

BEFORE THE NATIONAL GREEN TRIBUNAL, PRINCIPAL BENCH,
NEW DELHI

ORIGINAL APPLICATION NO. 10 OF 2023

IN THE MATTER OF:

PUJA KUMAR

...APPLICANT

VERSUS

ANSAL API & ORS.

...RESPONDENTS

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RESPONDENT NO. 5
THROUGH



ROHAN PODDAR AND SHIVALIKA RUDRABATLA

A-89, GROUND FLOOR, DEFENCE COLONY,

NEW DELHI – 110024

email: shivalika.rudrabatla@lawchambers.in

Mob: (+91) 6370344354

Date: 16.12.2024

New Delhi

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ADDITIONAL REPLY ON BEHALF OF RESPONDENT NO. 5

PURSUANT TO THE ORDER DATED 27.11.2024

MOST RESPECTFULLY SHOWETH:

1. The present additional reply is being filed on behalf of Respondent No. 5/Medanta Holdings Private Limited pursuant to the order dated 27.11.2024 passed by this Hon'ble Tribunal. Over the course of arguments, the Hon'ble Tribunal raised queries in respect of the green cover in Medanta Hospital, Lucknow. The Hon'ble Bench sought details regarding compliance of the green belt with the guidelines of the Central Pollution Control Board ('CPCB').
2. The Environmental Clearance dated 25.06.2015 issued to Respondent No. 5 stipulates a green cover of 20.83 percent of the net plot area, i.e., 10,605.5 square meters (**Pg. 671 of the court record; Pg. 44 of the Reply filed by Respondent No. 5 dated 04.09.2024**). The EC further

stipulates at General Condition No. 68 (Part A), that the green belt comprise of 50 percent trees, 25 percent shrubs and 25 percent grass **(Pg. 676, Reply filed by Respondent No. 5).**

3. The number of trees would comply with the Building Construction and Development Bye-laws, 2008 (as amended in 2011, 2016 and 2018) implemented by the Department of Housing and Urban Planning, Government of Uttar Pradesh (**'Building Byelaws'**), which provide in Clause 3.11.10 that buildings having built-up area of 5,000 sq. m. to 1,50,000 sq. m. shall comply with the environmental conditions provided in Appendix 15–17. Appendix 17 at Serial No. 6 provides that – *“A minimum of 1 tree for every 80 sqm of land shall be planted and maintained. The existing trees will be counted for this purpose. Preference should be given to planting native species.”* A copy of Appendix 15-17 of the Building Byelaws is annexed herewith as **Annexure A.**
4. Furthermore, Clause 2.2.3(II) of the Building Byelaws provides that, for the purposes of landscaping, the Landscaping Plan must have 125 trees per hectare to be planted in open spaces.
5. Medanta Hospital, Lucknow has a built-up area of 50,909 sq. m. which is around 5.09 hectares. Therefore, in accordance with Clause 3.11.10

of the Building Byelaws, the requisite number of trees would be 636 trees ($50909 \div 80$). Similarly, the number of trees for landscaping as per Clause 2.2.3(II) of the Building Byelaws would also be 636 trees (125×5.09 hectares).

6. Pursuant to the above-stated provisions of law, Respondent No. 5 has planted a total of 926 trees till date within the premises of Medanta Hospital, Lucknow. The aforesaid trees have been planted keeping in view the Guidelines issued by the CPCB titled 'Guidelines for Developing Greenbelts' PROBES/75/1999-2000 (March 2000) ('CPCB Guidelines'), which provides recommendations for the choice of plants for green belts. The following table provides details of the kinds of species planted within Medanta Hospital, Lucknow:

S.No.	Type of tree	Number of trees
1.	Plumeria (चंपा)	161
2.	Phyllanthus Emblica (आँवला)	32
3.	Azadirachta (नीम)	10
4.	Tabebuia Rosea (बसंत रानी)	8
5.	Cassia Fistula (अमलतास)	32
6.	Morus Alba (शहतूत)	5
7.	Delonix Regia (गुलमोहर)	106
8.	Pongamia Tree (करंज)	30
9.	Syzygium Cumini (जामुन)	6
10.	Saraca Ashoka (अशोक)	203
11.	Moringa Oleifera (सहजन)	1
12.	Ficus Benamina (बेंजामिन वृक्ष)	241

13.	Bauhinia Variegata (कचनार)	19
14.	Psidium Guajava (अमरूद)	10
15.	Mango Tree (आम)	6
16.	Lagerstroemia thorelli (सवानी)	13
17.	Chukrasia Tabularis (चिकरासी)	32
18.	Plumeria Rubra (प्लुमेरिया)	7
19.	Mimusops Elengi (मोलश्री)	2
20.	Jackfruit (कटहल)	2
21.	Blackboard tree/ Alstonia scholaris (सप्तपर्णी)	1
	Total	928

7. It is submitted that out of the 928 trees planted, 720 trees are recommended in the CPCB Guidelines, which is well above the required number of trees, i.e, 636. The green cover at Medanta Hospital, Lucknow comprises of trees over and above the recommended species as well, including Plumeria (चंपा) (161 trees), Tabebuia Rosea (बसंत रानी) (8 trees), Chukrasia Tabularis (चिकरासी) (32 trees) and Plumeria Rubra (प्लुमेरिया) (7 trees), bringing the total count to 928. A copy of the CPCB Guidelines for Developing Green Belts is annexed herewith as **Annexure B**. Photographs of each species of trees are annexed herewith by way of example as **Annexure C (Colly)**.
8. In light of the above, it is submitted that the green cover at Respondent No. 5's hospital is as per the CPCB Guidelines for Developing Greenbelts.

9. It is further submitted that Respondent No. 5 has also obtained its renewed Authorization for Operating a Facility for Collection, Reception, Treatment, Storage, Transport and Disposal of Biomedical Wastes dated 03.12.2024. A copy of the same is annexed herewith as Annexure D.



RESPONDENT NO. 5
THROUGH

A handwritten signature in black ink that reads "Shivalika".

ROHAN PODDAR AND SHIVALIKA RUDRABATLA
A-89, GROUND FLOOR, DEFENCE COLONY,
NEW DELHI – 110024
email: shivalika.rudrabatla@lawchambers.in
Mob: (+91) 6370344354
9650893374

Date: 16-12-2024
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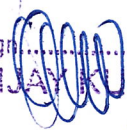


AFFIDAVIT

I, Dr. Rakesh Kapoor, authorized representative of Medanta Holdings Pvt. Ltd./ Respondent No. 5 herein, aged about 68 years, having office at Sector – A, Pocket – 1, Sushant Golf City, Amar Shaheed Path, Lucknow, Uttar Pradesh 226030, do hereby solemnly affirm on oath and declare as under:

1. I am the duly authorised representative of Respondent No. 5 in the present proceedings *vide* Letter of Authority dated 09.02.2024. I am fully competent to swear and affirm the present affidavit on behalf of Respondent No. 5 in the captioned matter.
2. That I am fully conversant with the facts and circumstances to swear and verify the present affidavit. The information contained in the accompanying Additional Reply is based on information and records available with Respondent No. 5.
3. That the contents of the Additional Reply are true to my knowledge and belief, and based on legal advice received and believed to be true.

SWORN & VERIFIED
BEFORE ME

Sign:  Dt. 16/12/2024
VIJAY KUMAR DWIVEDI
Advocate & Notary
Regn. 22366 Govt. of India

I state that no part of it is false and nothing material has been concealed therefrom.

- 4. That the facts stated in the accompanying Additional Reply may be read as part and parcel of this affidavit which are not being repeated herein for the sake of brevity.



DEPONENT

VERIFICATION

Verified at Lucknow on the 16th day of December 2024, that the contents of my above affidavit are true and correct to my knowledge and no part of it is false and nothing material has been concealed therefrom.



DEPONENT

SWORN & VERIFIED BEFORE ME

Sign DI 16/12/2024
 VILAY KUMAR DWIVEDI
 Advocate & Notary
 Regn. 22366 Govt. of India

Annexure A

ifjf'k"V&15**Environmental Conditions for Building and Construction
(Category "A": 5000 sqmt - 20000 sqmt)**

(उपविधि संख्या-3.11.10)

Sl. No.	Medium	Environmental conditions	MBBL Ref. Clause
1	Natural Drainage	The inlet and outlet point of natural drain system should be maintained with adequate size of channel for ensuring unrestricted flow of water.	-
2	Water conservations - Rain Harvesting and Ground Water Recharge	A rain water harvesting plan needs to be designed where the recharge bores (minimum one per 5000 sqm of built-up area) shall be provided. The rain water harvested should be stored in a tank for reuse in household through a provision of separate water tank and pipeline to avoid mixing with potable municipal water supply. The excess rain water harvested be linked to the tube well bore in the premise through a pipeline after filtration in the installed filters.	Table 9.1
2(a)		The unpaved area shall be more than or equal to 20% of the recreational open spaces.	10.2.1 (iv)
3	Solid Waste Management	Separate wet and dry bins must be provided at the ground level for facilitating segregation of waste.	10.2.5 (b)
4	Energy	In common areas, LED/ solar lights must be provided.	10.2 3c)
5	Air Quality and Noise	Dust, smoke and debris prevention measures such as screens, barricading shall be installed at the site during construction. Plastic/ tarpaulin sheet covers must be used for trucks bringing in sand and material at the site.	-
5 a)		The exhaust pipe of the DG set, if installed, must be minimum 10m away from the building. In case it is less than 10m away, the exhaust pipe shall be taken up to 3m above the building.	-
6	Green cover	A minimum of 1 tree for every 80 sqm of land shall be planted and maintained. The existing trees will be counted for this purpose. Preference should be given to planting native species.	10.2.1 (i)
6(a)		Where the trees need to be cut, compensatory plantation in the ratio of 1:3 (i.e. planting of 3 trees for every 1 tree that is cut) shall be done with the obligation to provide continued maintenance for such plantations.	10.2.1 (ii)

ifjfk"V&16

**Environmental Conditions for Building and Construction
(Category "B": 20000 sqmt - 50000 sqmt)
(उपविधि संख्या-3.11.10)**

Sl. No.	Medium	Environmental conditions	MBBL Ref. Clause
1	Natural Drainage	The inlet and outlet point of natural drain system should be maintained with adequate size of channel for ensuring unrestricted flow of water.	-
2	Water conservations - Rain Water Harvesting and Ground Water Recharge	A rain water harvesting plan needs to be designed where the recharge bores (minimum one per 5000 sqm of built-up area) shall be provided. The rain water harvested should be stored in a tank for reuse in household through a provision of separate water tank and pipeline to avoid mixing with potable municipal water supply. The excess rain water harvested be linked to the tube well bore in the premise through a pipeline after filtration in the installed filters.	Table 9.1
2(a)		The unpaved area shall be more than or equal to 20% of the recreational open spaces.	10.2.1 (iv)
3.	Solid Waste Management	Separate wet and dry bins must be provided at the ground level for facilitating segregation of waste.	10.2.5 (b)
4.	Energy	In common areas, LED/ solar lights must be provided.	10.2 3c)
4(a)		At least 1% of connected applied load generated from renewable energy source such as photovoltaic cells or wind mills or hybrid should be provided.	10.2
4(b)		As per the provisions of the Ministry of New and Renewable energy solar water heater of minimum capacity 10 litres/4 persons (2.5 litres per capita) shall be installed.	10-2.4-iv
4(c)		Use of flyash bricks: Fly ash should be used as building material in the construction as per the provisions of Fly Ash Notification of September, 1999 and as amended from time to time.	10.2.6(b)
5	Air Quality and Noise	Dust, smoke and debris prevention measures such as screens, barricading shall be installed at the site during construction. Plastic/ tarpaulin sheet covers must be used for trucks bringing in sand and material at the site.	-
5 a)		The exhaust pipe of the DG set, if installed, must be minimum 10m away from the building. In case it is less than 10m away, the exhaust pipe shall be taken up to 3m above the building.	-
6	Green cover	A minimum of 1 tree for every 80 sqm of land shall be planted and maintained. The existing trees will be counted for this purpose. Preference should be given to planting native species.	10.2.1 (i)
6(a)		Where the trees need to be cut, compensatory plantation in the ratio of 1:3 (i.e. planting of 3 trees for every 1 tree that is cut) shall be done with the obligation to provide continued maintenance for such plantations.	10.2.1 (ii)

Environmental Conditions for Building and Construction
(Category "C": 50000 sqmt - 150000 sqmt)
 (उपविधि संख्या-3.11.10)

Sl. No.	Medium	Environmental conditions	MBBL Ref. Clause
1	Natural Drainage	The inlet and outlet point of natural drain system should be maintained with adequate size of channel for ensuring unrestricted flow of water.	-
2	Water conservations - Rain Water Harvesting and Ground Water Recharge	A rain water harvesting plan needs to be designed where the recharge bores (minimum one per 5000 sqm of built-up area) shall be provided. The rain water harvested should be stored in a tank for reuse in household through a provision of separate water tank and pipeline to avoid mixing with potable municipal water supply. The excess rain water harvested is to be linked to the tube well bore in the premise through a pipeline after filtration in the installed filters.	Table 9.1
2(a)		The unpaved area shall be more than or equal to 20% of the recreational open spaces.	10.2.1 (iv)
2(b)		The ground water shall not be withdrawn without approval from the competent authority	
2(c)		Use of potable water in construction should be minimized.	
2(d)		Low flow fixtures and sensors must be used to promote water conservation.	
2(e)		Separation of grey and black water should be done by the use of dual plumbing system.	
3.	Solid Waste Management	Separate wet and dry bins must be provided at the ground level for facilitating segregation of waste.	10.2.5 (b)
3(a)		All non-biodegradable waste shall be handed over to authorized recyclers for which a written tie-up must be done with the authorized recyclers.	
3(b)		Organic waste composter/vermiculture pit with a minimum capacity of 0.3 Kg/tenement/day must be installed wherein the STP sludge may be used to be converted to manure which could be used at the site or handed over to authorized recyclers for which a written tie-up must be done with the authorized recyclers.	
4.	Energy	In common areas, LED/solar lights must be provided.	10.2 3c)
4(a)		At least 1% of connected applied load generated from renewable energy source such as photovoltaic cells or wind mills or hybrid should be provided.	10.2
4(b)		As per the provisions of the Ministry of New and Renewable energy solar water heater of minimum capacity 10 litres/4 persons (2.5 litres per capita) shall be installed.	10.2.4-IV
4(c)		Use of flyash bricks: Fly ash should be used as building material in the construction as per the provisions of Fly Ash Notification of September, 1999 and as amended from time to time.	10.2.6(b)

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(पृष्ठ-2/2)

4(d)		Use of concept of passive solar design of buildings using architectural design approaches that minimize energy consumption in buildings by integrating conventional energy-efficient devices, such as mechanical and electric pumps, fans, lighting fixtures and other equipment, with the passive design elements, such as building orientation, landscaping, efficient building envelope, appropriate fenestration, increased day lighting design and thermal mass.	10.2(3)
4(e)		Optimize use of energy systems in buildings that should maintain a specific indoor environment conducive to the functional requirements of the building by following mandatory compliance measures (for all applicable buildings) as recommended in the Energy Conservation Building Code (ECBC) 2007 of the Bureau of Energy Efficiency, Government of India.	10.2(3)
5	Air Quality and Noise	Dust, smoke and debris prevention measures such as screens, barricading shall be installed at the site during construction. Plastic/ tarpaulin sheet covers must be used for trucks bringing in sand and material at the site.	-
5 a)		The exhaust pipe of the DG set, if installed, must be minimum 10m away from the building. In case it is less than 10m away, the exhaust pipe shall be taken up to 3m above the building.	-
6	Green cover	A minimum of 1 tree for every 80 sqm of land shall be planted and maintained. The existing trees will be counted for this purpose. Preference should be given to planting native species.	10.2.1 (i)
6(a)		Where the trees need to be cut, compensatory plantation in the ratio of 1:3 (i.e. planting of 3 trees for every 1 tree that is cut) shall be done with the obligation to provide continued maintenance for such plantations.	10.2.1 (ii)
7	Sewage Treatment Plant	Sewage treatment plant with capacity of treating 100% waste water shall be installed. Treated water must be recycled for gardening and flushing.	4.32.4
8	Environment Management Plan	The environment infrastructure like Sewage Treatment Plant, Landscaping, Rain Water Harvesting, Power backup for environment, Infrastructure, Environment Monitoring, Solid Waste Management and Solar and Energy conservation, should be kept operational through Environment Monitoring Committee with defined functions and responsibility.	-

GUIDELINES FOR DEVELOPING GREENBELTS



CENTRAL POLLUTION CONTROL BOARD
MARCH 2000

Programme Objective Series :
PROBES/75/1999-2000

GUIDELINES FOR DEVELOPMENT OF GREENBELTS

ENVIS Centre, CPCB (www.cpcbenvvis.nic.in)



CENTRAL POLLUTION CONTROL BOARD
(Ministry of Environment & Forests, Govt. of India)
Parivesh Bhawan, East Arjun Nagar
Delhi – 110 032



केन्द्रीय प्रदूषण नियंत्रण बोर्ड

(भारत सरकार का संगठन)

पर्यावरण और वन मंत्रालय

Central Pollution Control Board

(A Govt. of India Organisation)

Ministry of Environment & Forests

Phone : 2204948

FOREWORD

Green vegetal cover is not only pleasing to the eyes but also beneficial in many ways such as conservation of bio-diversity, retention of soil moisture, recharge of groundwater and moderation of micro-climate. Yet another important role of vegetal cover, which is not well recognised, relates to containment of pollution. Besides acting as a carbon sink, certain species of plants can even absorb the pollutants while others can thrive in polluted atmosphere.

