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Anticipated Performance Index (API) of some selected phanerophytes considered for Green Belt Development.

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ABSTRACT

Advancement of countries with rapid economic growth often shows imbalance between development and environment. In spite of EIA and compensatory restoration, environment shows derangement as pollution and degradation. The restoration strategy whether in urban or rural situations have started adopting Green Belt Development (GBD) strategy with phanerophytes selected on the basis of their API (Anticipated Performance Index) score which depends up on plant-response to different parameters like APTI, habit, canopy-structure, plant-type, laminar structure and economic value. The present work addresses such environment-issue by API-grading of 12 species selected from the greeneries of Burdwan University campus, West Bengal. Fresh leaf-samples were collected and total chlorophyll content, leaf- pH, relative leaf water content and ascorbic acid content were determined. APTI value of which were combined with some relevant biological and socio-economic characters to find the API-scores and putting into different grades, on the basis of API-score *Swietenia mahogani, Putranjiva roxburghii* and *Mangifera indica* was graded as 'very good'; *Ficus benghalensis* as 'good'; *Mimusops elengi* and *Albizia saman* as 'moderate'; *Senna siamea, Cassia fistula* and *Markhamia stipulata* as 'poor'; *Polyalthia longifolia* as 'very poor'. Both *Saraca asoca* and *Lagerstroemia speciosa* are not eligible to be recommended for GBD. Such trees as *Swietenia mahogani, Putranjiva roxburghii, Mangifera indica, Ficus benghalensis, Mimusops elengi* and *Albizia saman* were found to be so suitable environmental optimizers in the campus that they are suitable in modeling of "green belt" elsewhere.

Keywords: Environmental Impact Assessment (EIA), compensatory restoration, restoration strategy, Green belt development (GBD), Anticipated performance index (API)

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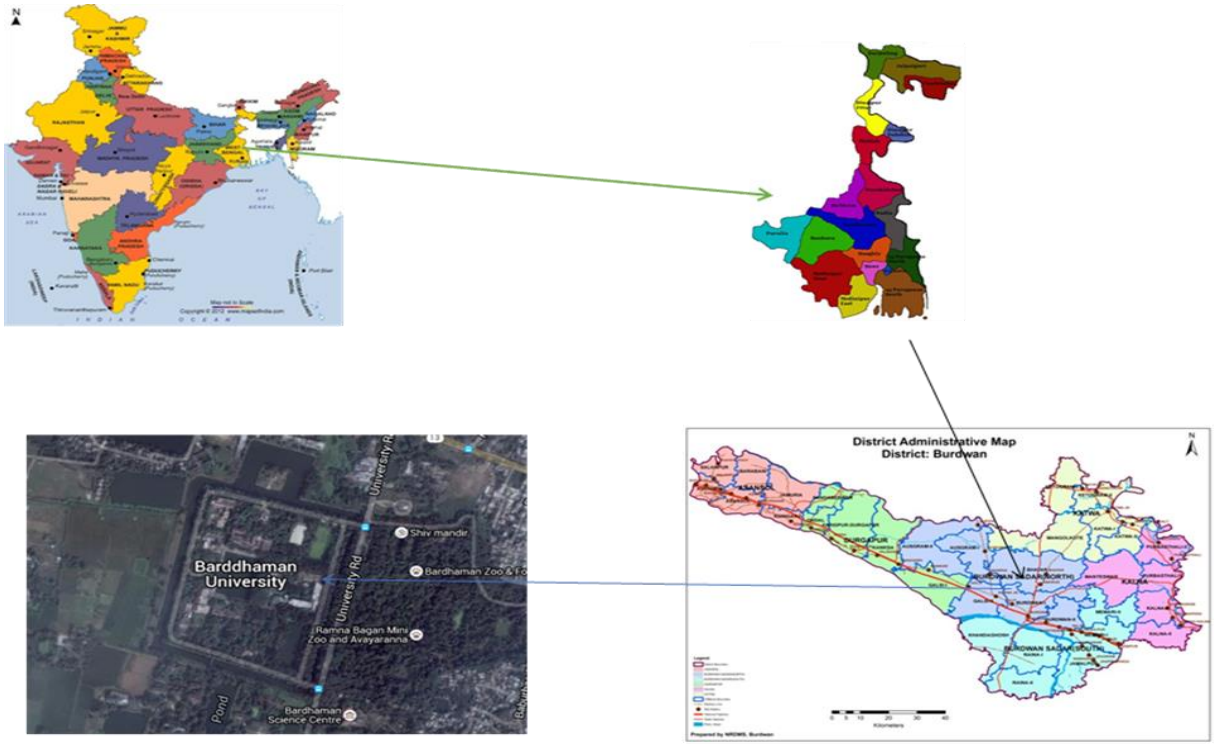
INTRODUCTION

