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Air Pollution Tolerance Index (APTI), Anticipated Performance Index (API), Carbon Sequestration and Dust Collection Potential of Indian Tree Species – A Review

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Abstract—

Air pollution today is the most important aspect of environmental study as every progress by mankind has deteriorated the air quality. Artificial technologies have proved insufficient to address this problem. So a better and a natural way to combat the air pollution is plantation. However, all plants do not show the same response to a particular type of pollutant. Hence, all plants cannot remediate all kinds of air pollution. There are various parameters on which plant species are selected for plantation viz. APTI, API, dust accumulating potential, carbon sequestering potential etc. Each of these parameters should be well analyzed before selecting any plant species for plantation. The selection should also be done as per the requirement of the area. The present review is an attempt to diagnose Air Pollution Tolerance Index (APTI), Anticipated Performance Index (API), Carbon Sequestration and Dust Collection Potential of Indian tree species and to certify them on the basis of the purpose of plantation.

Keywords— APTI, API, Dust accumulating potential, Carbon sequestering potential, Plantation

I. INTRODUCTION

Air pollution is the most serious discussed topic now a day because the threats associated with it are many and affect all forms and class of life. Hence the remedy associated with these threats needs to be discussed well. One such threat of air pollution is the global warming and its effect is the rise in global temperature which is the parent of many other associated problems. Many scientific techniques have come up to combat the global warming issue but none better than plantation and green vegetation, more so because of the multipurpose aspect of green plants.

Plants are the natural way to ameliorate air pollution as they trap the carbon dioxide and store it within them as reserve food material. Plants being the initial acceptors of air pollutants act as a scavenger to the later. Leaves provide surface area for impingement, absorption and adsorption of air pollutants as well as dust particles [1]. Few plants are sensitive to certain air pollutants while others are tolerant. The former act as pollution indicators while the latter act as sink [2]. Plants experience physiological changes before getting damaged when the leaves are exposed to air pollutants [3]. The tolerant species are preferred over the sensitive species for plantation. To analyse the species, various variables are used like Air Pollution Tolerance Index (APTI) which is based on biochemical parameters, Anticipated Performance Index (API) which is based on biological and socio-economic aspect of a plant. The carbon trapping and dust accumulating potential also varies from species to species.

Carbon fixation is another such aspect plants are associated with to tackle the global concerns relating to the carbon dioxide concentration in the atmosphere and global warming. Afforestation, reforestation, forest conservation, landscaping are considered in the tropics to achieve this objective by many forest managers and hence promotes research on carbon sequestration by natural and artificial forests.

Plants are very often selected for plantation according to its APTI value only. However, this selection may not reflect the correct idea and very often may end up without addressing the actual problem and purpose of plantation. For instance, the primary target for road side plantation is to trap dust and fugitive emissions generated due to traffic. So selecting a species merely on the APTI value without assessing its dust trapping potential won't serve the purpose. Likewise, the plants used for green belt development near a thermal power plant should be selected on the basis on carbon sequestering potential and anticipated performance index (API). An integration of various parameters rather than a single one can serve good for the purpose of global air pollution mitigation. Various parameters used for the selection of species for plantation are discussed below.

II. AIR POLLUTION TOLERANCE INDEX (APTI)

The APTI serves as an important guiding tool to suggest the tolerance of a particular plant species against air pollution. A single parameter cannot suggest the behaviour of a plant species towards air pollution. Hence, APTI is a dependent parameter which is based on four biochemical parameters viz. leaf extract pH (P), total chlorophyll content (TC), ascorbic acid content (AA) and relative water content (RWC). It has been found that ROS (Reactive Oxygen Species) tend to decrease the chlorophyll content under water stress condition [4]. The higher ascorbic acid content acts as a defence against any oxidative damage under this environmental stress [5]. High leaf extract pH has shown an improvement in the tolerance of plant against air pollution [6]. APTI can be calculated by the formula given by [7] as:

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

R= Relative Water Content in %
A= Ascorbic acid content in mg/g
T= Total Chlorophyll in mg/g
P= pH of the leaf extract

Classification of species on the basis of APTI:
Sensitive Species < 10
Intermediate Species 10 – 16
Tolerant Species ≥ 17

III. ANTICIPATED PERFORMANCE INDEX (API)

The API value can give a good and logical reason to integrate various plant species for green belt development, afforestation and reforestation. The API not only takes APTI into consideration but also the biological and socio-economic aspect of the species. The combination of these biochemical and physiological parameters gave a more reliable result than those of individual parameter [8]. Table I shows the various parameters on which API is calculated and Table II shows the various categories of plant species as per their API score. API is particularly useful in selection of those species for plantation which can perform a dual function of improving the air quality and providing aesthetic and recreational value. API can be calculated by the formula:

$$Anticipated\ Performance\ Index\ (API) = \frac{No. of "+" obtained}{Total\ no. of "+"} X\ 100$$

Table I: Gradation of plant species based on air pollution tolerance index (apti) as well as biological parameters and socio-economic importance [4]

Grading Character		Pattern of Assessment	Grade Allotment
Tolerance	APTI	9.0 – 12.0	+
		12.1 – 15.0	++
		15.1 – 18.0	+++
		18.1 – 21.0	++++
		21.1 – 24.0	+++++
Biological and Socio-economic	Plant Habit	Small	-
		Medium	+
		Large	++
	Canopy Structure	Sparse/irregular/globular	-
		Spreading crown/open/semi-dense	+
		Spreading dense	++
	Type of Plant	Deciduous	-
		Evergreen	+
Laminar Structure	Size	Small	-
		Medium	+
		Large	++
	Texture	Smooth	-
		Coriaceous	+
	Hardiness	Delineate	-
		Hardy	+
	Economic Value	Less than 3	-
		3 or 4 uses	+
		5 or more uses	++

Table II: Anticipated performance index (api) grading chart of plant species [4]

Grade	Score (%)	Assessment Category
0	Up to 30	Not Recommended
1	31 – 40	Very Poor
2	41 – 50	Poor
3	51 – 60	Moderate
4	61 – 70	Good
5	71 – 80	Very Good
6	81 – 90	Excellent
7	91 – 100	Best

IV. ABOVE AND BELOW GROUND BIOMASS

Carbon sequestration is the process of removal of carbon dioxide by plants and storing in them in form of reserved food material. Trees and forest ecosystem are the natural reservoir of carbon on earth storing huge quantities of carbon and regulating the carbon cycle [9]. Above ground biomass (AGB) and below ground biomass (BGB) is one of such indirect method (without uprooting the plant) of measuring carbon sequestering potential of a plant species which helps to form a baseline data to study carbon budget. The carbon trapping potential can be very useful to suggest the type of plants to be selected for reforestation, social forestry and green belt to mitigate the global warming.

Biomass of a tree is the biomass of its root and shoot taken together. The best practiced method of estimating the tree biomass keeping the ecological ethic intact (without destroying the ecosystem by uprooting the tree), is to estimate the bio-volume of the tree which involves the tree height measurement (can be measured both by instrumental and non-instrumental methods) and the girth at breast height (GBH) measurement. However, the saplings are reported to sequester carbon at a faster rate and hence have a better chance of survival [10]. The following points are to be kept in mind while estimating carbon sequestration through the AGB and BGB method.

The plants with a GBH > 30 cm are to be considered as trees.

When branched below the measuring height, the girth of individual branches is to be taken.

The branches with a girth > 10 cm should be considered.

When branched at the measuring height, the girth should be measured just below the bulge.

Biomass is estimated by multiplying the bio volume with the wood density of the tree species.