Raising of green belts with right types of species can serve as a useful buffer to contain the menace of pollution from different sources. With this in view, a study was commissioned by the Central Pollution Control Board (CPCB) for enlisting the plant species suited to various bio-climatic conditions. The study was also intended to evolve a theoretical model for design and development of green belt for optimum attenuation of air pollution. Apart from morphological features affecting the plant response to pollutants, the other important considerations in optimisation of green belt development include : distance from the source of pollution and dispersion of pollutants under different atmospheric stability conditions. An exercise was also made to identify the species which are suitable for revegetation of mine spoils, degraded habitats and stabilisation of fly ash dumps.

The report provides a mathematical model to optimise the specifications of a green belt. The report also contains a list of 200 species recommended for raising of green belt under specific bio-climatic regimes.

I am thankful to Prof. S. B. Chapekar, University of Pune, Shri R. K. Kapur, Nuclear Power Corporation, Mumbai, Shri V. K. Gupta, Atomic Energy Regulatory Board, Mumbai and the team of my colleagues including Dr. B. Sengupta, Shri Lalit Kapur, Dr. Sajeév Paliwal and Shri M. K. Gupta for their collective efforts in bringing out the publication.

Based on the inputs provided by CPCB and information contained in this report, a scheme for raising green belt for pollution abatement and environmental improvement has been launched in Tamil Nadu.

We hope, the guidelines and information contained in this report will be useful to all concerned "with environmental cleaning through greening"

(Dilip Biswas)

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EXECUTIVE SUMMARY

Chapter 1 : Introduction

Green belts are recommended for containment of air pollution in the human environment, especially in industrial and urban environs. Improvement of aesthetics is a bonus derived through the presence of greenery in these areas.

Chapter 2 : Plant-Pollutant Interactions

Advantages notwithstanding, green plants are not a panacea for the environmental ills. As living organisms, plants have their limits to tolerate toxicity of air pollutants and to function as pollution ameliorants. Nature and levels of sensitivities of plant species towards anthropogenic air pollutants, are discussed.

Chapter 3 : Theoretical Models for Development of Green Belts

Green belt as a back-up to technological pollution abatement measures could substantially reduce pollution hazard. Mathematical model to optimize dimensions of green belts is presented and explained here.

Chapter 4 : Agro-climatic Zones of India

A vast country encompasses a variety of agro-climates suitable for different types of plant species. Zones and subzones of India are described, along with their soil types (as Appendix A) to assist in selecting plant species for cultivation, suitable to agro-climates.

Chapter 5 : Choice of Plants for Green Belts

Plant species suitable for removal of particulate matter and gaseous pollutants differ in their morphological characteristics. Sizes and shapes of crowns, periodic phenomena like leaf-shedding, also contribute to plant efficiency for pollution abatement. Discussion on these points is followed by description of a large number of plant species (in Appendix B), stressing characters useful for sorption of pollutants. Combining information in chapters 4 and 5, zonewise lists of plants recommended for green belts are presented (in Appendix C).

Chapter 6 : Stabilization of Fly-ash with Plants

Coal is likely to be used on an increasing scale for power generation, and will lead to aggravation of pollution problem due to fly-ash. Stabilisation of ash with plants provides viable solution. Strategies for achieving the same, are discussed in this chapter.

CHAPTER-1

INTRODUCTION

Most of the human activities generate pollution of one or other types and of different magnitudes, to which all the organisms are exposed. More often than not, exposures to some pollution types are considered unavoidable. Resistance of organisms help them overcome the hazards caused by such exposures. At the same time, organisms, especially animals tend to avoid, or move away, from pollution. By avoidance or by tolerance, organisms struggle and survive in polluted environments.

Such survival however, is hardly desirable and has limitations, in terms of health and vitality of organisms. Hence, it is imperative that pollution is controlled at the source itself. Numerous mechanical devices are available for controlling pollution at the process level itself. Some trace amount however, is still likely to get released. This is especially true of air pollutants from thermal power plants, swelling and refining processes, autoexhausts, mining and quarrying, etc. It is often stated that zero pollution process is only hypothetical. With more than 99% efficiency of pollution abatement machinery, some amount of pollution still gets released in the atmosphere. Such pollution too is of wide occurrence.

Green belts are thought to be effective in such scenarios, where green plants form a surface capable of sorbing air pollutants and forming sinks for pollutants. Leaves with their vast area in a tree crown, sorbs pollutants on their surface, thus effectively reduce their concentrations in the ambient air. Often, the sorbed pollutants are incorporated in metabolic stream and thus the air is purified. Plants grown in such a way as to function as pollutant sinks are collectively referred to as green belts.

An important aspect of a green belt, some times overlooked, is that the plants constituting green belts are living organisms, with limits to their tolerance towards air pollutants. As a result, crossing the threshold limits in terms of pollution load, would lead to injury to plants causing death of tissues and reducing their absorption potential. Sink efficiency of unhealthy and dead tissues and leaves is known to be extremely low, thus defeating the very purpose of a green belt. In short, a green belt is effective as pollution sink only within the tolerance limits of constituent plants.

Species of plants are studied for their relative sensitivities towards different air pollutants. Thus, we recognise species sensitive to SO_2 , species sensitive to O_3 , or sensitive to HF, etc. In terms of tolerances however, it is difficult to identify species that are selectively tolerant to pollutant species. Statements like HF-sensitive gladiolus is tolerant to SO_2 , is obviously not accurate. Moreover, an industrial or urban scene invariably consists of several pollutants rather than a single pollutant. Pollution sinks hence, aim at cultivating plants that are tolerant to air pollutants in general, rather than tolerant to SO_2 , to HF, or to O_3 , etc. Scattering of a few known sensitive plants, (including selectively sensitive species) within a green belt however, do carry out an important function of indicating the presence of pollutants which the tolerants would not indicate.

Two types of approaches are recognised while designing green belts - i) Source oriented

approach and ii) receptor- oriented approach. Both these approaches have their own advantages and limitations. It is generally felt that the first approach is advantageous where a single industry is situated and the pollutants emitted by the same are sought to be contained. The latter approach is desirable in urban- industrial complexes with multiple sources of pollution in an industrial - urban mix. A very large proportion of polluted areas in this country, where human settlements are intricately mixed with industries, form examples deserving the second approach for green belt designing.

Whereas, it is easy to state that tolerant plant species should form green belts, it is very difficult to state confidently about several other aspects about the belts, e.g. i) which bio-geographic regions of the country are suitable for what plant species, ii) what extent soil quality contributes to the sources (or otherwise) of growth of plants in the belts, iii) what should be the distance, width and height of the belt with reference to pollution source, iv) what is the ideal density of plant crowns, and v) what are the limits of pollution dosages upto which green belts would function optimally. Attempts are made in the following chapters, to seek answers to these questions, on the basis of our present knowledge in this field. It is felt that experience gained from functioning of green belts being planned in the country, would give reliable answers.

Apart from functioning as pollutant sinks, green belts would provide other benefits like aesthetic improvement and providing possible habitats for birds and animals, thus re-creating hospitable nature in an otherwise drab urban- industrial scene. One of the worst examples of the latter type of scene is provided by deposits of coal-ash from thermal power plants. The problem is on the rise in the country, where coal is a fuel long-lasting surety of availability. Covering of ash using plants - another type of green belt is recommended to overcome the hazards posed by ash. The last chapter in this report is devoted to the problem of ash stabilization and making ash-dumps environmentally acceptable.

CHAPTER-2

PLANT - POLLUTANT INTERACTIONS

A large amount of information has been generated about the nature of plant-pollution interactions; very little authentic information in Indian context has been generated about the role of plants in absorption of air pollutants. Most of the information available is from "Forest Vegetation as a Sink for Gaseous Contaminants" (Smith, 1981). As per the discussion therein, even sensitive plants like alfalfa have been used for estimation of sink efficiency of plants.

Another point to ponder is about the areas where green belts should be set up. Obviously, since a green belt is expected to neutralize pollutants, their location should aim at screening off the source of pollutants from society. Areas around industrial establishments, residential areas and roadsides, should be the ones targetted for green belts.

Plants are living organisms and hence are prone to suffer toxicity of air pollutants like any other organism. Still, they are expected to scavenge pollutants from the ambient air through the limited capacity they possess for sorption, and neutralize the absorbed pollutants. Major primary pollutants of industrial origin are considered here.

The philosophy is that when primary pollutants are taken care of, formation of secondary pollutants will not reach menacing proportions. Primary pollutants of concern are - SO_2 , HF, NO_x , CO, CO_2 , NH_3 , H_2S , Cl_2 , SPM and organics. Industrial and man-made sources of these pollutants are given in Table-2.1. Common secondary pollutants are also included in the same Table.

Since the project aims at mitigation of air pollutants with plants, discussion here is confined to air pollutant interactions with plants. Other forms of life are not considered. Mode of absorption of a pollutant by plants and fate of the pollutant inside plant body are given. Rate at which a pollutant is absorbed, total amount that can be absorbed and form of the pollutant in which it ends inside the plant, determine the success of the scavenging process. It is known that when pollutant is absorbed at a rate higher than the rate of its assimilation, accumulation takes place, resulting in plant injury and ineffectiveness of the green belt.

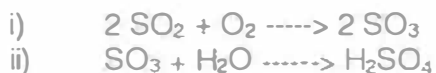
SO_2 : Though several oxides of sulphur may be the result of industrial processes, SO_2 is considered to be the most important one. Background level of SO_2 in the atmosphere is 0.001 ug L^{-1} or less (Kellogg et. al., 1972). About 10^9 million metric tons (mmt) of SO_2 are estimated to be added to the earth's atmosphere every year (Helbwachs, 1983).

Quantities of SO_2 liberated by different types of industries, are given in Table-2.2. Emission of SO_2 by different types of fuels is given in Table-2.3. In India, SO_2 emission was 6.76 mmt in 1979 and is expected to reach 13.19 mmt by the turn of this century (Kumar and Upadhyay, 1981).

SO_2 enters plants mainly through the stomatal apertures. Cuticle and wax on leaf

epidermis and suberin on stem being impervious, more than 95% of the pollutant enters a plant through the routes of gaseous exchange. Hence stomata, their structure, position and functions are important in the entry of gas in a leaf. Once inside the leaf, it passes into the intercellular spaces of mesophyll and gets absorbed on the wet cell-walls to finally diffuse gradually into the cell sap (Knabe, 1976). Whereas absorption of SO_2 by mesophyll tissue of a leaf is proportional to the stomatal conductance (Winner and Mooney, 1980), diffusion of SO_2 into cell sap is a function of its water solubility, which is fairly high (Table-2.4).

Chemical reactions leading to leaf injury or absorption of S from SO_2 into the metabolic stream have been described variously. A widely accepted view is that SO_2 inside leaf gets oxidised to SO_3 , which in turn combines with water to form sulphuric acid.



The acid thus formed, upsets the critical balance between inorganic and organic sulphur in plants affecting several metabolic processes, leading to reduction in productivity. Slow absorption of SO_2 on the other hand, especially when the rate of SO_2 absorption equates the rate of S utilization as a nutrient, leads to improvement in productivity. These possibilities of diametrically opposite effects on plant productivity due to SO_2 absorption, are presented in Fig.2.1.

The adverse effect of SO_2 on chlorophyll pigments leading to reduced productivity may be considered under two cellular pH conditions. At pH 2.2 to 3.5, the free H^+ ions generated in the cell from the splitting of H_2SO_3 into SO_3^{2-} and H^+ , displace the Mg^{2+} from chlorophyll molecule to degrade the latter into phaeophytin molecule, a non-photo-synthetic brown pigment (Rao and Le Blanc, 1966). At pH above 3.5, SO_2 affects the thylacoid membrane of chloroplast by causing oxidation of carotenoids through generation of O_2^- from HSO_3^- (Pieser and Yang, 1978). The unprotected chlorophyll molecule then is oxidised and lost. Free O_2^- also increases level of H_2O_2 in the presence of SOD (superoxide dismutase), leading to oxidation of chlorophyll molecules. SO_2 is also considered to reduce chlorophyllide synthesis, through its effects on ascorbic acid (Keller and Schwager, 1977).

Initial visual symptom of foliar injury caused by SO_2 is the formation of marginal and interveinal chlorotic, bronzed or necrotic areas, starting with dark green or dull colouration, with water-soaked appearance. Necrotic areas extend and are visible on both epidermal surfaces. Older leaves having just attained full expansion are the most susceptible ones.

NO_x : Three types of oxides of nitrogen are collectively referred as NO_x . These are N_2O (Nitrous oxide), NO (Nitric oxide) and NO_2 (Nitrogen dioxide). High temperature reactions in the presence of air lead to oxidation of atmospheric nitrogen, giving rise to oxides of nitrogen. Whereas background level of NO_2 is only $1.9 \mu\text{g m}^{-3}$, that of N_2O may be as high as $450 \mu\text{g m}^{-3}$ (Urone, 1976).

On absorption in leaves across stomatal apertures, NO_x react on cell walls to form HNO_2 and HNO_3 , the former being more toxic. pH drop and reaction of acids with unsaturated compounds causing isomerization and free radical formation, lead to toxicity. Nitrosamines

are formed, cellular pH is lowered and acetate metabolism inhibited, leading to growth suppression (Mudd, 1973; Taylor et al, 1975; Zeevart, 1976).

Injury symptoms are visible as discoloured spots of gray-green or light brown colour. Bleached or necrotic spots in interveinal areas of leaves is a later development, appearing as stripes in advanced stages.

NO_x are not considered to be of major concern as phyto-toxicants, since several studies suggest that levels sufficient to injure vegetation would be far above known or monitored ambient levels. Importance of NO_x in the atmosphere however, lies in the fact that they are the raw material for formation of important secondary pollutants like O_3 , Smog and PAN.