Air pollution is one the major problems today which is adversely affecting the environment locally as well as globally mainly due to industrialization and vehicular combustion [8] releasing particulate matters into the air in addition to nitrogen oxide, carbon dioxide, sulphur dioxide, carbon monoxide as well as smoke [14]. It has become ardently necessary to monitor and abate the pollution load immediately. Scientists have been trying to address such an issue with plants. Plants, the basic integral component of a functional ecosystem as primary producers, sink and living filter, are the most affected ones during air pollution [11, 2]. They are more sensitive to air pollution than animals and for being in stationary state, for being able to be resilient adequately to the environmental resistance, they become the most suitable agency for bio-monitoring environmental state [7]. Green Belt Development is an important consideration for addressing this problematic issue by maintaining the ecological balance in circumstances of population overgrowth which is exceeding the carrying capacity of the place. The general concept of "Green Belt" has evolved in recent years to encompass "greenspace" and "green structure", taking into account urban green space, an important aspect of sustainable development in the 21st century [9]. If the present situation is taken into account, the developed and developing countries are meeting with rapid growth of economy and population and it has led us conclude that, development does not always compromise with environment. In spite of steps like Environmental Impact Assessment (EIA) and compensatory restoration, environment seems to fall victim to derangement in form of pollution as well as degradation. The restoration strategy whether in urban or rural situations have started adopting Green Belt Development (GBD) and for successful development, selection of species is of prime importance for which indigenous species are initially prioritized. From among species appropriate species is finally selected for GBD on the basis of Anticipated Performance Index (API) of individual species. In view of the forewing, the present work was undertaken to evaluate the API grade [13]. Plants are different, by considering the reference to their responses towards pollutants, by being sensitive, highly sensitive and some intermediately tolerant. On the basis of the APTI and some relevant biological and socioeconomic characters, the anticipated performance index (API), from “best” to “not recommended” categories, of various plant species was determined for GB development. Anticipated performance index (API) of a species for Green Belt Development depends up on its response to different grading parameters like Air Pollution Tolerance Index (APTI), Plant habit, Canopy structure, Type of plant, Laminar structure (size, texture and hardiness), Economic Value. Evaluation of the API might be very useful in selecting the sink potential of selected plant species [4].

Study site



"Golapbag" an academic campus of Burdwan University is located at 23.25° N 87.85° E, which is 131 ft above the mean sea level. Presently, there are numerous individual trees of *Barringtonia acutangula, Polyalthia longifolia, Swietenia mahagoni, Drypetes roxburghii, Saraca asoca, Markhamia stipulata, Manilkara hexandra, Aphanamyxis polystachia, Albizia saman, Naringi crenulata, Pongamia pinnata* and several others in the garden. An immense number of species are unique in their occurrence in the campus for having been either introduced or surviving as the reminiscent of the indigenous flora that no more exists outside the campus area today.

MATERIALS AND METHODS

Selection of 12 species (*Albizia saman, Cassia fistula, Ficus benghalensis, Lagerstroemia speciosa, Mangifera indica, Markhamia stipulata, Mimusops elengi, Polyalthia longifolia, Putranjiva roxburghii, Saraca asoca, Senna siamea, Swietenia mahagoni*) was based on their predominance in the area and efficiency in carbon sequestration [3, 5]. For determination of Anticipation Performance Index (API) it was necessary to follow the work schedule as given here under.