Basal Area = (GBH)2/4π

Bio-volume = Basal Area x Height of the tree

Above Ground Biomass (AGB) in t/ha = Bio-volume x Wood Density

Below Ground Biomass (BGB) in t/ha = AGB x 0.26

Above Ground Carbon (AGC) in t/ha = AGB/2

Below Ground Carbon (BGC) in t/ha = BGB/2

Total Standing Biomass (t/ha) = AGB + BGB

Total Carbon Sequestered (t/ha) = AGC + BGC

Where, GBH= Girth at breast height and 0.26 = Factor of the root to shoot ratio

The quantum of carbon can be converted to the quantum of carbon-dioxide using the following formulae [11].

$$Quantum\ of\ Carbon\ dioxide = \frac{Quantum\ of\ carbon\ X\ 44}{12}$$

Wood density of tree species ranges from 0.45g/cm3 or 450 kg/m3 can be taken [12].

V. DUST COLLECTION POTENTIAL

Dust trapping efficiency of a plant is another most important factor on which selection of a species depends upon especially for the plantation in and around traffic and road side areas. Different plants have different potential to accumulate dust in their leaf surface as it depends upon various factors like the canopy, structure, height and geometry of the tree. Leaves of the plant help in deposition of particulates and fallout of particulates on the leeward side of the vegetation [13][14]. The efficiency of leaf petioles is found to be more as particulate impactors than twigs or leaf lamina [15]. Plants with short petioles and rough surface are found to accumulate more dust than plants with long petioles and smooth leaf surface [16]. The dust trapped by a leaf can be calculated using the equation:

$$W = \frac{w2 - w1}{a}$$

Where, W = Dust content (mg/cm2)

w1 = Weight of the leaf without dust

w2 = Weight of the leaf with dust

a = Total area of the leaf in cm2

VI. ANALYSIS AND DISCUSSION

A total of 89 research articles were studied and reviewed about the APTI, API, carbon trapping potential through above and below ground biomass and dust collection efficiency of Indian species available commonly throughout India. Various species showed variability in their APTI behaviour with change in area and climatic condition. However, a general view was observed in each of the data set and research articles i.e. the species selection for plantation was done on the assessment of a single parameter of a tree and not by the integration of various parameters. To avoid confusion and ambiguity, however, only three data sets were selected to review the parameters. Table III below shows the data sets and their source to represent the various parameters of 5 most commonly used Indian plant species for plantation.

Table III: APTI, API, Carbon storing efficiency and dust trapping efficiency of few Indian plants

Name of tree species	*APTI Grade	*API Grade	*Assessment Category as per API	**Carbon t/sp	***Dust Collection efficiency mg/cm^2
Tectona grandis	-	1	Very poor	13.54	0.009
Ficus religiosa	2	4	Good	16.01	0.009
Mangifera indica	3	4	Good	15.23	0.009

Tamarindus indica	2	2	Poor	55.95	0.004
Azadirachta indica	2	3	Moderate	19.28	0.003

Data Source: * – [17], ** – [9], *** – [16].

It was expected that a plant species with a good API scoring would show a good dust trapping and carbon sequestering potential because API is based on biological parameters as well. However, the analysis and subsequent observation was not as expected and is also reflected in Table III. It can be clearly seen that, under Indian climatic condition, *T. grandis* shows a very poor API score and a very low APTI value hence is deemed unfit for plantation in green belt region. However, it has the highest dust accumulating potential and hence can be selected for plantation in heavy traffic and road side areas. Similarly, *T. indica* has low APTI and API grade and hence is considered in poor category for plantation but has highest carbon sequestering potential and so can be used for reforestation. Similarly, *F. religiosa*, *M. indica* and *A. indica* have good APTI and API scoring but show a relatively low value for carbon sequestration and hence are not suitable in forest plantation.

VII. CONCLUSIONS

Selection of the right plant species is a very important task to combat the air pollution problem. Hence the selection should always be based on the purpose and area of plantation. A good analysis of a plant species for plantation as per the requirement of the area can actually solve a lot of air quality issues related to a particular area.

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