HF : Fluorine is a universally distributed element, hence is to be found in all places-soil, water and air (Treshow, 1970). About 0.05 mgm^{-3} is present in air and in traces in surface waters and in soil. Some parts of Rajasthan are reported to have unusually high concentrations of the element in soils. Combustion of fossil fuels, smelting of ores like bauxite and reduction of phosphatic rock in the manufacture of fertilizers, are some of the industrial processes, responsible for release of HF in the atmosphere. Few to several hundred pounds of fluorine is released into the atmosphere every year, according to several estimates (Treshow, 1970).

Fluoride enters leaf through stomata, and from the intercellular spaces of mesophyll, diffuses into vascular tissues. It moves along transpiration stream towards leaf tips and margins, where accumulation takes place. Due to absence of visible injury, such accumulation goes unnoticed for long. In some sensitive plants, injured tissues in tips and margins have shown values of 50-200 ppm HF concentrations. In tolerant species visible injury was not noticeable even at 500 ppm concentration level.

Chlorosis of leaf tip is the first visible injury. With increasing accumulation, the injury may extend along margins and inwards along veins. Injured, brown or dead areas of leaves become necrotic, leading to premature leaf fall (Weinstein, 1977).

CO and CO_2 : Incomplete combustion of fuels including fossil fuels, leads to formation of CO. Automobiles are the commonest source of CO. Oil refineries, metallurgical operations, etc. are other sources of significance. Annual global input of this toxic gas is estimated to be 6 billion tons (Seiler, 1974).

CO is not a phytotoxic gas. Green plants function as natural sinks for CO (or its readily converted form, CO_2). Soil and oceans are also vast sinks for the gas. Since CO gets gradually oxidized to CO_2 , which is absorbed and utilized by plants on large scale, and since increase in CO_2 concentration from its normal 300 ppm to higher levels are still non-toxic to plants, CO or CO_2 are not treated as serious phyto-toxicants.

NH_3 : Decomposition of organic matter of different origins including excreta, fertilizer breakdown, coal combustion and releases from industries lead to pollution by ammonia. Though localized, ambient concentrations of 20 ppm have been recorded (Choiak, 1952).

Blackening and bleaching of leaves, spotting, brown lesions between veins and colour change of fruits, are symptoms of injury by ammonia.

Generally, emission of NH_3 is of an accidental nature, during transfer and transpiration or due to poor maintenance of containers. Best control of NH_3 is achieved through proper care and maintenance at 'in house' level.

Cl₂ : This pollutant is also a result of industrial accidents, escape from manufacturing processes and leakages from cylinders and sewage treatment systems. Chlorosis, reddening, stipple and necrosis of leaves are reported to be injury symptoms on plants.

Exposure of sensitive plants like radish and alfalfa to 10 ppm of Cl_2 for 2 hours, showed foliar injury, while plants like tobacco, zinnia, corn and sunflower were injured when exposed to the same concentration for 4 hours (Brennan, et. al., 1965). Chlorosis, stipple, necrosis and reddening were the types of injuries observed on foliage of plants exposed.

Hydrocarbons (HC) : Organic compounds containing carbon and hydrogen are emitted from automobiles, oil refining processes and chemical factories. On reaching ground, the HC are degraded by soil micro-organisms. In traces, HC like ethylene gas acts as a growth hormone by stimulating formation of lateral buds. At pollution levels however, it causes distortion of foliage, excessive curvature in growth, chlorosis, senescence and flower abscission (Smith, 1981).

H₂S : Pattern of injury caused by this pollutant is different from that by others. Necrosis and death of young tissues is reported rather than that of old tissues. Tips of leaves are also injured. Injury at chronic levels of the pollutant is unknown, toxic levels are found to be much above the known ambient concentrations of the gas. The most sensitive plant species have been reported to be injured at 86 ppm ($12 \times 10^4 \text{ ug m}^{-3}$) after 5 hours exposure (US EPA, 1976).

SPM : Suspended particulate matter is released during metal refining, by foundries, cement factories and as fly ash from thermal power plants, mine tailings, etc. and autoexhausts. Heavier particles, above 1 μ diameter size, tend to settle while finer and lighter particles remain airborne for days together and travel for hundreds of kilometers over wind currents. Chemical dusts are more injurious and under humid conditions, their phytotoxicity increases further (Chaphekar, 1972).

Finer particles clog stomatal apertures and prevent gaseous exchange by leaves. Physical weight on foliage and a film of dust causing rise in leaf surface temperature are other hazardous situations for plants. Dust particles deposited on stigmatic surfaces of flowers reduce effective pollination and hence fruit yields.

Dust is captured by leaves of plants, leaf epidermal outgrowths like hairs and scales, hairy axils of stems and leaf bases, etc. (Das, 1981).

Mixtures of pollutants : In India, as in several other places, many industries are located in the same region and the air is a mix of several pollutant gases. A large number of studies indicate synergistic nature of pollutant mixture effects on plants. It is practically

impossible to assess the pollutant removal efficiency of plants under the numerous possible combinations of mixing proportions of different pollutants detected. Bearing in mind however, the synergistic nature of the reactions, it is again emphasized that the concentrations of ambient pollutants have to be well below the threshold limits of tolerance (e.g. as cited in Table 2.5), for plants to function effectively for removal of pollutants.

The sensitive plants indicate injury symptoms due to air pollution, that are specific to the type of pollutant. Ranges of dosage of the pollutants to which sensitive plants respond, are given in Table-2.5.

A large amount of research has been carried out in India, during the last two decades. Compilation of this work has been presented in a comprehensive Table 2.6.

Within their limits of tolerance, plants absorb pollutants and to that extent remove the same from ambient air. The plant uptake of air pollutants as investigated by Hill (1971) and Bennett and Hill (1973, 1975), appeared to follow the following order :

HF > SO₂ > Cl > NO₂ > O₃ > PAN > NO > CO.

The rate of pollutant removal is found to increase linearly as the concentration of the pollutant increased over the ranges of concentration that are encountered in ambient air and which are low enough not to cause stomatal closure. Pollutants are absorbed most efficiently by plant foliage near the canopy surface where diffusion process is high due to favourable light conditions. An example of the magnitude of absorption of pollutants by seedlings of plants is given in Table-2.7.

Smith (1981) has given estimated absorption of gaseous pollutants by dry soil and vegetative surfaces to emphasize relative differences in their efficiencies to remove pollutants (Table 2.8). He also assessed pollutants removal efficiency of a 'Model Forest Hectare' developed by U.S. EPA, in which composition of plant species is as follows:

Species	No. of trees Planted	Tree surface area (m ²)	Total vegetative area (m ²)
Maple	69	36.8	2.54 x 10 ³
Oak	69	36.1	2.50 x 10 ³
Poplar	69	52.5	3.63 x 10 ³
Linden	69	23.0	1.56 x 10 ³
Birch	69	27.2	1.88 x 10 ³
Pines	700	4.2	2.90 x 10 ³

This hectare, consisting of 5-year old plants, is estimated to remove gaseous pollutants annually in quantities as :

O₃ - 9.6 x 10⁴, SO₂ - 748, CO - 2.2, NO_x - 0.38 and PAN - 0.17 (all values in tonnes).

Fig. 2.1 Summary diagrammatic representation of the effects of sulphur dioxide on plants

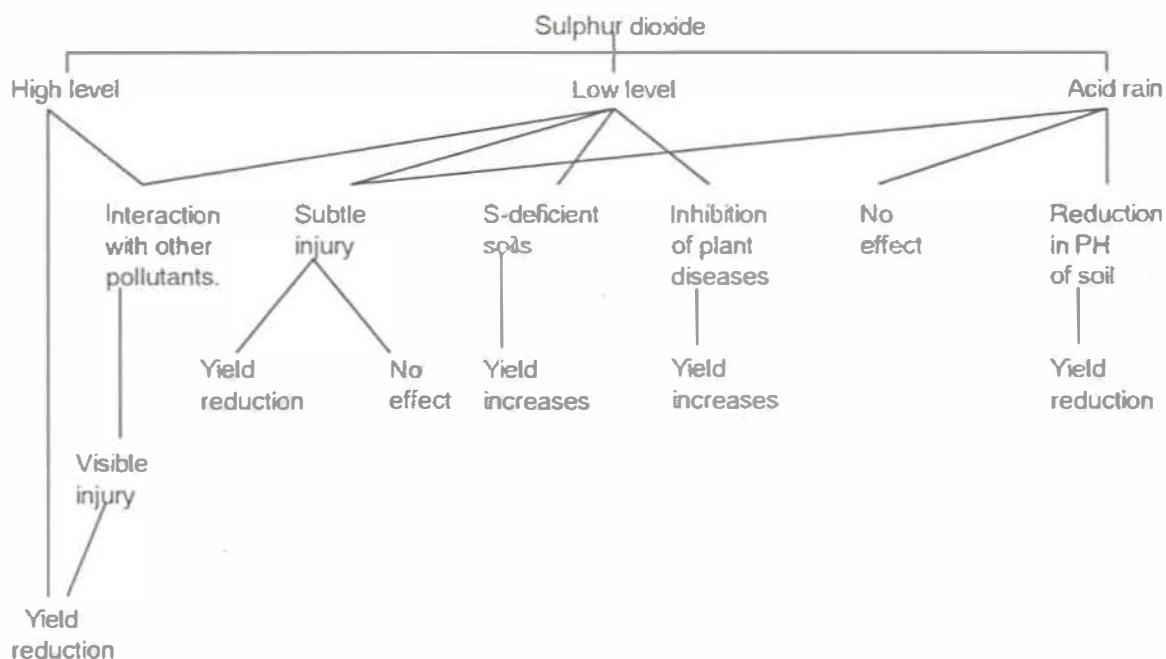


Table 2.1 Industrial sources of major air pollutants

S.No.	Pollutant	Sources
01	Sulphur dioxide (SO ₂)	Coal, fuel oil and petroleum combustion.
02	Nitrogen dioxide (NO ₂)	High temp. combustion of coal, oil, gas and gasoline in power plants and internal combustion engines.
03	Hydrogen fluoride (HF)	Phosphate rock processing, aluminium industry, iron smelting, brick and ceramic works, and fibreglass manufacturing.
04	Chlorine (Cl)	Leaks in chlorine storage tanks, hydrochloric acid mist.
05	Ammonia(NH ₃)	Leakages in fertilizer manufacturing factories, transfers and transport of the chemical.
06	Hydrogen sulphide (H ₂ S)	Decay and decomposition of organic wastes, dumps, sewage, etc.
07	Carbon oxides (CO and CO ₂)	Products of combustion of fuels- incomplete combustion/Organic respiration.
08	Ethylene (C ₂ H ₄)	Incomplete combustion of coal, gas, and oil for heating, and automobile and truck exhaust.
09	Particulates (SPM)	Combustion (esp. incomplete) processes, Fly ash, Thermal power plants, Cement factories, Automobiles, etc.
10 *	Ozone(O ₃)	Dissociation of NO ₂ (NO ₂ ---> NO+O) (O ₂ +O ---> O ₃)
11 *	Peroxyacetyl	Ozonated olefin nitrate (PAN)
12 *	Smog	Combination of fine particulates and NO _x in air
13 *	Acid precipitates	Combination of NO ₂ and / or SO ₂ with water vapour in the atmosphere

(Source : Painter D.E. 1974, except for * No. 10-13).

Table 2.2 Quantities of SO₂ liberated during different types of industrial activities

Source	SO ₂ emission factor (in kg)
Combustion of coal	4.536 per 1000 kg coal (Variable).
Combustion of fuel oil	9.9 per 10,000 L oil (Variable).
Municipal incineration	0.544 - 0.907 per 1000 kg refuse.
Sulphuric acid manufacture	9.07 - 3.75 per 1000 kg 80% acid.
Cu smelting (Primary)	635.04 per 1000 kg conc. ore.
Pb smelting (Primary)	299.376 per 1000 kg conc. ore.
Pb smelting (Sec. cupola)	29.03 per 1000 kg metal changed.
Zn smelting (Primary)	494.424 per 1000 kg conc. ore.
Kraft mill recovery furnace	1.088 - 1.078 per 1000 kg air dry pulp.
Sulphite mill recovery furnace (assuming 90% recovery)	18.144 per 1000 kg air dry pulp.

(Source : Kumar and Prakash, 1978.)

Table 2.3 Amount of SO₂ emitted by burning different types of fuels

Fuel	SO ₂ emission in kg per tonne of fuel
Firewood	20
Coal	6 to 15.0
Oil	6 to 7.6
LPG	0.0002 to 0.008
Natural Gas	0.2
Petrol	5.4
Diesel	5 to 6

(Source : Kumar and Prakash, 1978.)

Table 2.4 Solubilities of pollutant gases in water

Pollutant	Solubility at 20°C (cm ³ gas ml ⁻¹ H ₂ O)
CO	0.02
NO	0.05
CO ₂	0.88
PAN	--
O ₃	0.26
NO ₂	Decomposes
Cl ₂	2.30
SO ₂	39.40
HF	446

(Source : Hill and Chamberlain, 1974.)

Table 2.5 Injury symptoms and pollution dose thresholds of tolerance by sensitive species of plants

S. No.	Pollutants	Threshold dose	Plant injury symptoms
1.	Sulphur dioxide	0.70 ppm ($1820 \mu\text{g m}^{-3}$) for 1 hr.; 0.18 ppm ($468 \mu\text{g m}^{-3}$) for 8 hr.; 0.008-0.017 ppm ($21/44 \mu\text{g m}^{-3}$) for growing season. (Linzon 1978)	Interveinal necrotic blotches. Red brown dieback or banding in pines.
2.	Nitrogen oxides	20 ppm ($38 \times 10^3 \mu\text{g m}^{-3}$) for 1 hr.; 1.6 - 2.6 ppm ($3000-5000 \mu\text{g m}^{-3}$) for 48 hr.; 1 ppm ($1900 \mu\text{g m}^{-3}$) for 100 hr.; (National Academy of Sciences, 1977)	Interveinal necrotic blotches similar to those by SO_2 . Red brown distal necrosis in pines.
3.	Fluoride	< 100 $\mu\text{g g}^{-1}$ fluoride (Weinstein 1977)	Tip and margin necrosis,
4.	Ammonia	55 ppm ($38 \times 10^3 \mu\text{g m}^{-3}$) for 1 hr.;	Interveinal necrotic blotches similar to those by SO_2 . Distal necrosis in pines.
5.	Chlorine	0.5 - 1.5 ppm ($1400 - 4530 \mu\text{g m}^{-3}$) for 0.5 - 3 hr.	Chlorosis, upper surface fleck similar to O_3 . Distal necrosis in pines.
6.	Ethylene	Variable, undetermined	Chlorosis, necrosis, abscission, Dwarfing, premature defoliation.
7.	Hydrogen sulphide	100 ppm ($14 \times 10^4 \mu\text{g m}^{-3}$) for 5 hr.; (U.S. Environ. Protection Agency 1976)	Interveinal necrotic blotches. Distal necrosis in pines.
8.	Trace metals	Variable, undetermined	Interveinal chlorosis, tip and margin necrosis, Distal necrosis.
9.	Ozone	0.20 - 0.30 ppm ($392 - 588 \mu\text{g m}^{-3}$) for 2-4 hr.; Some conifers 0.08 ppm ($157 \mu\text{g m}^{-3}$) for 12-13 hr. (National Academy of Sciences 1977b)	Upper surface flecks Distal necrosis and stunted needles in pines.
10.	Peroxy acetyl nitrate	0.20 - 0.80 ppm ($989-3958 \mu\text{g m}^{-3}$) for 8 hr. (Davis 1975)	Lower surface bronzing, Chlorosis, early senescence.
11.	Acid rain	pH < 3.0	Necrotic spots, Distal necrosis pines.