Calculation of Air pollution tolerance index (APTI)

Leaf samples were collected from the selected plants. The fresh leaves were immediately taken to the laboratory and were preserved on the refrigerator for further analysis.

Total chlorophyll content (TCh)

The chlorophyll content was determined by the colorimeteric method [1]. Firstly 3g of fresh leaves were blended in a motar and pestle and then extracted with 20 ml of 80% acetone and left for 15 minutes. The liquid portion was centrifuged at 2,500 rpm for 3 minutes. The supernatant was separated from the pellet and absorbance was taken at 645 nm and 663nm for Chlorophyll a and Chlorophyll b using a spectrophotometer. Calculations were done using the formulae given below:

Chlorophyll a = $[(12.7 \times O.D_{645} - 2.69 \times O.D_{663}) \times V] / (1000 \times W)$ mg/g
Chlorophyll b = $[(22.9 \times O.D_{645} - 4.68 \times O.D_{663}) \times V] / (1000 \times W)$ mg/g
Total chlorophyll content (TCh) = Chlorophyll a + Chlorophyll b (mg/g)

where, V = Total volume of the chlorophyll solution (ml) and W = Weight of the tissue extracted (g)

Relative leaf water content (RWC):

The relative leaf water content was determined by the following formula [12].

$$RWC = [(FW - DW) / (TW - DW)] \times 100$$

where, FW = Fresh weight, DW = Dry weight, TW = Turgid weight

The fresh leaves of the collected sample were weighed in order to obtain the fresh weight, then immersed in water overnight, blotted dry and weighed in order to get the turgid weight. The leaves were then kept overnight in an oven at 70° C and re-weighed in order to obtain the dry weight of the individual samples. Three replicas of each sample were taken to avoid inappropriate results.

Leaf extract pH (P)

In order to measure the pH of the leaf extract, 1g of the fresh leaves was homogenized in 10ml of deionised water and filtered [13] and then caliberated in the pH meter with buffer solution of pH 4 and 9.

Ascorbic acid content (AA)

In order to determine the ascorbic acid content, colorimetric method was followed [10]. Firstly, 10 ml of 6% trichloroacetic acid (TCA) was added to 1g of the fresh foliage leaves in mortar and pestle to homogenize

and then centrifuged at 5000 rpm for 5 minutes. The supernatant was separated and to it, a pinch of activated charcoal was added and filtered. The volume of the filtrate was made up to 100 ml by adding distilled water. 5 ml of diluted supernatant was taken in a test tube and mixed with 3 ml of 2% 2, 4 - DNPH in 9 (N) H_2SO_4, to which 1-2 drops of 10% thiourea solution in 70% ethanol was added and was boiled for 15 minutes in water bath and cooled at room temperature. To each sample, 5 ml of 80% H_2SO_4 was added at 0°C. The absorbance was measured at 530nm with a colorimeter after 30 minutes. The concentration of unknown samples was extrapolated from a standard ascorbic acid solution of 50ppm using the formula:

Concentration of unknown solution

= (Concentration of standard solution x $O.D_{530}$ of unknown) / $O.D_{530}$ of standard solution

Air pollution tolerance index (APTI) determination :

This was done by following the formula of APTI is given as [13]:

APTI = [A (T+P) + R] / 10 where, A = Ascorbic acid content (mg/g), T= Total chlorophyll content (mg/g), P = pH of leaf extract, R = Relative water content of leaf (%)

Based on the APTI values the plants were conveniently grouped into categories as mentioned in the following [6]:

APTI value Response
30 to100= Tolerant
29 to17= Intermediate
16 to 1 =Sensitive
<1 =Very sensitive

Determination of API (Anticipated performance Index):

APTI values along with some relevant biological and socio-economic characters (Plant habitat, canopy structure, type of plant, laminar structure and economic values) were combined in order to calculate the API for different species. Based on these characters, different grades (+ or -) are allotted to plants. Different plants are scored according to their grades.

