Research Article　　　　　　　　　　　　　　　　　　　　　OMICS International

Efficient Control of Air Pollution through Plants a Cost Effective Alternatives

Kapoor CS[1]* and Chittora AK[2]

[1]Department of Environmental Science, Mohan Lal Sukhadia University, Udaipur-313001, Rajasthan, India

[2]Department of Basic Science, Maharana Pratap University of Agriculture and Technology, Udaipur-313001, Rajasthan, India

*Corresponding author: Kapoor CS, Department of Environmental Science, Faculty of Earth Science, Mohan Lal Sukhadia University, Udaipur-313001, Rajasthan, India, Tel: +919829887010; E-mail: drcskapoor@yahoo.in

Abstract

Plants can be used as both bio-monitors and bio-mitigators in urban an industrial environments to indicate the environmental quality and to ameliorate pollution level in a locality. Many studies reveal that plants absorb gaseous particulate pollutants and help in controlling and natural means for controlling air pollution. In order to test certain plants as an effective and natural means for controlling air pollution present studies were undertaken. The present study was conducted to evaluate the impact of air pollution on comparative basis with references to photosynthetic pigments as well as biochemical parameters of plants of different polluted and unpolluted sites around Udaipur city receiving varying levels of pollution load. Our studies suggest that certain plants species (*Holoptelea integrifolia* L., *Mangifera indica* L., *Pongamia pinnata* (L.) Pierre, *Dalbergia sissoo* Roxb.) can be successfully grown in an area for monitoring and control of air pollution effectively besides acting as shade tree and being a source of food for animals and birds. Our results confirm that industrial and vehicular pollution level in Udaipur city is shifting beyond limits.

Keywords: Air pollution; Tree plantation; Biochemical studies; Green belt; *Dalbergia sissoo* Roxb

Introduction

Natural air pollution existed around us for millions of years, but during the last century, pollution created by humans has become a major concern. Air pollution is a major environmental health problem affecting the developing and the developed countries alike. It is not only the ambient air quality in the cities but also the indoor air quality in the rural and the urban areas that are causing concern and highest air pollution exposures are in the indoor environment. We are most familiar with visible air pollution like smog; however, many other types of air pollution, including some of the most dangerous, are totally invisible. Air pollutants rarely exist singly; but the combined pollutants may have synergistic, additive or antagonistic effects. These directly affect the quality of life, human and other beings' health, and climate. Because of its general impact on environment and health, air pollution is continuously monitored worldwide in the bigger cities. A dictionary of Indian raw materials and Industrial products, vol. Medicinal Plants [1]. With increasing industrialization, forests are being affected adversely because of contamination of air, water and soil by growth inhibiting (or generally toxic) substances that include gases, acids and particles, etc. It has been observed that various stresses affect plants in different ways. Inhaled air pollutants have serious impact on the lungs so on the respiratory system and may reach all over the body. Air pollution control is more complex than most other environmental challenges. No physical or chemical method is known to ameliorate aerial pollutants. A suitable alternative may be to develop a biological method by growing green plants in and around industrial and urban areas. In all cites of the India, air pollution is the major environmental problem due to the industrial plants, power plants, domestic heating and especially motor traffic. Increased concentrations of air pollutants

and the variety of pollutants have negative effects on the increasing population density in the city. Air pollution harms not only human beings but also plants and animals living together in the city. Epidemiological studies throughout the world have established a close association between urban pollution and human diseases where ambient air quality was much more above the National standards [2]. Some of the plants species have been identified that have an ability to absorb, detoxify and tolerate high level of pollution [3]. Air pollution is complex mixture of various gases, particulates, hydrocarbons, transition metals, etc. More comprehensive assessment of the potential effect of the air pollution complex might lead to better environment for human habitation & existing flora. Health effects and time course of particulate matter on the cardio-pulmonary system in rats with lung inflammation [4]. Urban air pollutants cause a wide range of acute and chronic effects on the respiratory system. Exposure to automobile exhaust is associated with increased respiratory symptoms and may impair lung function. Environmental pollution affects large areas of forest, and field assessment of these effects is a costly, site-specific process. The past two decades have seen growing interest in air pollution-vegetation effects [5]. The evaluation of these biochemical parameters represents a non-invasive, simple and reproducible approach of assessing plant responses to environmental stressors that is also applicable to other species. Plants that are constantly exposed to environmental pollutants absorb, accumulate and integrate these pollutants into their systems. It reported that depending on their sensitivity level, plants show visible changes which would include alteration in the biochemical processes or accumulation of certain metabolites [6]. The impact of industrial air pollutants on some parameters and yield in wheat and mustard plants [7]. Physiological and biochemical studies on some common tree species in Udaipur city under pollution stress [8]. Studies on the quality of ambient air in the Udaipur City, Rajasthan [9]. The health risk from particulate pollution is high for some susceptible groups, i.e., the children and the elderly