(Source : Smith W.H. 1981.)

Table 2.6 Compilation of research in India indicating sensitive and tolerant species, with reference to industrial pollutants

Name of Plant	Sensitive	Tolerant	Reference
<u>Mangifera indica</u>	Coal dust		
<u>Citrus lemon</u>		Coal dust	Rao, 1971
<u>Phaseolus aureus</u> (Green gram)	Petro cake		Prasad and Rao (1981)
<u>Zea mays</u>	Cement dust		Sree Rangaswamy <u>et al.</u> , (1973)
<u>Syzygium cumini</u>	Cement dust		Jafri <u>et al.</u> , (1979)
<u>Psidium guajava</u>	Cement dust		Yunus and Ahmed (1980)
<u>Triticum aestivum</u>	Cement dust		Singh and Rao (1980 a)
<u>Calotropis procera</u>	Cement dust		Yusuf and
<u>Cassia fistula</u>	Cement dust		Vyas (1982)
<u>Dalbergia sissoo</u>	Cement dust		
<u>Withania somnifera</u>	Cement dust		
<u>Glycine max</u>	Cement dust		Singh and Rao (1978 a)
<u>Hordeum vulgare</u>		5% fly ash	Bhatia (1978)
<u>Portulaca sp.</u>			
<u>Triticum aestivum</u>	above 20% Fly ash		Pawar and Dubey (1982)
<u>Triticum aestivum</u>		6g/m ² /day fly ash 4g/m ² /day fly ash	Dubey <u>et al.</u> , (1982)
<u>Dolichos lablab</u>		4g/m ² /day fly - ash	Pawar <u>et al.</u> , (bean) (1983)
<u>Abelmoschus esculantus</u> Var Pusa savani	Cement and Coal dust	fly - ash	Pawar <u>et al.</u> , (1982)
<u>Commelina benghalensis</u>	Air borne dust		Chaphekar <u>et al.</u> , (1980)
<u>Brassica oleraceae</u>	Urban		Garg and
<u>Chenopodium album</u>	air		Varshney (1980)
<u>Cicer arietinum</u>			
<u>Dolichos lablab</u>			
<u>Sonchus asper</u>			
<u>Withania somnifera</u>			
<u>Tabernaemontana coronaria</u>	Polluted environment		Srivastava <u>et al.</u> (1980)
<u>Calotropis procera</u>		Polluted conditions	Yunus and Ahmed(1981)

(Contd.....)

Table 2.6 (Contd.....)

Name of Plant	Sensitive	Tolerant	Reference
<u>Calotropis gigantea</u>	Polluted areas		Bhirava Murthy and Kumar (1983)
Baro paddy. Var. Ratna	Urban dust		Das and Pattanayak (1978)
<u>Mangifera indica</u>		Dust Collector	Shetye and
<u>Thespesia populnea</u>			Chaphekar (1980)
<u>Erythrina indica</u>	Poor dust Collector		---
<u>Polyalthia longifolia</u>			
<u>Ficus benghalensis</u>		Dust Collector	Das 1981 and
<u>Ficus infectoria</u>			Das <u>et al.</u> (1981)
<u>Ficus religiosa</u>			
<u>Mangifera indica</u>			
<u>Tectona grandis</u>			
<u>Polyalthia longifolia</u>			
<u>Shorea robusta</u>			
<u>Terminalia arjuna</u>			
<u>Cassia fistula</u>	Poor dust Collector.		Das (1981) and
<u>Poinciana regia</u>			Das <u>et al.</u> (1981)
<u>Sesbania sp.</u>			
<u>Pithecolobium dulce</u>		Better dust collector.	Rao (1971)
<u>Argyrea speciosa</u>			
<u>Leucaena leucocephala</u>			
<u>Melilotus alba</u>	Polluted area		Ghouse and Khan (1983)
Banana Crop.	SO ₂ and dust From brick Kiln		Bedi <u>et al.</u> (1982)
<u>Lycopersicum esculentum</u>	SO ₂ and dust from brick Kiln		Bell and Bedi (1981)
<u>Mangifera indica</u>	SO ₂		Rao 1972 Shetye 1979 Giridhar (an published data) Pawar and Dubey (1983)
<u>Helianthus annus</u>	To pollute areas		Chaphekar <u>et al.</u> (1980 a)
<u>Crotalaria juncea</u>			
<u>Commelina benghalensis</u>			
<u>Cyamopsis tetragonoloba</u>			
<u>Cicer arietinum</u>	Fly ash SO ₂		Dubey <u>et al.</u> (1982)

(Contd.....)

Table 2.6 (Contd.....)

Name of Plant	Sensitive	Tolerant	Reference
<u>Medicago sativa</u> (Alfa-alfa)	SO ₂		Singh and Rao (1979, 1980)
<u>Sorghum vulgare</u> var CSH - 1	SO ₂		Boralkar and Chaphekar (1978)
<u>Glycine max</u>	SO ₂		Pandey and Rao (1979), Prasad and Rao (1982)
<u>Phaseolus aureus</u>	SO ₂		Singh and Rao (1980)
<u>Arachis hypogea</u>	SO ₂		Mishra (1980)
<u>Dolichos lablab</u>	SO ₂		Banerjee and Chaphekar (1978)
<u>Phaseolus aureus</u> Var. Vaishakhee	SO ₂		Boralkar and Chaphekar (1980)
<u>Trigonella foenum- graecum</u>	SO ₂		Boralkar and Chaphekar (1983)
<u>Pisum sativum</u>	SO ₂		Varshney and Varshney (1978)
<u>Crossandra undulaefolia</u>	SO ₂		Chaphekar and Karbhari (1974)
<u>Mirabilis jalapa</u>			
<u>Amaranthus spinosus</u>	SO ₂		Boralkar and Chaphekar (1980)
<u>Spinacea olercea</u>			
<u>Raphanus sativus</u>	SO ₂		Banerjee and Chaphekar (1978)
<u>Commeling benghalensis</u>			
<u>Erythrina indica</u>			
Barley, Cotton, Wheat, Aster, Cosmos, Verbena, Zinnia, Sweet Pea, Ipomoea purpurea, 4 o'clock plant, Bean Beet, Carrot, Chilli, Pumpkin, Radish Bhendi, Sunflower etc. Most trees	SO ₂	SO ₂	Pandey and Vaidya (1979) Pandey and Vaidya (1979)
<u>Mangifera indica</u>	SO ₂		Chaphekar (1972)
<u>Terminalia catappa</u>			
<u>Malachra capitata</u> Dahlia			
<u>Croton, Plumeria</u>		SO ₂	Chaphekar (1972)
Opuntia, Nerium			
<u>Dahlia, Petunia,</u> Alfalfa, cotton Barley	SO ₂		Vaishnavi (1975)

(Contd.....)

Table 2.6 (Contd....)

Name of Plant	Sensitive	Tolerant	Reference
<u>Dalbergia sissoo</u>	SO ₂		Yunus and Ahmed (1979)
<u>Terminalia arjuna</u>			
<u>Cassia fistula</u>			
<u>Cedrela toona</u>			
<u>Syzygium cumini</u> Oat, Pea, Brinjal, Potato Cucurbit		SO ₂	Yunus and Ahmed (1979)
<u>Azadirachta indica</u>			
<u>Ficus religiosa</u>			
<u>Pithecolobium dulce</u>			
<u>Calotropis procera</u> Trees, Bushes, crops of those areas.			Agrawal and Rao (1983)
<u>Phaseolus aureus</u>	SO ₂ , O ₃ , SO ₂ +O ₃	SO ₂ , O ₃ , SO ₂ +O ₃	
<u>Cicer arietinum</u>			
<u>Oryza sativa</u>	SO ₂ , O ₃ , SO ₂ +O ₃	SO ₃ , O ₃ , SO ₂ +O ₃	
<u>Panicum miliaceum</u>			Bolalkar and Shinde (1983) Sharma (1981)
<u>Solanum melongena</u>	SO ₂ , O ₃ , SO ₂ +O ₃		
<u>Vicia faba</u>	SO ₂ , O ₃ , SO ₂ +O ₃		
<u>Abelmoschus esculentus</u> Var. Pusa savani	SO ₂ , O ₃ , SO ₂ +O ₃		
<u>Abelmoschus esculentus</u>	SO ₂ , O ₃ , SO ₂ +O ₃ , SO ₂ , HF, SO ₂ +HF		Prasad and Rao (1979) Prasad (1980) Rao <i>et al.</i> , (1983)
<u>Phaseolus aureus</u>			
<u>Triticum aestivum</u>			
<u>Brassica juncea</u>			
<u>Triticum aestivum</u>	NO ₂		Rao <i>et al.</i> , (1983)
<u>Triticum aestivum</u>	NO ₂ +SO ₂		
<u>Dalbergia sissoo</u>	SO ₂		
<u>Madhuca indica</u>			
<u>Pisum sativum</u> var. Bonneville, <u>Pisum sativum</u> var. T163 <u>Hordeum vulgare</u> <u>Zea mays</u>	NaF		Arya (1971) Pandey (1979)
<u>Lycoopersicum esculentum</u>	NaF		
<u>Terminalia tomentosa</u>	HF		
<u>Buchanania lanzan</u>			
<u>Zea mays</u>	HF		Rao and Pal (1978 b) Pandey and Rao (1980 a)
<u>Gladiolus</u> sp.	HF		

(Contd....)

Table 2.6 (Contd.....)

Name of Plant	Sensitive	Tolerant	Reference
<u>Spinacia oleracea</u>	Gasoline Vapour.		Prasad (1980)
<u>Abelmoschus esculantus</u> <u>Cyamopsis tetragonoloba</u> <u>Crotalaria juncea</u> <u>Trigonella foenum-graecum</u>	Ammonia		Chaphekar and Boralkar (1979)
<u>Nerium indicum</u>	SO ₂		Varshney, (Unpublished)
<u>Cynodon dactylon</u>	HF		Meenakshy <u>et al</u> (1981)
<u>Cicer arietinum</u> <u>Nasturtium indicum</u> <u>Petunia alba</u> <u>Tradescantia axillaris</u>	SO ₂		Varshney and Varshney (1981)
<u>Madhuca indica</u>	SO ₂ , fly-ash		Agrawal M (1989)
<u>Cassia siamea</u> <u>Delonix regia</u> <u>Shorea robusta</u> <u>Acacia arabica</u>	-- " --	SO ₂ , fly-ash	
<u>Acacia catechu</u> Zizyphus sp.			
<u>Mangifera indica</u>		Dust	Agrawal & Khanam (1989)
<u>Ficus benghalensis</u> L <u>Ficus infectoria</u> Roxb <u>Holoptelia integrifolia</u> Planch <u>Ipomoea fistulosa</u> Mart ex choisy <u>Lagerstroemia</u> sp. <u>Nyctanthes arbortristis</u> L <u>Peltophorum pterocarpum</u> (DC) K. Heyne		Dust	Ahmad Yunus <u>et al</u> (1991)
<u>Tectona grandis</u> L <u>Terminalia arjuna</u> W & A <u>Thevetia nerifolia</u> Jass <u>Acacia arabica</u> Willd <u>Bougainvillea spectabilis</u> Willd <u>Hibiscus rosa sinensis</u> Willd <u>Morus alba</u>		Dust	Ahmad Yunus <u>et al</u> (1991)

(Contd.....)

Table 2.6 (Contd....)

Name of Plant	Sensitive	Tolerant	Reference
<u>Nerium indicum</u> Mill <u>Thevetia nerifolia</u> juss <u>Dalbergia sissoo</u> Roxb		Cement dust	
<u>Azadirachta indica</u> A.Juss <u>Brassica campestris</u> L <u>Citrus aurantium</u> L <u>Delonix regia</u> Raffin <u>Syzygium cuminii</u> (L) skeel <u>Mangifera indica</u> L <u>Pisum sativum</u> L <u>Tabernaemontana coronaria</u> Willd <u>Triticum aestivum</u> L <u>Zizyphus mauritiana</u> Lamk <u>Helianthus annus</u> L	Cement dust		Pandey, Misra <u>et al</u> (1994)
<u>Opuntia monochantha</u> <u>Opuntia dillenii</u> <u>Kalanchoe marmorata</u> <u>Crassula</u> <u>Bryophyllum</u> <u>Aloe</u> <u>Bryophyllum tabiflorum</u> <u>Euphorbia cattamindoios</u>		fly ash SO ₂	Raza S.H., Shylaja G. (1992)
<u>Caesalpinia pulcherima</u> <u>Eugenia jambolana</u> <u>Polyalthia longifolia</u> <u>Pongamia pinnata</u> <u>Caesalpinia pulcherima</u> <u>Pithecolobium dulce</u> <u>Cassia fistula</u> <u>Pongamia globra</u> <u>Polyalthia longifolia</u>		SO ₂ SO ₂ SO ₂ SO ₂ Dust Dust	Murthy M.S.R. <u>et al</u> (1990) Raza S.H. <u>et al</u> (1991)
<u>Pithecolobium dulce</u> <u>Caesalpinia pulcherrima</u> <u>Polyalthia longifolia</u> <u>Pongamia pinnata</u>		SO ₂ SO ₂	Raza S.H. <u>et al</u> (1989)

Table 2.7 Absorption of SO₂ by seedlings fumigated at 1.0 ppm for 1 hour in a controlled chamber (27 ± 1°C, 51 ± 7 R.H., 1300 fc)

Species	SO ₂ uptake	
	mg SO ₂ dm ⁻² hr ⁻¹	mg SO ₂ g ⁻¹ hr ⁻¹
Red maple	0.088	0.260
White birch	0.086	0.268
Sweetgum	0.074	0.267
Firethorn	0.072	0.213
Privet	0.068	0.134
Rhododendron	0.056	0.079
White ash	0.046	0.118
Azalea	0.044	0.072

(Source: Roberts 1974.)

Table 2.8 Guesstimated gaseous pollutant flux rates for dry soil and vegetative surfaces

Pollutant	µg m ⁻² hr ⁻¹	
	Soil surface	Vegetative surface
CO	1.9 × 10 ⁴	2.6 × 10 ³
NO _x	2.0 × 10 ²	2.3 × 10 ³
O ₃	1.0 × 10 ⁹	6.2 × 10 ⁴
PAN	----	1.2 × 10 ³
SO ₂	7.7 × 10 ⁶	4.1 × 10 ⁴

(Source: USEPA 1976.)

THEORETICAL MODELS FOR DEVELOPMENT OF GREEN BELT

Introduction

The air pollution emitted by industries settles on the ground and vegetation of surrounding area. The plants interact with both gaseous and particulate pollutants and to great extent absorb them and thus, remove them from the atmosphere. This pollution removal property of the plants has been known for a long time. For several years tree planting has been promoted by USSR scientists and city planners for the purpose of reducing ground level air pollution. Many scientists have also suggested the use of green belt, which is rows of trees, for reducing the pollution originating from industrial operations. (Kalyushnyi *et al.*, 1952; Flemming 1967; Hanson and Throne, 1970; Warren 1973; Ganguly, 1976).

The capability of plants to act as a sink for air contaminants has been addressed by a number of reviews. (USEPA, 1976; Smith and Dochinger 1976, Bennett and Hill 1975; Hill 1971; Environmental Health Science Centre 1975; Keller 1978). All these studies indicate that the surface of vegetation provides a major filtration and reaction surface to the atmosphere for removing pollutants from the atmosphere.

Mechanism of Deposition

Interaction of pollution with vegetation has always been expressed by a common parameter known as the deposition velocity of the pollutants. The concept of deposition velocity has also been widely used in agriculture to calculate the dose of fertilizer and pesticides for crop growth and its protection. The deposition velocity is defined as follows :

$$\text{Deposition Velocity (Vd)} = \frac{\text{Amount of pollutant deposited per unit area of surface per second}}{\text{Concentration of pollution per unit volume above surface}}$$

It has dimension of Ms^{-1} (see McMohan & Denison 1979 for values of Vd for commonly released pollutants).