RESULT AND DISCUSSION

In order to design a pollution free environment, various ecological modelling are proposed by various ecologists among whom Green Belt Development is one of them. For designing such models following points has been taken into consideration,

- Local agro-climatic conditions,
- Source and type of pollutants, and
- Selection of the right type of tree species.

On the basis of certain parameters the tree species are being selected for plantation to create a salubrious environment to live in. Anticipated Performance Index (API) is a relevant index on the basis of which a species can be selected in order to design a Green Belt thereby helping in restoration strategies of the ecologists.

The Air Pollution Tolerance Index (APTI) is one of the parameters to determine API, which was again calculated on the basis of total chlorophyll, relative water content, pH of leaf extract and ascorbic acid content of the selected plant species of Golapbag Campus. The APTI was then estimated accordingly (Table 1, Fig 1). Among the 12 species studied *Putranjiva roxburghii* (72.69) stands out solitary to be the most tolerant species followed by *Swietenia mahogani* (61.82), *Mimusops elengi* (50.63), *Cassia fistula* (45.66), *Ficus benghalensis* (36.58), *Mangifera indica* (31.15), *Saraca asoca* (26.26), *Lagerstroemia speciosa* (24.86), *Markhamia stipulata* (24.65), *Polyalthia longifolia* (24.40), *Albizia saman* (20.93) and *Senna siamea* (20.02).

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Table 1: Analysis of Air Pollution Tolerance Index (APTI) of selected plant species

Sl. No	Name of the species	Total Chlorophyll (T)	Relative water content (R)	Ascorbic acid Concentration (A)	pH of Leaf extract (P)	APTI
1	*Albizia saman*(Jacq.) Merr.	0.211	69.81	21.05	6.42	20.93
2	*Cassia fistula* L.	0.605	63.80	52.63	6.86	45.66
3	*Ficus benghalensis* L.	1.683	89.42	30	7.53	36.58
4	*Lagerstroemia speciosa* (L.)Pers.	5.632	64.58	16	5.87	24.86
5	*Mangifera indica* L.	0.218	96.63	47.36	4.32	31.15
6	*Markhamia stipulata* (Wall.) Seem.	1.5	70.56	20	7.30	24.65
7	*Mimusops elengi* L.	0.408	85.89	55.26	7.20	50.63
8	*Polyalthia longifolia* (Sonn.) Thwaites	1.425	96	18	6.80	24.40
9	*Putranjiva roxburghii* Wall.	2.832	91.34	78.94	5.22	72.69
10	*Saraca asoca* (Roxb.) Willd.	1.292	89.20	20	7.38	26.26
11	*Senna siamea* (Lam.) H.S.Irwin& Barneby	0.546	60	28.94	4.30	20.02
12	*Swietenia mahogani* (L.) Jacq.	0.634	73.01	71.05	7.04	61.82