persons those suffering from diseases of the heart and lungs [10]. Comparative studies were carried out on some tree species commonly found in Udaipur and its adjoining areas and it revealed that tree species, viz., *Mangifera indica* L., *Pongamia pinnata* (L.) Pierre, *Dalbergia sissoo* Roxb., and *Holoptelea integrifolia* L. act as efficient sink for air pollutants and help rejuvenating the industrial and urban environment [11-15]. Status of Air Quality and Noise level of Udaipur City, India during Diwali Festival [16]. The main objectives of this study is to establish tree plantations as a cost effective means to control air pollution caused due to industries, vehicles and climatic disturbances in the areas where it can be successfully grown. Besides this it's economic worth can be utilized which is an added advantage. Although the results and interpretations represent a particular study at a determined time, but investigations must be carried periodically, that will help continuous monitoring and assessment of the ambient air quality regularly to save any disastrous situation. In the present study ambient air quality of Udaipur, city India is assessed SPM, RSPM, SO_2 and NOx. Effect on plants is assessed by the variations in selected biochemical parameters in plant leaves.

Materials and Methods

Study area

Indian subcontinent lies entirely to the north of the equator between latitudes 8° and 36° N. India is categorized as a tropical country in spite of the fact that its northern part-the Gangetetic plain belongs geographically to the north temperate zone of the world. The climate of the India is mainly controlled by the physiography of several hills and ranges, like Himalayan range mountain ranges of Meghalaya and Arunachal, the Western Ghats together with the Nilgiris and other hills in south and the Aravalli range in the west. The climate of India is of monsoon type. According to Meteorological Department, Government of India, there are following four seasons in the country:

The seasons of the north-east monsoon.

The 'cool season 'from mid-December to February.

The 'hot dry season' from March to mid-June.

The seasons of the south-east monsoon.

The 'wet season' from mid-June to mid-September.

The 'season of retreating monsoon' from mid-September to mid-December.

The Udaipur (state Rajasthan, India) known as city of lakes is situated about 600 m above the mean sea level and is located among the lush green hills of Aravalli range between 24°35'N latitude and 73°42'E longitude (Figure 1). There are three major lakes around Udaipur and within, e.g., Fateh Sagar, Swaroop Sagar and Pichhola. The city has a population around 0.65 million and has a distinct tropical climate with marked monsoonal effect. The climate of Udaipur can be divided into three distinct seasons, i.e., summer (March-June), rain (June-September) and winter (November-February). The average temperature ranges from 5°C in winter to maximum of 41°C in summers. The annual average rainfall ranges between 62.5-125 cm during normal monsoon regime. In order to assess the status of air pollution on the growth, biochemical and physiological parameters along with morphological changes three sites were selected, viz., Forest area (Kevede ki Naal lying at 24°25'00.90"N and 73°46'05.40"E and elevation 449 m), Industrial area (Madri Industrial Area lying at