Particulates are deposited on plant surface by three processes - sedimentation by the gravity action, impaction under the influence of eddy currents, and deposition under the influence of precipitation.

Sedimentation usually results in the deposition of the particles on the upper surfaces of the plant and is most important for large particles. Sedimentation velocity varies with particle density, shape etc. Impaction occurs when air flows past an obstacle and the air stream divides. The efficiency of collection via impaction increases with decreasing diameter of the

collection obstacle and increasing diameter of the particle. It has been suggested that impaction is the principal means of deposition if particle size is of the order of tens of micrometers (μm) or greater, obstacle size is of the order of centimeters or less, approach velocity is of the order of meters per second or more and the collecting surface is wet, sticky, hairy, or otherwise retentive. For particles of dimension 1-5 μm , impaction is not efficient and interception by fine hairs on vegetation is possibly the most efficient retentive mechanism. The efficiency of washout of particles by rain is high for particles approximately of 20-30 μm size. The capturing efficiency of rain drops falls off very sharply for particles of 5 μm or less.

The hypothesis that trees are important particulate sinks is supported by evidence obtained from studies dealing with diverse particulates including radioactive, trace element, pollen, spore, salt, precipitation dust and other unspecified particles. So far as gaseous pollutants are concerned, substantial evidence is available to support the fact that plants in general and trees in particular function as sinks for gaseous pollutants. The gaseous pollutants are transferred from the atmosphere to vegetation by the combined forces of diffusion and flowing air movement. Once in contact with the plants, gases may be bound or dissolved on exterior surfaces or taken up by the plants via stomata. If the surface of the plant is wet and if the gas is water soluble, the former process can be very important. When the plant is dry or in the case of gases with relatively low water solubilities, the latter mechanism is assumed to be most important. For example, hydrogen fluoride, sulphur dioxide, nitrogen dioxide and ozone which are soluble and reactive, are readily absorbed, while nitric oxide and carbon monoxide, which are very insoluble, are absorbed relatively slowly or not at all by vegetation. It should be noted that when vegetative surfaces are damp, the pollutant removal rate may increase up to ten fold. Under damp condition, the entire plant surface - leaves, twigs, branches, stems - is available for uptake of gaseous pollutant.

The interaction of these various sized particles and gaseous pollutants with exceedingly diverse vegetative surfaces under conditions of extremely variable microclimate and pollutant source characteristics suggests an enormously complex relationship. These studies have expressed uptake of pollution by plants in terms of deposition velocity. This concept though suitable for estimation of loss of pollutant over a vegetation surface, is hard to apply for a case when pollution travels horizontally through a canopy (e.g. through green belt). The mathematical models so far available in literature for green belt are applicable only for ground level air pollution source. The only theoretical model available for estimation of depletion of pollutants by green belt is developed by Kapoor and Gupta (1984). This model expresses pollution attenuation factor A_f of green belt in terms of different dimensions and characteristics of green belt under various meteorological conditions. The model is described in next section.

About the Model

Mathematical model for the estimation of pollution attenuation by a green belt exists only for a ground level pollution source. Such ground level releases can occur by break in storage vessels and under various conditions such as follows :

- (i) Fugitive emissions

- (ii) Elevated releases reaching ground level due to
- stack downwash due to low discharge velocity
 - effect of obstacles upstream
 - short stack near a long flat building
 - downwash in the wake of a cliff
 - fumigation conditions due to breaking up of ground based temperature inversion.

The green belt model introduces the concept of a pollution attenuation coefficient for estimating the removal of pollutant while passing through the green belt. The formulation of pollution attenuation coefficient makes use of parameters such as leaf area density of the tree plantation, deposition velocity of the pollutant on leaf surface and wind speed in the green belt. The model gives the dependence of the pollution attenuation factor A_f of a green belt on various physical parameters of the green belt such as its height, width, distance from the pollution source and on atmospheric stability conditions and hence, the model can be used to optimise the design of the green belt in obtaining the desired degree of attenuation of the pollution around an industry.

The application of model has been made for two different situations viz. a source oriented approach and a receptor oriented approach. In the former case, the model is applied for estimation of pollution attenuation factor of a green belt planted around a source i.e. an industrial establishment. In the latter case, the model has been applied in studying the pollution attenuation by planting green belt around a receptor, which needs to be protected from the effects of the pollution.

The details of the model, its application aspects including its limitations are given in following sections.

Development of the Model

Various field experiments carried out by Raynor *et al.*, (1974) at Brookhaven National Laboratory USA aiming to estimate the deposition of particulates by forest using pollens and spores have indicated that the mass flux of the pollutant decreases almost exponentially with travel distance within the forest. Chamberlain (1970) and Chadwick and Chamberlain (1970) also proposed exponential removal law for removal of pollutants. Hence considering the exponential law, if the mass flux of a pollutant which enters the green belt is Q_c , the mass flux Q_x at a travel distance X within the green belt is given by

$$Q_x = Q_c e^{-kx} \quad (1)$$

Where, k = pollution attenuation coefficient, m^{-1} .

Because of the non-availability of experimentally measured values for the following relationship for k in terms of easily measurable parameters was proposed in the model.

$$k = K P t V_d / U_c \quad (2)$$

Where V_d = dry deposition velocity of pollutant for vegetative canopy, ms^{-1}

U_c = average wind speed through the green belt, ms^{-1}

P_t = average foliage surface area density of a single tree, of green belt m^2m^{-3}

$K = P_c / P_t$

P_c = average foliage surface area density of the green belt, m^2m^{-3}

The constant K depends on the spacing of the trees in the green belt and is introduced to consider the overall foliage surface area density. For an ideal green belt, the value of K will be unity when such a green belt has the same foliage surface area density as that of a single tree.

The above formulation of K as given in equation (2) has been tested by Kapoor and Gupta (1984) using experimental data and is discussed here. For this testing, it is necessary to demonstrate that the value of K as obtained by using equation (2) compares reasonably well with the value estimated using equation (1) for the same set of field measurements. The study conducted by Raynor et al., (1974) regarding the measurements of variation of mass flux of pollens (having size 20 μm) with distance provides such a comparison. The average value of K obtained from the experiments conducted by Raynor et al using equation (1) is $0.0187 + 0.0047 m^{-1}$ and for the same set of experiments, the value of K calculated by using equation (2) ranges between 0.0088 to 0.0181 m^{-1} which compare reasonably well.

Effectiveness of a green belt

A schematic diagram of the green belt around a pollution source i.e. an industry is given in Fig. 3.1.

The pollution attenuation factor A_f gives the effectiveness of a green belt in attenuating pollution. The attenuation factor A_f has been defined as the ratio of mass flux of pollutant reaching a given distance in the absence of green belt to the mass flux of pollutant reaching the same distance in the presence of the green belt. Mathematically,

$$A_f = \frac{Q_{wB}}{Q_B} \quad (3)$$

Where, Q_{wB} = Mass flux of pollutant reaching at distance in the absence of a green belt

Q_B = Mass flux of pollutant reaching at the same distance in the presence of the green belt

The value of pollution attenuation factor, A_f is calculated in the following five stages.

STAGE-1

Massflux reaching at the inner edge of the green belt

The depletion of pollutant, because of the dry deposition over the travel distance upto the inner edge (X_1) of the green belt and above it (X_2) is obtained using the source depletion model (Chamberlain, 1970). The mass flux Q_A reaching the location A (as per figure 3.1) can be evaluated by

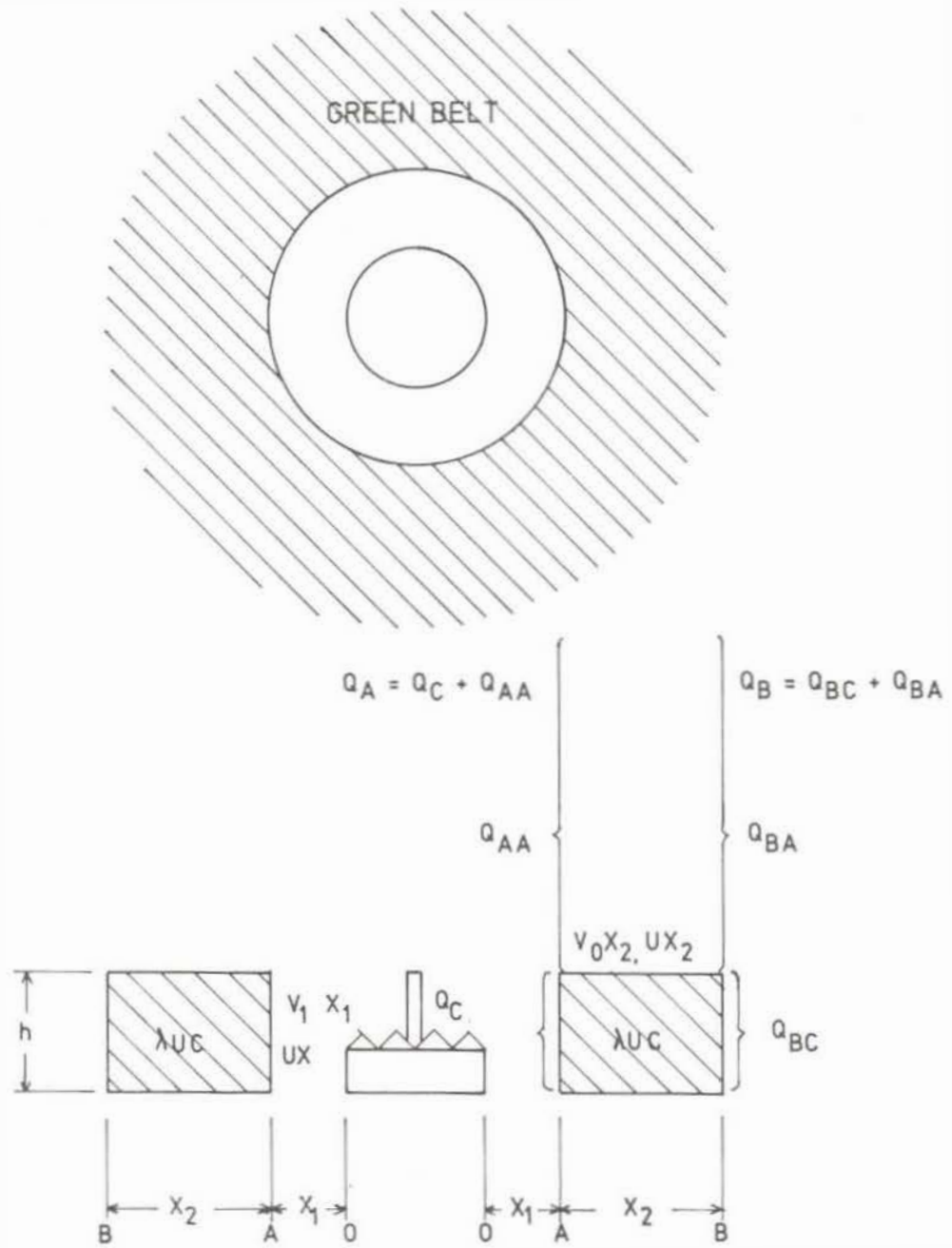


Fig. 3.1 Diagram of a Green Belt Around a Ground Level Pollution Source Illustrating the Parameters of Pollution Attenuation Model

$$QA = Q_0 FD \dots\dots\dots (4)$$

Where, Q_0 is the mass flux at the source, and, the FD is the deposition correction factor which is given by :

$$FD = \exp \left[-\frac{V_d}{U} \left(1 + \frac{2H}{\sigma_z} \right) \right] \dots\dots\dots (5)$$

- Where, H = release height
- σ_z = Standard deviation of concentration distribution in vertical direction
- V_d = dry deposition velocity
- U = mean wind speed
- X = travel distance

Value of FD can be obtained either from equation (5) or from table no. 3.1 (reproduced from Hukkoo et al 1988); which gives the value of F_{D0} for the ratio of $V_d/U = 0.01$ at various distances under different atmospheric stability conditions). The value of FD for any ratio of V_d/U is given by

$$FD = (F_{D0}) 100^{V_d/U} \dots\dots\dots (6)$$

The value of QA can thus be obtained with the help of equations (4) and (6).

STAGE-2 :

Fraction of mass flux QA entering the green belt

The material QA is divided into two parts, namely, Q_c which passes through the green belt and Q_{AA} which passes over it (see figure-3.1). The proportion in which QA is divided into these two parts depends upon the height of trees, distance X_r and atmospheric conditions.

The calculation of Q_c involves the effective height h_e of the incident air stream. If the height of the green belt is h, then h_e is given by

$$U(z)dz = hU_c \dots\dots\dots (7)$$

Where $U(z)$ is the wind speed at height Z profile outside the green belt and U_c is average wind speed through green belt. The methodology for calculation of h_e , is given by Kapoor and Gupta (1984) and values of h_e for different heights of trees under different atmospheric stability conditions reproduced from that work is given here in Table 3.2. The quantity Q_c is then evaluated as follows.

$$Q_c = QA \int_{h_e}^{\infty} \frac{U(z)}{U_c} dz \dots\dots\dots (8)$$

X (X, σ, σ) the centre line ground level concentration at down wind travel distance X.

Where, concentration C is given by $\dots\dots\dots (9)$

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Where, y and z are dispersion coefficients and are in fact the standard deviations of concentration distribution in crosswind and vertical directions respectively at down wind distance X . This is a standard atmospheric dispersion equation. More information on this and other atmospheric dispersion models can be obtained from Sutton, 1953; IAEA publications 1980; 1986. Equation (8) after substitution and carrying out the integration over y and z , can be written as,

$$Q_c = Q_A \dots\dots\dots (10)$$

Where
 $\dots\dots\dots (11)$

The value of the mass flux which passes over the green belt, Q_{AA} can thus be obtained using the following relation

$$Q_{AA} = Q_A - Q_C \dots\dots\dots (12)$$

Table 3.2 Values of h_e

Tree (m)	Values of h_e (m) for height Atmospheric stability condition					
	A	B	C	D	E	F
10	3.62	3.68	3.04	3.29	3.49	4.52
15	5.04	5.12	4.17	4.42	4.76	6.12
20	6.40	6.49	5.52	5.49	5.95	7.56
25	7.71	7.80	6.29	6.50	7.07	8.91
30	8.99	9.08	7.29	7.48	8.14	10.16

Stage-3

Mass flux Q_{BC} coming out of green belt

The material Q_c is depleted in the green belt according to the relation given in equation (1). Value of Q_c for the pollutant and applicable to the green belt can be obtained using equation (2).

Thus,
 $Q_{BC} = Q_c \exp(-K X_2) \dots\dots\dots (13)$

Where X_2 is the width of the green belt. The amount of material Q_{AA} which passes over the green belt will also get depleted to mass flux Q_{BA} by loss of material at the top surface of the green belt. The value of Q_{BA} is evaluated for travel distance X_2 from (4) and (6) by replacing Q_0 by Q_{AA} .

Stage-4 :

Total mass flux Q_B reaching at the outer edge of the green belt

The total mass flux Q_B reaching at the outer edge of the green belt (location B) is thus given by

$$Q_B = Q_{BC} + Q_{BA} \text{ ----- (14)}$$

Stage-5 :

Calculation of attenuation factor, A_f

In the absence of a green belt, the mass flux Q_{WB} reaching the distance $X_1 + X_2$ is evaluated using equations (4) and (6). The attenuation factor A_f of the green belt at location B is then obtained using equation (3).