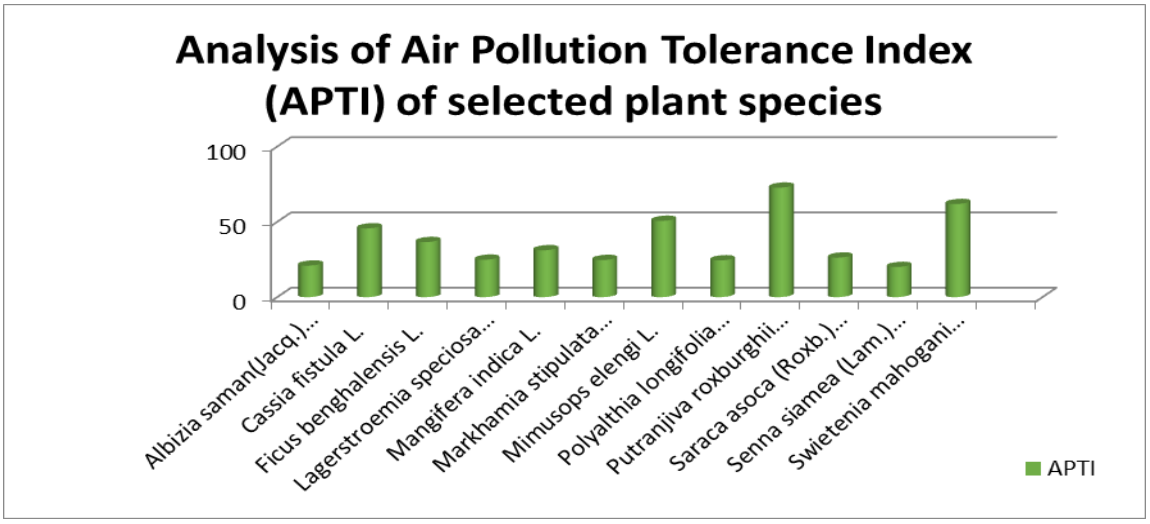

Fig-1

The other parameter concerns biological and socio-economic values, which are tree habit, canopy structure, type of tree, laminar size, laminar texture, laminar hardness and economic values of the selected tree species. There were allotment of gradation (Table 2) and assessment (Table 3) on the basis of which the selected tree species were being graded and were assessed according to their achieved scores (Table 4, Fig 2). Out of 12 species *Swietenia mahogani, Putranjiva roxburghii* and *Mangifera indica* were found to be very good to be grown and are expected to perform well. They have a dense tree canopy of evergreen nature, the foliage of which can afford protection from pollutant stress. Economic and aesthetic values of these trees are well-known and may be recommended for profuse plantation in the first layer.

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Table 2: Allotment of gradation to selected plant species

Grading Character allotted	Pattern of Assessment		Grade
a.) Tolerance :			
1. Air Pollution Tolerance Index(APTI)	10-20		-
	20-30		+
	30-40		++
	40-50		+++
	50-60		++++
	60-70		+++++
	70-80		++++++
b.) Biological and Socio-economic :			
1. Tree habit	Small		-
	Medium		+
	Large		++
2. Canopy structure	Sparse/ irregular/ globular		-
	Spreading crown/ semi dense		+
	Spreading dense		++
3. Type of tree	Deciduous		-
	Evergreen		+
4. Laminar structure	Size	Small	-
		Medium	+
		Large	++
	Texture	Smooth	-
		Coriaceous	+
	Hardness	Delineate	-
		Hardy	+
5. Economic value	Less than three		-
	Three to five		+
	More than five		++
Total plus (+) that can be scored by a plant = 17			

Table 3: Anticipated Performance Index (API) score assessment

Sl. No.	Score (%)	Grade	Assessment Category
1	Up to 30	0	Not recommended
2	Up to 31-40	1	Very poor
3	Up to 41-50	2	Poor
4	Up to 51-60	3	Moderate
5	Up to 61-70	4	Good
6	Up to 71-80	5	Very good
7	Up to 81-90	6	Excellent
8	Up to 91-100	7	Best

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Table 4: Anticipated Performance Index (API) assessment parameters of selected plant species

Sl.No.	Name of species	APTI	TH	CS	TT	LS	LT	LH	E	Total plus (+) obtained	% scoring	API grade	Assessment
1	*Albizia saman*(Jacq.) Merr.	+	++	++	+	++	+	-	+	10	59	3	Moderate
2	*Cassia fistula* L.	+++	+	-	+	++	-	-	-	7	41	2	Poor
3	*Ficus benghalensis* L.	++	++	++	+	+	-	+	++	11	65	4	Good
4	*Lagerstroemia speciosa* (L.)Pers.	+	+	-	-	+	-	-	-	3	18	0	Not recommended
5	*Mangifera indica* L.	++	++	++	+	++	+	+	++	13	76	5	Very good
6	*Markhamia stipulata* (Wall.) Seem.	+	+	+	-	++	+	+	-	7	41	2	Poor
7	*Mimusops elengi* L.	++++	+	+	+	+	-	+	+	10	59	3	Moderate
8	*Polyalthia longifolia* (Sonn.) Thwaites	+	++	-	+	++	-	-	-	6	35	1	Very poor
9	*Putranjiva roxburghii* Wall.	++++++	+	+	+	+	-	-	++	12	71	5	Very good
10	*Saraca asoca* (Roxb.) Willd.	+	-	-	+	++	-	-	+	5	29	0	Not recommended
11	*Senna siamea* (Lam.) H.S.Irwin & Barneby	+	+	-	+	++	-	-	++	7	41	2	Poor
12	*Swietenia mahogani* (L.) Jacq.	+++++	++	-	+	++	-	-	++	12	71	5	Very good