24°35'01.23"N and 73°44'59.52"E and elevation 600 m) and Urban area (Surajpole lying at 24°34'45.95"N and 73°41'46.31"E and elevation 612 m).
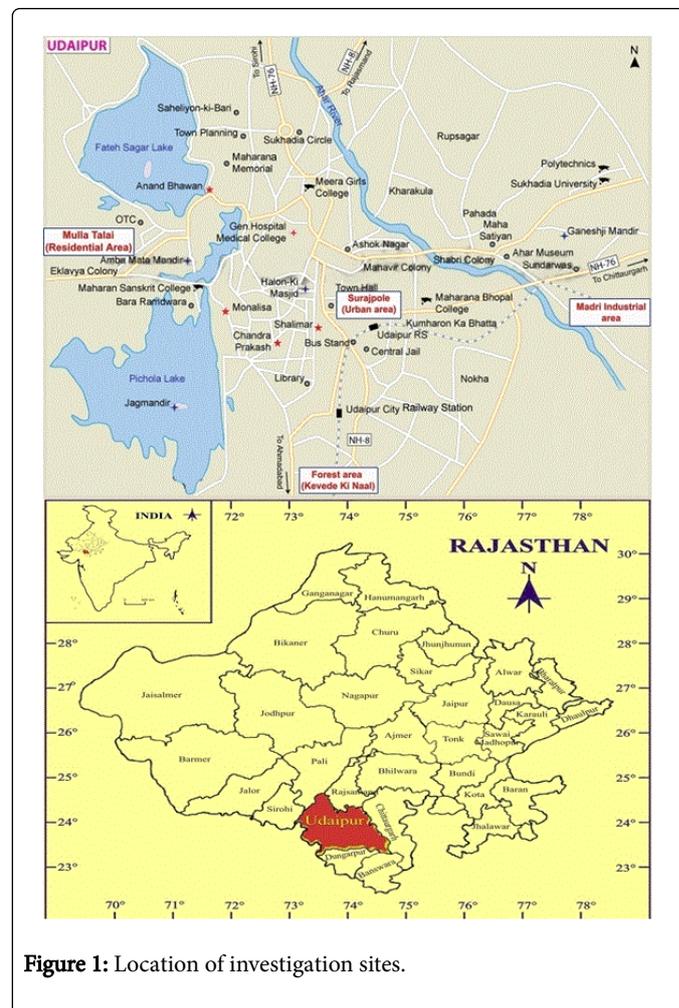

Figure 1: Location of investigation sites.

Methodology

The plant growth parameters studied were amount of chlorophyll a, chlorophyll b, total chlorophyll, and carotenoid was measured by Jenson [17]. The activities of two oxidative enzymes peroxidase and polyphenol oxidase were studied along with the above parameters in the described schedule [18]. Increased activity of these two enzymes has been found in plants facing pollution. Dust capturing capacity of the leaves of sample trees was another parameter which substantiated our data on the effect of ambient air pollution and its monitoring. Dust capturing capacity and leaf size of the leaves of sample trees were measured by method given by Pandey et al. [19]. Total carbohydrate [20] and total protein of the plant samples as a soluble fraction were determined [21]. The SPM & RSPM concentration were measured using filter paper method [22]. The concentration of SO_2 was measured by West and Gaeke [23] and NOx was measured by the method of Jacob and Hochheiser [22].

The ambient air quality and toxic effect of air pollutants on the tree species as above were investigated at these points for two consecutive years, i.e., from September, 2007 to October, 2009 on bimonthly basis. Ambient air samples were collected using High volume sampler

(Envirotech model, APM-410) and Respirable dust sampler (Envirotech model APM 460) with suitable gas attachment. SPM and RSPM were collected on glass fiber filter papers by using high volume sampler and Respirable dust sampler [22]. Particulate concentrations were determined gravimetrically by taking pre- and post-sampling filter weights and considering the sampled air volume. Gaseous pollutants were scrubbed separately in 0.1 M potassium tetrachloromercurate and sodium hydroxide (0.1 N), respectively.