Combining all the five above stages and after doing the necessary mathematical simplifications, the pollution attenuation factor, A_f is finally given by,

$$FD(X_1+X_2) A_f = \text{----- (15)}$$

Where,

$FD(X_1+X_2)$ = deposition correction factor for travel over distance (X_1+X_2)

$FD(X_1)$ = deposition correction factor for travel over distance X_1

$FD(X_2)$ = deposition correction factor for travel over distance X_2

Other parameters have their usual significance as described earlier.

Optimization of Green Belt

In previous section, a model for the development of green belt around pollution sources for reducing pollution levels has been described which can be used for the optimization of the physical dimensions of the green belt. This optimization methodology is further described below.

It may be reiterated that the model incorporates following parameters for the computation of pollution attenuation factor, A_f : (i) physical characteristics of the green belt, e.g., distance from the source, width, height and leaf surface area density; (ii) aerodynamic properties eg., wind speed through green belt and effective height of the incident air stream, (iii) deposition velocity of the pollutant, and (iv) atmospheric stability conditions. The estimated value of attenuation factor, A_f for different combinations of green belt parameters i.e. X_1, X_2, h, U under different atmospheric stability conditions can be used to optimise the design of the green belt. The parameters X_1, X_2 and h are critical for optimisation. The choice of remaining parameters (h and U) is restricted and decided mostly by the local conditions. For example, it is preferable to have taller trees with high foliage density, but trees of height greater than 20 meters are not common at most sites.

In optimising the physical dimensions of green belt for a ground level source as described above, factors like; the variation in the density of tree plantation and interfacial mass exchange through upper boundary of green belt were not considered. Since, these factors also play important role in effectiveness of green belt, these are discussed in next section.

Effect of Density of Tree plantation

The effect of density of tree plantation on attenuation factor has been dealt in details by Gupta and Kapoor (1992). It has been found out that the value of attenuation factor increases with increase in the density of tree plantation [K of equation (2)] upto an optimum value of K but decreases thereafter for $X_2 = 4$ Km. However, this concept is true only when interfacial mass exchange of pollutants through upper boundary of the green belt is not considered.

The interfacial mass exchange of pollutant in vertical across upper boundary of green belt would modify source mass flux moving through and above it and would thus influence the value of A_f . Consideration of interfacial pollutant exchange results in net movement of material from higher pollution region to lower pollution region. Value of A_f reduces when pollution moves out of canopy region to the region above. Whereas, when pollution enters from above to within canopy region, A_f increases. Reduction in A_f is seen for all values of density of tree plantation (K) for $X_2 < 2$ Km and for $K < 0.7$ for $X_2 > 2$ Km. A small increase in A_f is seen for $K = 0.7$ for $X_2 > 2$ km. These studies help to optimise K for a green belt of given h and X_2 to obtain maximum A_f . Optimum value of K giving maximum A_f for different X_2 for with and without interfacial mass exchange is given in Table 3.3 (Gupta and Kapoor, 1992).

Table-3.3 Value of maximum A_f and optimum K with and without interfacial mass exchange for different widths of green belt for neutral stability condition (category 'D').

X_2 (m)	Without interfacial pollutant exchange		With interfacial pollutant exchange	
	Maximum A_f	Optimum K	Maximum A_f	Optimum K
500	2.17×10^1	0.9	1.87×10^1	0.9
1000	6.64×10^1	0.7	3.10×10^1	0.8
2000	2.13×10^2	0.6	3.84×10^1	0.7
3000	5.87×10^2	0.5	4.67×10^1	0.7
4000	1.46×10^3	0.4	5.67×10^1	0.7
5000	3.76×10^3	0.4	6.88×10^1	0.7

Effect of other parameters

As an illustrative example for optimisation, values of A_f are calculated for a few selected values of parameters and the results are discussed here. The calculations are performed for removal of particulate material by a green belt for $\alpha = 0.02\text{m}^{-1}$ and tree height varying from 10-30m. Amongst the other parameters, value of V_{dx_1} and V_{dx_2} are assumed to be equal and assigned a value of 0.0156ms^{-1} (which is the gravitational settling rate for 20 μm particle size). Similarly U_{x_1} and U_{x_2} are assumed to be the same as $U(10)$. The values of $U(10)$ & UC used in these calculations under different atmospheric stability conditions are given below.

Stability condition	:	A	B	C	D	E	F
$U_{(10)}$:	2	2	4	5.5	3	2
UC	:	0.5	0.5	0.75	1.0	0.6	0.5

Variation of A_f with X_1 and X_2

For a fixed height of tree, the value of A_f is expected to increase with increase in X_2 and with decrease in X_1 . Though it is preferable to plant the green belt as close as possible to the pollution source (i.e, low value of X_1), practical considerations may not permit very low values of X_1 . Similarly for fixed value of X_1 and X_2 , the value of A_f is greater for taller trees. The variation of A_f with X_1 and X_2 and h under different atmospheric stability conditions is discussed below.

Unstable condition, A

The variation of A_f with X_1 for a fixed value of $X_2 = 500\text{m}$ and with X_2 for a fixed value of $X_1 = 50\text{m}$ for stability condition A are given in figures 3.2 and 3.3 respectively. It can be seen from figure 3.2 that the value of A_f is close to unity even for taller trees if $X_1 = 300\text{m}$ or more. Reducing the value of X_1 is of advantage only in the case of tall trees and a value of $A_f = 6$ is obtained for 30m tall tree if X_1 is kept at 50 m.

Figure 3.2 shows that the value of A_f remains constant beyond a certain value of X_2 depending on the height of trees. This suggests that increasing the value of X_2 more than 300m does not serve any useful purpose for stability condition A for $h = 10$ to 30 m.

Stable condition, F

Figures 3.4 and 3.5 which are similar to figure 3.1 and 3.2 present the variation of A_f in stability condition F. The value of A_f , as high as 10^4 , is attainable in this stability condition (see fig - 3.4) for trees of height 15m or more for $X_2 = 500\text{m}$ and $X_1 = 50\text{m}$. This figure also shows that if the tree height is more than 25m, the value of A_f is of the same order even if X_1 is increased to 100m. Figure 3.5 shows that the value of A_f increases with X_2 upto a certain distance and thereafter the increase in A_f is not significant. This feature of more or less constant value of A_f beyond a certain distance helps in estimating the optimum width of the green belt. For the conditions considered in this example, this distance is 500, 700 and 1700m for tree heights 10, 15, and 30 m respectively.

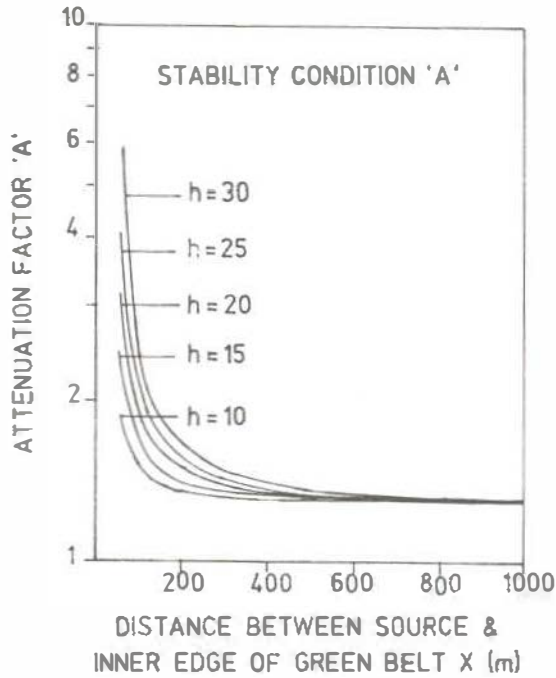


Fig. 3.2 Attenuation Factor as a Function of Distance Between the Source and Inner Edge of Green Belt and the Tree Height, for $X_1=500\text{m}$, $\lambda = 0.02\text{m}^{-1}$ and for Atmospheric Stability Condition A

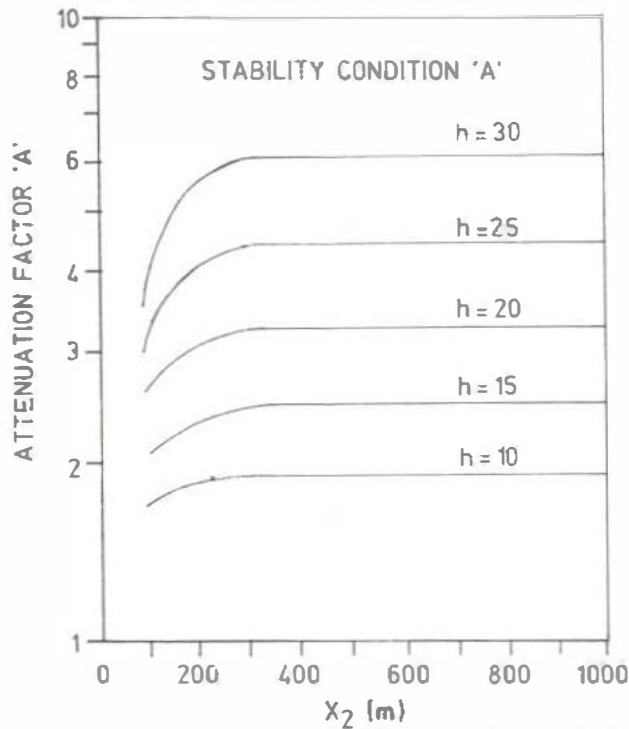


Fig. 3.3 Attenuation Factor as a Function of Width of Green Belt and the Tree Height, for $X_1=50\text{m}$, $\lambda = 0.02\text{m}^{-1}$ and for Atmospheric Stability Condition A

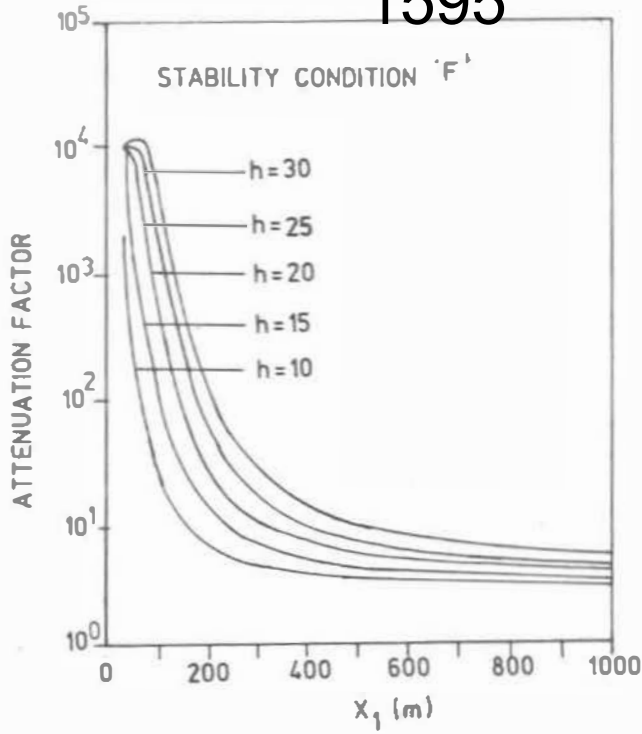


Fig. 3.4 For Atmospheric Stability Condition F

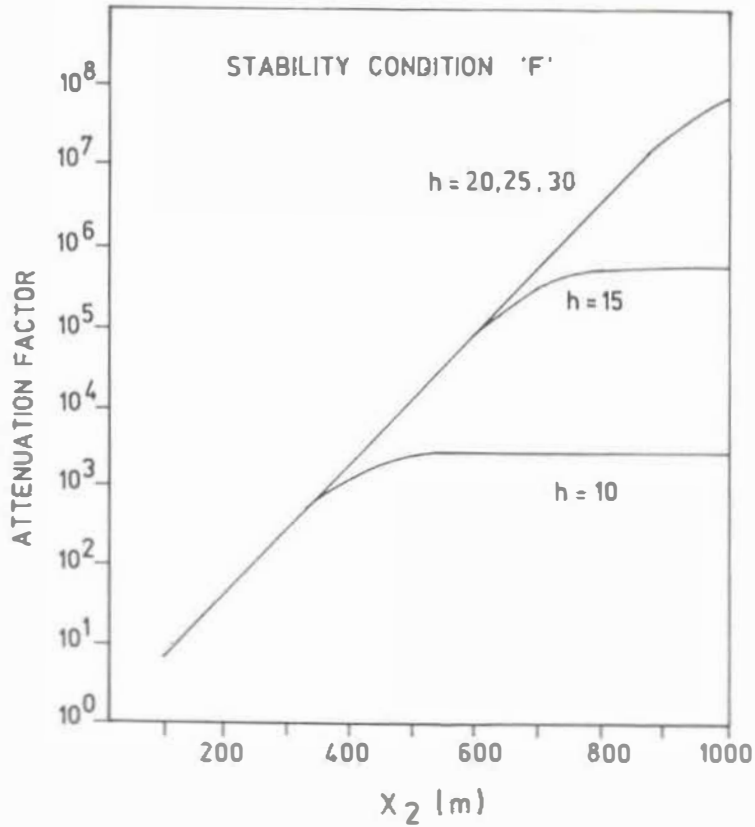


Fig. 3.5 For Atmospheric Stability Condition F

Variation in other Atmospheric stability conditions

The above discussion pertains to only two extreme atmospheric stability conditions. The values of A_f for intermediate stability conditions lie mostly in between the two extreme values (Table-3.4). It can be seen from this Table that, for 15m high trees, advantage gained by increasing the width of green belt from 500 to 1000m is not significant in all the stability conditions except for F where A_f of more than 10^4 is obtained for $X_1 = 50m$. However, if the tree height is increased to 30m, an attenuation factor of greater than 10^4 is possible in stability category E also for a green belt width of 1000m, whereas, in stability category D, the attenuation factor obtained is 600. This suggests that a green belt consisting of tall trees around an industry could provide significant attenuation factors for about 50% of the time in a year for the case considered here.

X_2 (m) (m)	h value of A_f for stability class					
	A	B	C	D	E	F
500	15	2.5	3.6	4.5	1.7×10^3	1.2×10^2 1.1×10^4
30	6.2	1.4×10^1	2.6×10^1	6.0×10^2	1.4×10^4	1.1×10^4
1000	15	2.5	3.6	4.5	1.7×10^3	1.2×10^2 5.9×10^5
30	6.2	1.5×10^1	2.6×10^1	6.0×10^2	1.1×10^5	8.2×10^7

Application of Green belt Model

The green belt model developed here is applied to two different cases for studying the usefulness of green belt in reducing the impact of pollution. Out of the two applications, one is a source oriented approach and the other is receptor oriented approach. In the source oriented approach, green belt of suitable dimension is planted around a source emitting pollution and studies are made to know the usefulness of green belt in reducing the effects of pollution for ground level releases. In the second case i.e., in the receptor oriented approach, green belt of suitable dimension is planted around an object which is getting deteriorated or likely to get deteriorated as a result of pollution in and around it and studies made to protect it against pollution. These two examples are dealt within a little more detail in the following paragraphs.

Source oriented approach

A nuclear power reactor surrounded by a suitably designed green belt provides an example of the source oriented approach.

Gupta and Kapoor (1985) analysed the consequences of a hypothetical reactor accident, in which a large, cold, ground level release of radioactive nuclides takes place in the presence of a suitably designed green belt around a nuclear power plant. The release of 54 radionuclides from a 1000MWe light water reactor was considered. These radionuclides fall into two main categories : particulates and noble gases. The deposition velocity on

vegetation for particulates was taken as 0.01 ms^{-1} and zero for noble gases (being inert in nature). The calculations considered the building wake effect (effect of stagnation of pollutants and subsequent dilution owing to alignment of surrounding structures which give rise to eddy currents) and radio - active decay as well as deposition of radionuclides in the green belt.

