indicating that summer and winter seasons had greater levels of air pollution (Panda *et al.,* 2018).

In all cases the AA content was found to be highest in winter season. It indicates that levels of SO_2 being higher in winter season, which could be due to the release of a large amount of SO_2 generated from burning of coal in the brick kilns.

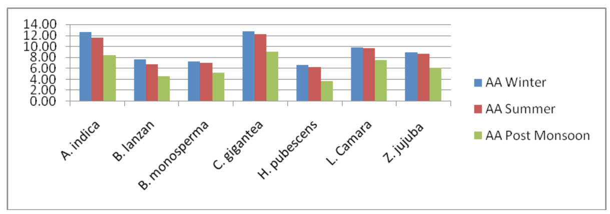

Fig. 4. Variations in ascorbic acid content of the plant species in different seasons.

APTI

A summary of the study's findings reveals that different plants react differently to different air pollutants. The APTI of 7 plant species were assessed using biochemical parameters from the leaves such as leaf-extract pH, RWC, chlorophyll, and AA (Table 2, Figure 5). In this study, the lowest APTI value (11.93) was found in *Holarrhena pubescens* in the Post Monsoon, while the highest value (22.87) was found in *Azadirachta indica* in the winter season.

Plants of same species growing in a polluted environment have a larger APTI value than those growing in a non-polluted environment, according to several observations (Rathore *et al.,* 2018). It means that greater APTI readings in the same plant species throughout any season indicate a higher amount of pollutants in air during that season (Shannigrahi *et al.,* 2004).

Except for Ziziphus jujuba, which had the greatest APTI values in summer, other plant species had their highest APTI values in winter. According to these data, overall air pollution due to brick kilns was found to be highest in winter and lowest in the post-monsoon season. *Calotropis gigantea* (aak) showed the highest average APTI in our study (21.56), followed by *Azadirachta indica* (neem) (20.90). Therefore these plants might be planted to help trap air pollutants in heavily polluted areas near brick kilns.

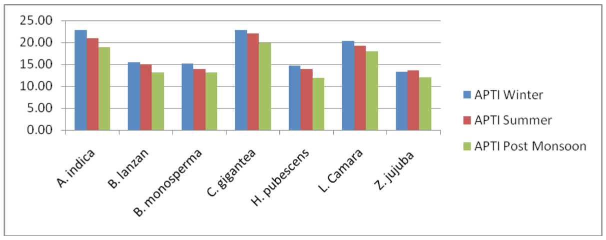

Fig. 5. Variations in air pollution tolerance indices of the plant species in different seasons.

Correlation Matrix Interpretation

Tables 3, 4 and 5 show the correlation coefficient values between biochemical parameters such as pH of the leaf extract, RWC, TC, and AA and the air pollution tolerance index of selected plants in winter, summer and post monsoon seasons.

Table 3. Correlation among biochemical parameters in winter season

	pH	RWC	AA	TC	APTI
pH	1				
RWC	0.580	1			
AA	0.382	0.259	1		
TC	0.335	0.343	0.438	1	
APTI	0.631	0.612	0.894	0.645	1

Table 4. Correlation among biochemical parameters in summer season

	pH	RWC	AA	TC	APTI
pH	1				
RWC	0.435	1			
AA	0.426	0.067	1		
TC	0.264	-0.273	0.613	1	
APTI	0.656	0.414	0.918	0.546	1

Table 5. Correlation among biochemical parameters in post monsoon season

	pH	RWC	AA	TC	APTI
pH	1				
RWC	0.828	1			
AA	0.554	0.273	1		
TC	0.278	0.178	0.713	1	
APTI	0.759	0.602	0.923	0.736	1

APTI showed a strong positive correlation with AA in the post monsoon season, having coefficients of 0.923 and 0.918 in summer season and 0.894 in the winter season. In the post monsoon there is also a positive correlation between APTI with pH with coefficient of 0.759 and Total chlorophyll with coefficient of 0.736. According to the findings of the study, the most important element of the biochemical parameters that determine the tolerance of the same species in different seasons is AA content in every season and some way pH and total chlorophyll in post monsoon season.

Seasonal variation of air quality parameters.

The obtained values air quality parameters such as SPM, SO_2, NO_X are given in Table 3 and presented graphically in the Fig. 6. It may be observed that levels of SPM and PM_{10} are high in summer season while lowest in post monsoon season. Concentration of SO_2 was seen to be high in winter and low in post monsoon while Concentration of NO_X was seen to be higher in winter and summer compared to post monsoon season.

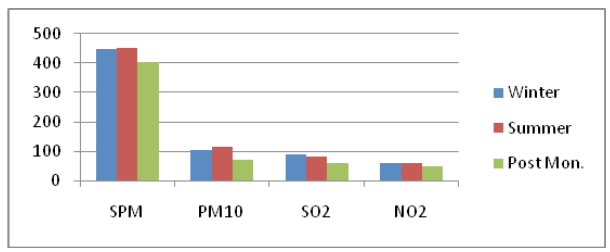

Fig. 6. Variations in air quality parameters in different seasons

CONCLUSION

Plants enhance air quality because they collect toxins on their leaf surfaces and are harmed by their build-up, resulting in aberrant symptoms or development, making them useful indication (or bioindicator) of environmental pollution. According to the findings it may be concluded that overall air pollution due to brick kilns is highest in winter whereas lowest in the post-monsoon season. A similarity of the conclusion may also be seen from the measured air pollution parameters.

This method is very much easy and cost effective and significantly useful in understanding the depth of air quality in different seasons. It will be useful for management of air quality in the site by developing green belt of suitable plant species according to the necessities of the sites.

It also aids in the selection of suitable plant species (with higher APTI) for plantation in highly polluted areas in order to reduce air pollution, as well as the use of plants as bioindicators to identify pollution levels, a cheap and simple technique for monitoring air pollution. Determination of APTI is important because combining a number of biochemical parameters results into more reliable output compared to relying on a single parameter. Future research in this area should focus on plant characteristics such as plant height, plant growth rate, changes in colour and morphology of leaves and their relationship to APTI values. In addition to that as soil pH and condition may also affect leaf parameters, more research in that area is needed.

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