Results

Air pollution

Results of investigation were recorded for two years (September 2007-October 2009) of the study. The mean average values of two years data are presented in Table 1. The national standards of SO_2/NOx, SPM and RSPM for urban area are 80 $\mu g/m^3$, 200 $\mu g/m^3$ and 100 $\mu g/m^3$ respectively. During study period SO_2 was lowest (4.99 $\mu g/m^3$) in urban area and recorded maximum (16.03 $\mu g/m^3$) in Madri industrial area. In case of SPM observed concentration was lowest (00.00 $\mu g/m^3$) in rainy season and highest (915.76 $\mu g/m^3$) in Madri industrial area. National standards for industrial area for SO_2/NOx are 120 $\mu g/m^3$, for SPM 500 $\mu g/m^3$ and RSPM is 150 $\mu g/m^3$. RSPM value was recorded lowest (25.59 $\mu g/m^3$) in urban area and highest value (746.06 $\mu g/m^3$) in Madri industrial area. NOx was observed lowest (35.64 $\mu g/m^3$) in urban area and highest value (63.94 $\mu g/m^3$) was recorded in madri industrial area. For forest area National standard of SO_2/NOx is 30 $\mu g/m^3$, for SPM it is 100 $\mu g/m^3$ and RSPM it is 75 $\mu g/m^3$ in the sensitive area.

Sampling Station		Range of Mean Concentrations of Air Pollutants ($\mu g/m^3$)							
		SO_2		NOx		SPM		RSPM	
		Min.	Max.	Max.	Min.	Min.	Max.	Min.	Max.
Madri indudtrial area	Ist year	5.36	16.03	21.74	40.64	131.49	915.76	35.58	746.06
	IIst year	5.07	14.21	25.55	63.94	131.48	571.4	36.96	196.31
Forest area	Ist year	2.53	6.29	23.94	37.65	204	309.5	73.5	110.05
	IIst year	2.55	6.69	24.8	39	197.5	353.5	75.35	110.5
Urban area	Ist year	5.35	10.72	21.44	35.64	78.17	375.33	26.67	179.52
	IIst year	4.99	8.3	24.35	48.38	0	493.09	25.59	147.55

Table 1: Mean values of ambient air quality during September, 2007-August, 2009 in studied sites of Udaipur City.

Biochemical parameters studied

During the two year of the study period *Dalbergia sissoo* Roxb. in industrial area were showed lowest amount of Chl a (0.181 mg/g), while higher amount was recorded (0.883 mg/g) in *Holoptela integrifolia* L. in the samples collected from forest area. The same pattern was observed in the case of Chl b. Total chl. was recorded minimum (0.292 mg/g) in the same plant *Dalbergia sissoo* Roxb. in industrial area while higher amount (1.876 mg/g) was observed in *Mangifera indica* L. in the sample of forest area. Higher value of Carotenoids was observed (0.1973 mg/g) in urban area in *Mangifera indica* L. and lowest value was recorded (0.064 mg/g) in industrial area in *Dalbergia sissoo* Roxb. In the case of Total carbohydrate higher value (10.8 mg/g) was estimated in Mangifera indica L. of forest area, while lower value 3.5 mg/g recorded in *Pongamia pinnata* (L.) Pierre from industrial area. Total protein was highest (10.2 mg/g) in *Dalbergia sissoo* Roxb. in forest area, and lowest value (4.38 mg/g) was observed in *Mangifera indica* L. from industrial area. Dust capturing capacity highest in industrial area in all plants ranging from 11.3 mg/cm^2 to 0.720 mg/cm^2 in *Mangifera indica* L. in forest area and lowest 16.11 mg/cm^2 in industrial area in *Dalbergia sissoo* Roxb (Table 2).