The radiological consequences were calculated in terms of early and continued mortalities. The radiation dose to four important body organs (viz. thyroid, lung, gastrointestinal tract, and bone marrow) of persons staying up to 100 kms from the reactor were calculated under different atmospheric stability categories. For calculation of early and continued mortality by the effect of radiation dose, the dose - mortality criteria of WASH 1400 (1975) were adopted.

The reactor accident consequences were calculated without a green belt and compared with the corresponding consequences when the reactor is surrounded by a 15m high green belt of 1500m width. The inner boundary of the green belt was taken as 50 m away from the reactor. Besides the decrease in mortality probability, the impact of green belt on reduction of other important consequences of lesser importance like relocation of population and banning of food produced in contaminated regions were also analysed. The analysis shows that, the benefits of developing a suitably designed green belt around nuclear power plants are as follows :-

- (i) The early and continued mortalities are practically eliminated beyond a distance of 3km.
- (ii) The relocation of population to protect it from long term external exposure from ground contamination may not be required.
- (iii) The supply of food from uncontaminated areas may be needed for populations living between 2 to 20 km only in the affected sector.

Since the siting requirements in many countries require exclusion distance ranging from 0.5 to 3 km from the reactor, it should be possible to develop a green belt around nuclear power plants that will substantially reduce the consequences of the accidents. The green belt would thus serve as another barrier between the nuclear power plant and the public and would strengthen the defense-in -depth philosophy adopted in the design of nuclear power plants. The assured availability of a suitably designed green belt throughout the year could also help in reducing the magnitude of emergency preparedness in the public domain.

Receptor oriented Approach

Mathematically both source and receptor oriented approach are the same, the only difference between the two is the manner in which the green belt is planted. In the source oriented approach, the green belt is planted around the pollution source, whereas in the receptor oriented approach the receptor is protected against pollution by planting a green belt around it. The case of protecting the Taj Mahal against air pollution by a green belt is presented here as an example of receptor oriented approach.

The value of the pollution attenuation factor, A_f is computed for different atmospheric

stability conditions, different heights, widths of the green belt and also for varying distances of green belt from the receptor. The results of the studies suggest that the green belt is more effective in attenuating pollution in stable atmospheric stability conditions and for smaller distance between source and green belt (X_1). Increasing the height of trees is of advantage in attenuating the pollution only for a smaller value of X_1 . Also, it is observed that increasing the width of green belt beyond 200m does not significantly increase the value of A_f , for the range of X_1 considered in the study. In general, the study indicates that, the value of A_f in the case of Taj Mahal is much smaller than that obtained by a source oriented approach. Significant values of A_f occur only for nearby ground level pollution sources and that also in stable atmospheric conditions.

Nomenclature

Symbol	Name	Unit
A_f	Pollution Attenuation Factor	Ratio
F_D	Deposition Correction Factor	Ratio
h	Physical height of green belt	m
h_e	Effective height of green belt	m
H	Pollution release height	m
K	Density of tree plantation in green belt	Ratio
Q	Mass flux of pollution	$\text{kg} \cdot \text{S}^{-1}$
U	Mean wind speed	mS^{-1}
$U_{(z)}$	Wind speed at height Z	mS^{-1}
U_c	Average wind speed through green belt	mS^{-1}
V_d	Pollutants deposition velocity	mS^{-1}
X	Travel distance	m
	Pollution Attenuation coefficient	m^{-1}
P_c	Average foliage surface area density of the green belt	m^2m^{-3}
P_t	Average foliage surface area density of a single tree	m^2m^{-3}
	Standard deviation of concentration in cross-wind direction	m
	Standard deviation of concentration in vertical direction	m
$X(x,y,z)$	Concentration of pollutant at travel distance x, Crosswind distance y and height z	$\text{kg} \cdot \text{m}^{-3}$

AGRO-CLIMATIC ZONES OF INDIA

A country of subcontinental dimensions and varied features of land and rivers, is endowed with a large number of biogeographic zones. Though there were several attempts to classify Indian vegetation types, the most commonly used classification is that by Champion (1938) with modifications. Since the accent of the present effort is on cultivation of plants, rather than on the naturally growing vegetation types, a suitable scheme recognizing bio-climates along with soil types is necessary. Carter (1954) divided India into six climatic regions, from arid to perhumid, based on Thornthwaite's system of climate classification. Krishnan (1988) identified 40 soil climatic zones based on major soil types and moisture index. Planning Commission, Government of India, New Delhi (Alagh, 1990), have recommended a scheme for agro-climatic classification of the country.

According to this scheme, there are 15 agro-climatic regions (Fig.4.1). Each of these regions is further divided into 68 sub-zones, based on detailed characteristic features, such as natural resources, typologies (land productivity level, relative pressure on land and environmental factors) etc.

Subtypes presented in the Planning Commission document further describe ranges of rainfall (Fig. 4.2), general climatic conditions and soil types (Fig. 4.3) prevailing in these regions. The emphasis here is on the development of resources and their optimum utilization in a sustainable manner within the framework of resource constraints and potentials of each region.

Under National Agricultural Research Project (NARP), a 120 sub-zone map has been prepared, based primarily on rainfall, existing cropping pattern and administrative units. More recently, using parameters such as physiography, soils, bioclimates and length of growing period, an agro-ecological map of the country (Fig. 4.4.) has been prepared. This scheme recognizes 6 regions, which are further divided into 20 sub-regions.

A sophistication to agro-climatic classification for kharif crops has been devised by Chowdhery et al,(1993), employing principal component analysis to agro-climatic variables for delineating India into homogenous zones.

During the present work, the scheme suggested by the Planning Commission has been adopted. Appendix A gives the 15 agro-climatic zones and their 68 sub-zones, for which details such as annual rainfall, climate, soil types and revenue districts covered by them, are given.

It is expected that user of this report refers to Appendix A, for identifying and locating one's area of concern, before proceeding further to the list of plants to be chosen for plantation programme.



Fig. 4.1 Agro Climatic Zones

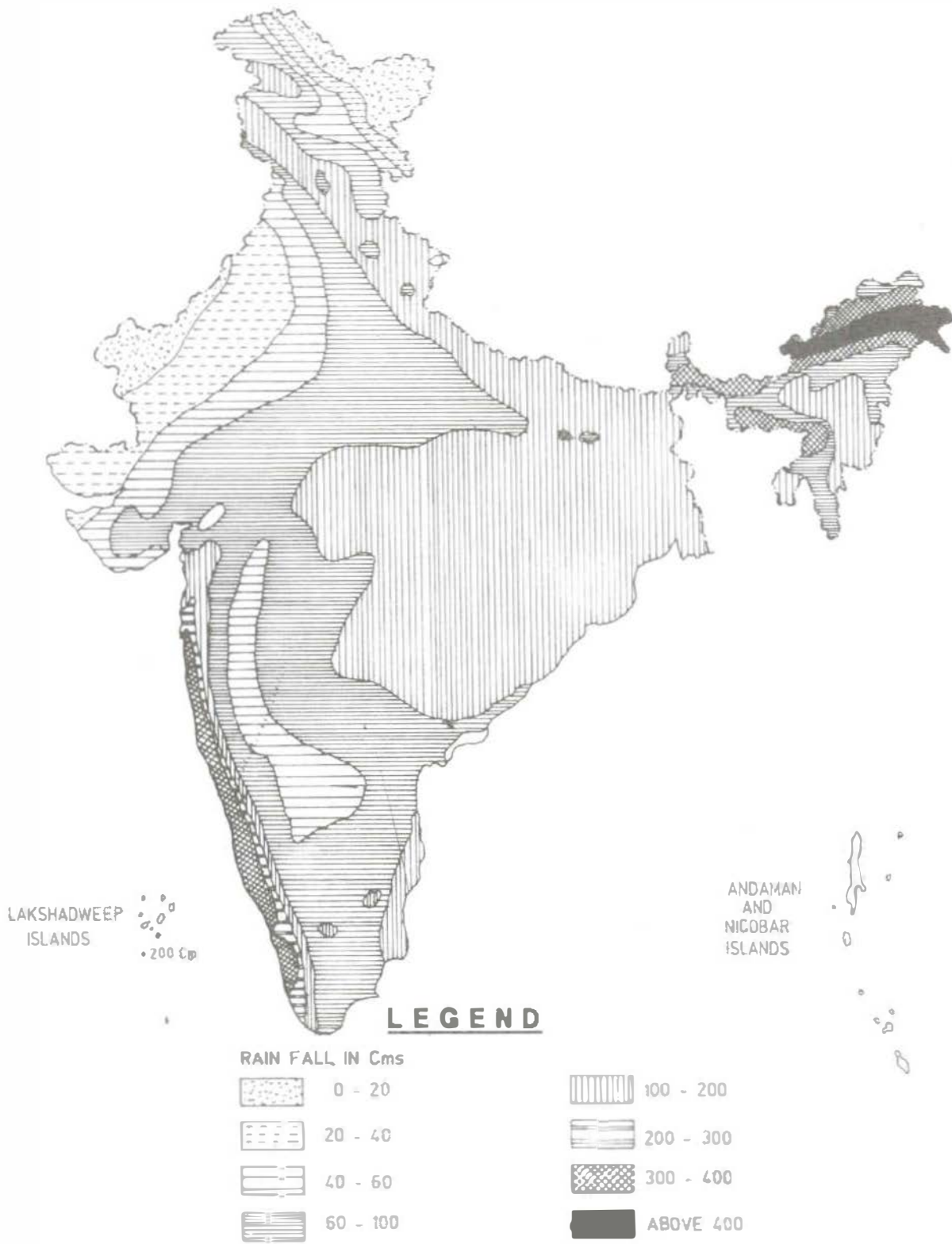
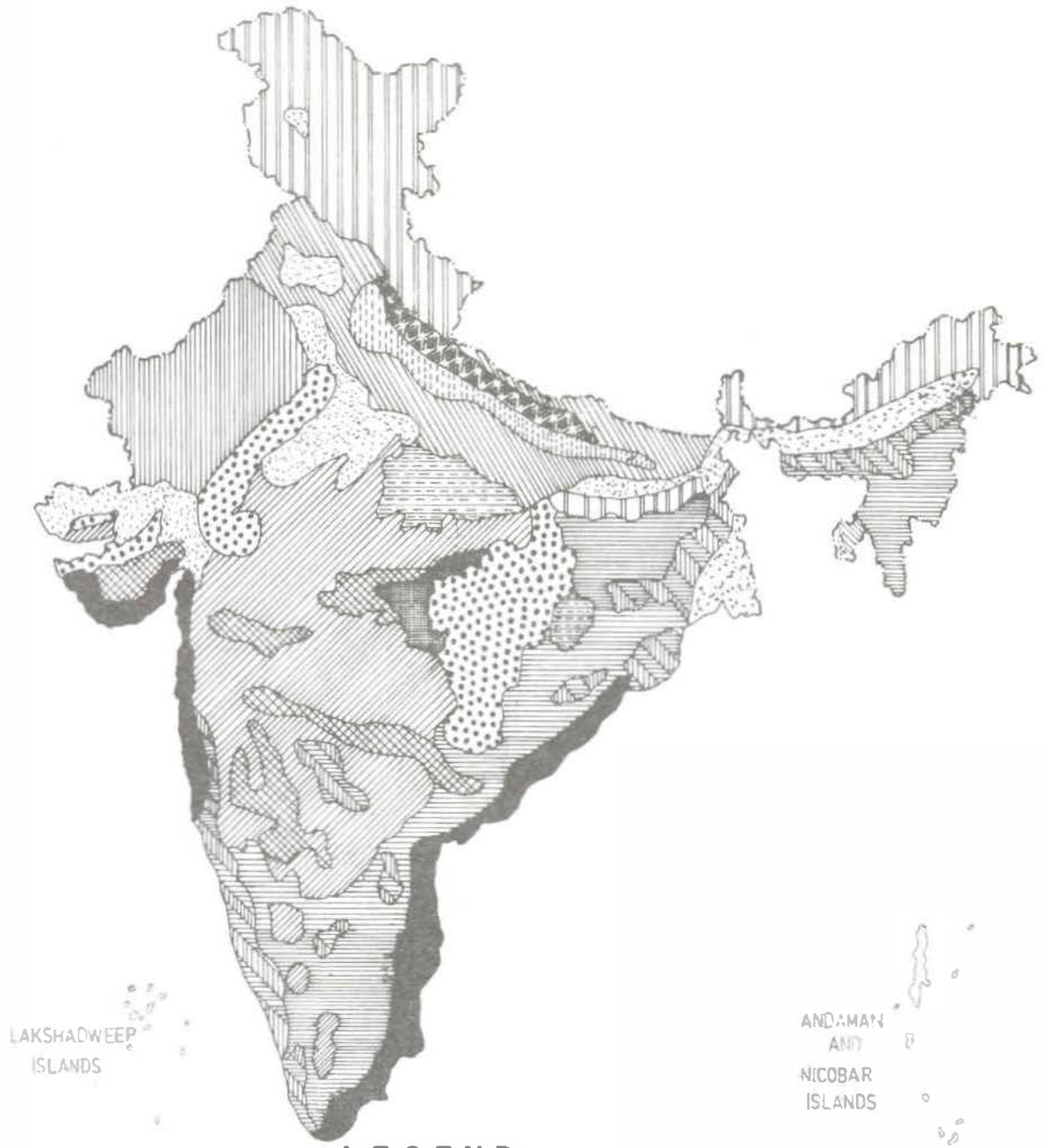


Fig. 4.2 Annual Rainfall



LAKSHADWEEP ISLANDS

ANDAMAN AND NICOBAR ISLANDS

SOILS TYPES

LEGEND

- | | |
|---|--|
|  ALLUVIAL SOILS |  DESERT SOILS |
|  COASTAL ALLUVIAL |  LATERITE SOILS |
|  GRAY AND BROWN |  RED LOAM |
|  GANGETIC ALLUVIAL |  FOREST AND HILL SOILS |
|  DEEP BLACK OR REGUR |  RED AND YELLOW |
|  MEDIUM BLACK SOILS |  SHALLOW BLACK |
|  MIX RED AND BLACK |  FOOT HILL SWAMPY |