APTI= Air pollution tolerance index; TH= Tree habit; CS= Canopy structure; TT= Type of tree; LS= Laminar size; LT= Laminar texture; LH= Laminar hardness; E= Economic value; API= Anticipated performance index

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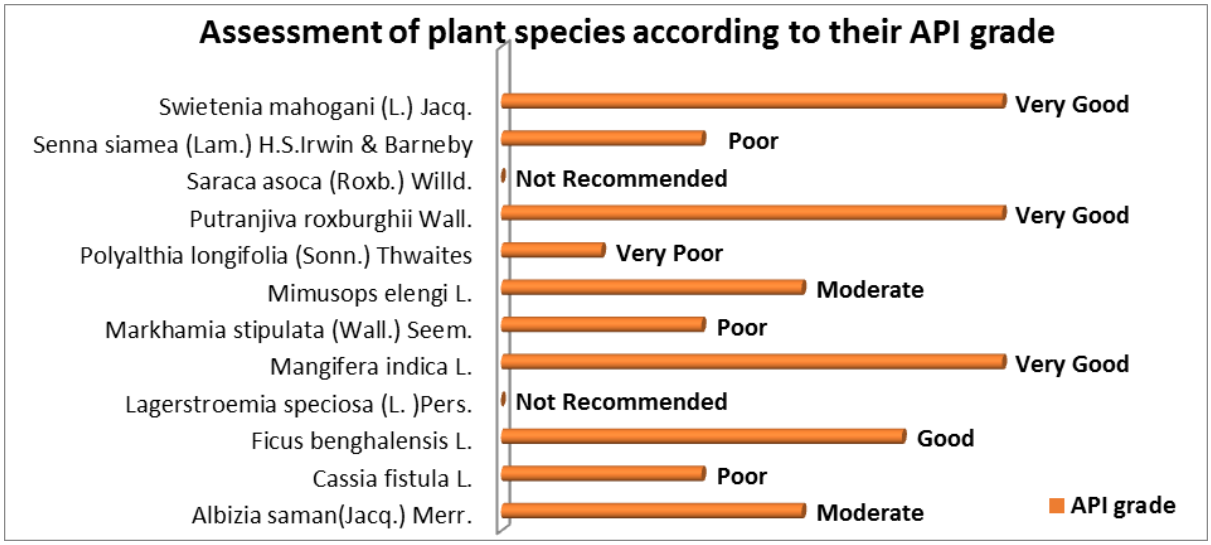

Fig- 2

Ficus benghalensis was observed to be good performer while *Albizia saman* and *Mimusops elengi* were found to be moderate performers. There were 3 poor, 1 very poor and 2 not recommended performer. On the basis of lower Anticipated Performance Index (API) values of the species they cannot be earmarked as pollution sink, but for their aesthetic value and other economic uses, they may be considered for plantation.

CONCLUSION

The present study reveals that, according to the Anticipated Tolerance Index (API) grade scored by the selected plant species *Swietenia mahogani, Putranjiva roxburghii, Mangifera indica, Ficus benghalensis, Mimusops elengi* and *Albizia saman* are the most suitable plants growing in the campus and these can be expected to perform well for the development of green belt elsewhere for optimization of environment especially in urban and industrial localities.

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