Discussion

Chlorophyll-a is found to be more sensitive to gaseous pollutants like SO_2 than chlorophyll-b [24,25]. Air pollution is the human introduction in to the atmosphere of chemicals, particulate matter or biological materials that cause harm or discomfort to humans or other living organism or damage the environment, various efforts have been done for environmental restoration in India but still it seems to be a formidable task. Plants, the main Green Belt (GB) component act as a sink and as living filters to minimize air pollution by absorption, adsorption, accumulation and metabolization without sustaining serious foliar damage or decline in growth, thus improving air quality by providing oxygen to the atmosphere. The effect of cement dust on soybean (*Glycine max* L. merr.) and maize (*Zea mays* L.) and the genotoxic effect of pollutants from thermal power plant on *Solanum melongena* [26,27] Air pollution can directly affect plants via leaves or indirectly via soil acidification. The high sensitivity of plants towards some pollutants means that a great variety of plants can be used as bio indicators of air pollution. The main focus of this work is to provide an assessment of the use of biochemical parameters of plants for GB. So that these biochemical indicators can be used for assigning. The effect of thermal power plant emission on the morphology and biochemical composition of different plant species (*Azadirchta indica*, *Ficus benghalensis*, *Ficus religiosa* and *Madhuca indica*) when the levels of suspended particulate matter and SO_2, NO_2 were much prominent and much above the threshold limit [28]. Trees play an important role in improvement of urban and industrial area air quality because of the capacity to intercept with the air borne matter; therefore plants are widely used as passive indicators of air pollution. Biochemical changes in plants follows the air quality trends hence biochemical parameters seems to be suitable markers of air pollution and can be used to draw or edit air quality maps [8,9]. Realizing the importance of tress and

their role in air pollution monitoring and control present study is conducted in field conditions. Main objective of the study is to provide a rational basis for air quality management and green belt development in urban areas. As a planting tree is one of the feasible strategies for reducing greenhouses gases [29-32].

Parameter Studied	Sites	*Dalbergia sissoo* Roxb.	*Holoptelea integrifolia* L.	*Mangifera indica* L.	*Pongamia pinnata* (L.) Pierre
Chl-a (mg/g)	Urban	0.294	0.465	0.619	0.445
	Industrial	0.181	0.726	0.261	0.201
	Forest	0.555	0.883	0.824	0.414
Chl-b (mg/g)	Urban	0.185	0.353	0.409	0.266
	Industrial	0.125	0.21	0.226	0.112
	Forest	0.362	0.97	0.933	0.593
Total Chlorophyll (mg/g)	Urban	0.465	0.7	0.83	0.741
	Industrial	0.292	0.486	0.47	0.332
	Forest	0.885	1.49	1.876	1.317
Carotenoids (mg/g)	Urban	0.102	0.177	0.1973	0.225
	Industrial	0.064	0.15	0.107	0.134
	Forest	0.188	0.278	0.302	0.687
Total Carbohydrates (mg/g)	Urban	4.23	3.76	6.3	4.4
	Industrial	4.17	3.38	4.3	3.5
	Forest	6.094	5.141	10.08	7.01
Total Protein (mg/g)	Urban	5.81	7.34	6.88	7.4
	Industrial	4.5	5.105	4.38	5.5
	Forest	10.24	8.38	10.1	9.8
Dust Capturing Capacity (mg/cm^2)	Urban	2.85	1.895	5.5	2.03
	Industrial	11.32	3.036	6.04	3.7
	Forest	1.2	1.072	0.72	0.567
Leaf size (cm^2)	Urban	19.89	42.41	62.83	45.33
	Industrial	16.11	35.83	41.41	37.5
	Forest	23.83	49.91	86.88	55.53

Table 2: Mean value of biochemical growth parameters of different plant species at different investigation sites of Udaipur city during two year of study (September, 2007-August, 2009).

Our result showed that most concerned about global warming is most serious problem of environment and ecological problems Considering plant's role in indication and abatement of air pollution, this study was carried out to assess the impact of pollutants on some biochemical parameters of four tropical tree species growing along the prevailing wind direction and their role as biomarkers of air pollution [11-15].

Conclusion

The present study suggests that plantation of *Mangifera indica* L., *Pongamia pinnata* (L.) Pierre, *Dalbergia sissoo* Roxb. and *Holoptelea integrifolia* L. is useful for bio-monitoring, the development of green belts as well as to reduce industrial air pollution. The 'green belt' or a 'buffer zone' of vegetation between industrial establishments and the residential areas is borne out because trees are being good bio-monitors. A cost effective means to control air pollution caused due to industries, vehicles and climatic disturbances in the areas where it can be successfully grown. Besides this it's economic worth can be utilized which is an added advantage. The road side trees serve as sink for toxic air pollutants as these absorb, detoxify and tolerate high level of pollution, The trees although tolerate but develop foliar injury and there is change in their metabolism under the influence of any toxic air pollutant.

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