Fig. 4.3 Soils

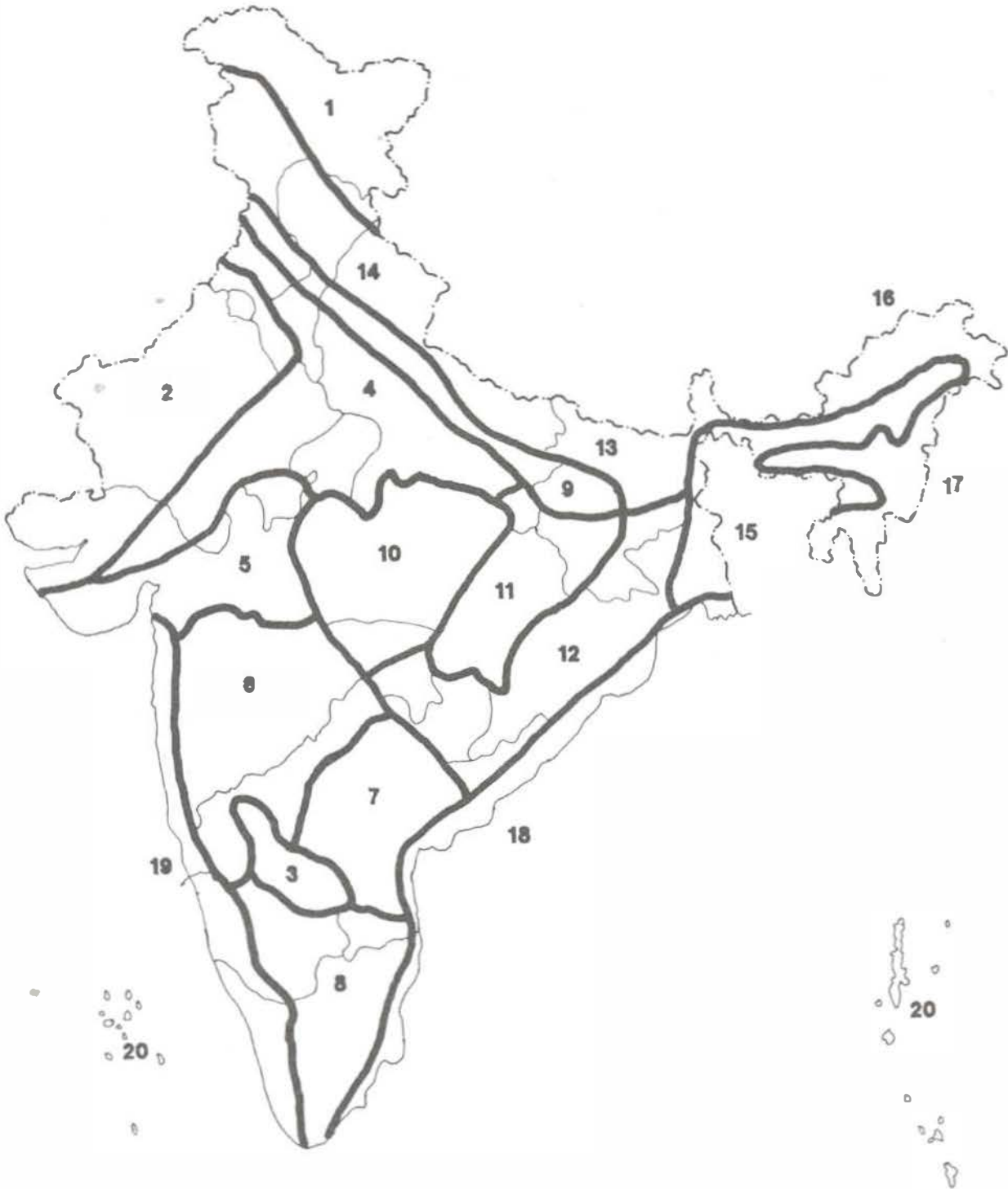


Fig. 4.4 Agro-Economical Regions

SELECTION OF PLANTS FOR GREEN BELTS

Discussion in earlier chapters indicate the nature of plant-air pollutant interactions and sensitivity indicated by plants. It also brings out the limitations under which plants are to function as scavengers of air pollutants. Other limitations for growing plants are the climatic conditions and soil characters. Of these, the latter get modified when plants are cultivated and grown under care, e.g. A standard horticultural practice involves planting of saplings in pits of substantial dimensions, i.e. 1m x 1m x 1m for big trees and almost half of these dimensions for smaller trees and shrubs. The pits are then filled with earth, sand, silt and manure in pre-determined proportions. Saplings planted in such pits are watered liberally. The growing plants are then cared for the first three years, or for at least two years under favourable conditions of climate and drainage. Nutrients in pits are supplemented and the juveniles provided protection. Hence, it is safe to assume that trees and bushes grown as green belt components in areas under human control, will have overcome the limitations imposed by soil characters to a great extent. Limitations imposed by climatic conditions on the other hand, cannot be overcome and hence will have to be taken into account while selecting species for plantation in different bio-climatic conditions.

While making choice of plant species for cultivation in green belts, weightage has to be given to the natural factor of bio-climate. It is also presumed that the selected plants will be grown as per normal horticultural (or forestry) practice given above and authorities responsible for plantation, will also make adequate provisions for watering and protection of the saplings.

For effective removal of pollutants, it is necessary that (1) plants grow under conditions of adequate nutritional supply (for health and vigour of growth), (2) absence of water stress (to maintain openness of stomatal apertures and form of epidermal structures), and (3) are well-exposed to atmospheric conditions of light and breeze (i.e. away from engineering structures hindering free flow of air) to maintain free interaction with gases.

Characters of plants including shapes of crowns (Fig.5-1) considered necessary for effecting absorption of pollutant gases and removal of dust particles are as follows :

For absorption of gases

- 1) Tolerance towards pollutants in question, at concentrations, that are not too high to be instantaneously lethal),
- 2) Longer duration of foliage,
- 3) Freely exposed foliage, through
 - a. Adequate height of crown,
 - b. Openness of foliage in canopy,
 - c. Big leaves (long and broad laminar surfaces),

- d. Large number of stomatal apertures,
- e. Stomata well-exposed (in level with the general epidermal surface).

For removal of suspended particulate matter

1. Height and spread of crown,
2. Leaves supported on firm petioles,
3. Abundance of surfaces on bark and foliage, through
 - a. Roughness of bark,
 - b. Epidermal outgrowths on petioles,
 - c. Abundance of axillary hairs,
 - d. Hairs or scales on laminar surfaces,
 - e. Stomata protected (by wax, arches/rings, hairs, etc.).

Note : All tolerant plants are not necessarily good for green belts. e.g. Xerophytes with sunken stomata can withstand pollution by avoidance but are poor absorbers of pollutants due to low gaseous exchange capacity.

It is unrealistic to expect, barring exceptions, that atmosphere in an industrial area will constitute only one species of air pollutant. More commonly, one comes across several pollutants, especially SO₂, NO₂ and oxidants, and SPM and also HF in the same region. It will hence be advisable to choose for cultivation of a green belt anywhere, plant species capable of sorption of chemicals as well as dust pollutants. Combined efficiency of a variety of species should contribute to reach the goals of green belts.

Models for Attenuation Coefficients given in chapter Three provide guidelines for positioning of plants with reference to particulate emission source at ground level. Width of the belt as presented by the model, may prove difficult for many industries to attain, for one or more reasons. Hence, it becomes necessary to decide to have green belts in places available around the industry (source-oriented plantation) as well as around habitats (receptor-oriented plantation). Lists of plants given in Appendix-C should be seen from this angle for selection of species combinations, in conformity with bioclimatic attributes of respective regions.

Plantation along Roadsides

Automobiles may be considered as ground level, mobile sources of pollution of both types - gaseous as well as particulate. Components of green belts on roadsides hence, should be both absorbers of gases as well as of dust particles, including even lead particulates. Sorption of the latter type has been estimated by Joshi (1990) who found high levels of lead sorption on ornamentals cultivated in traffic islands. Choice of plants for roadside (and traffic island) plantations may be for containment of pollution and for formation of a screen between traffic and roadside residences. This choice of plants should include shrubs of height 1 to 1.5 m and tree of 3 to 5 m height. The intermixing of trees and shrubs should be such that the foliage area density in vertical is almost uniform. A green belt of such a design and having a width of 30 to 50 m will give a pollution attenuation factor of 2 to 100 for unsuitable to plants atmospheric conditions. Thus medium-sized and small

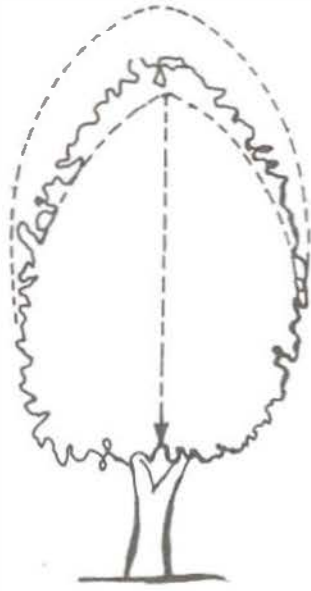
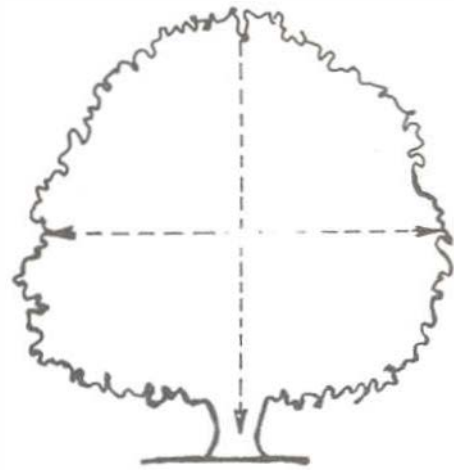
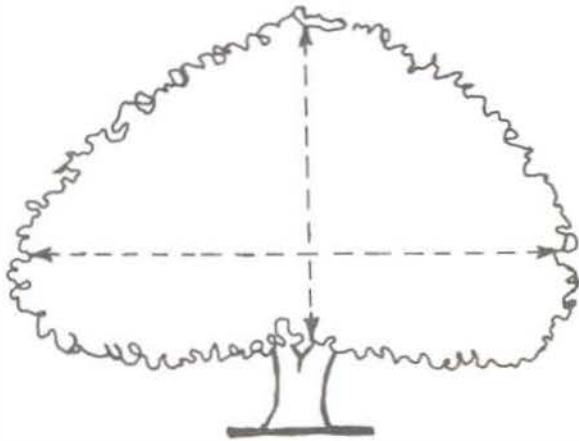
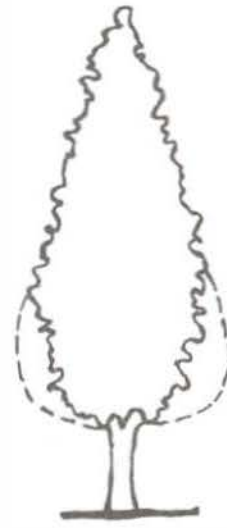
trees alternating with shrubs, aimed at sorption of particulates and gases, will be suitable here. Since safety of traffic is a major consideration, shrubs in traffic islands and along road-dividers will have to be short enough to be below the eye-level of motorists. An ideal design for roadside green belt is presented in Fig.5.2. Still, it is necessary to emphasize that each traffic island has its own character and needs to be studied separately for designing its green belt.

A comprehensive list of plants recommended for green belts in the country is presented in Appendix-B. The list consists of latin and common names of plants, natural order to which they belong and a number of relevant characteristic features, viz. tolerance or otherwise towards air pollution, habit, growth rate, flowering phenology, crown shape and approximate surface area, etc.

The list is not complete in itself. Several more species could be added to it. Criteria for inclusion of species in this list include availability, knowledge about their horticultural aspects, particularly propagation methods and growth rates and (sometimes) observed or reported information about their tolerance to air pollution. Numerous species, indigenous to certain regions, may also be included wherever possible. In extreme areas (e.g. where stresses due to water, salinity, salt-sprays, etc. are acute) only tolerant species should be chosen. Appendix C provides lists of plants recommended for cultivation in the six agro-climatic zones and their subzones.

The shapes given here are for convenience only. Many crown shapes range between those identified following, viz. Oblong-Round, Round-Spreading, Conical-Oblong, etc. Some shapes also change with age or environmental stresses.

Fig.5.1 TREE CANOPY SHAPES

**OBLONG****ROUND****SPREADING****CONICAL**

The shapes given here are for convenience only. Many crown shapes range between those identified following, viz. Oblong-Round, Round-Spreading, Conical-Oblong, etc. Some shapes also change with age or environmental stresses.

FIG. 5.1 TREE CANOPY SHAPES

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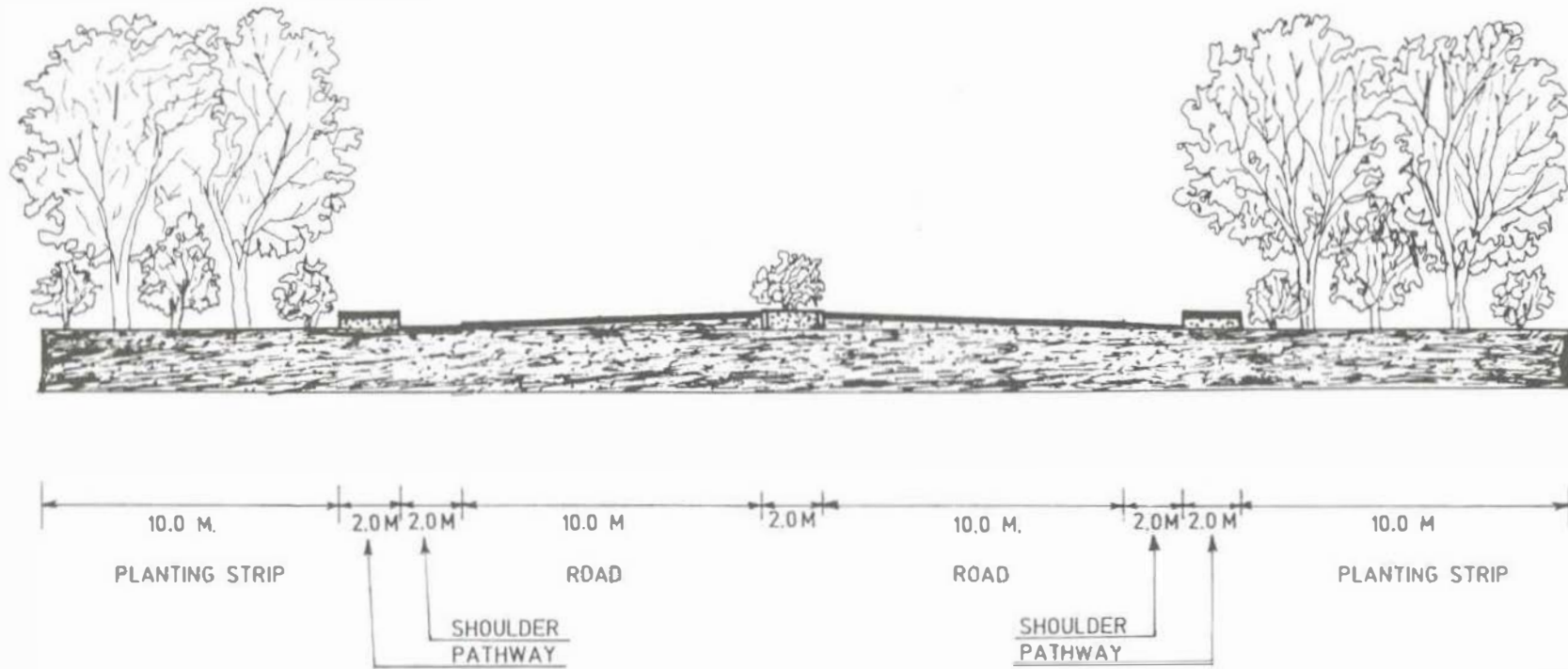


FIG. 5.2 TYPICAL ROAD-SIDE PLANTATION

STABILIZATION OF FLY - ASH WITH PLANTS

Introduction

Of all the sources of non-muscular energy, coal is the most abundant one (Tandon, 1989). Total stocks of coal in India are 1,70,460.54 million tons of which 49,376.28 million tons are proven ones. Compared to oil and natural gas reserves (16,000 mt potential), coal stocks are more long-lasting and hence more reliable for exploitation. Hydropower is clean but creates other environmental problems through construction of large impoundments. Moreover, most of the hydropower potential in India has already been harnessed, leaving very little scope for further expansion to meet increasing demands of times. Nuclear power potential is vast. Presently meeting only a fraction of countries energy needs. Energy from fusion may provide an answer, when it becomes available on commercial scale, at the required magnitude. By all accounts then, we have to resort to coal for energy production till other power sources can be harnessed satisfactorily.

Environmental hazards of utilization of coal

Of all the fossil fuels, coal is the dirtiest one. All the way - from coal mine to ash dumps, this fuel poses environmental hazards in one or another form. Acidic drainage from coal mines and pit-head dumps are reported repeatedly by several workers (Bradshaw and Chadwick, 1980). Fugitive dust escaping along coal transportation channels, from pit-heads to power plants and at the time of loading - unloading operations has also been observed (Rao, 1971). Once at power plants, every stage of coal utilization creates a different environmental hazard.

Coal arriving in power plant premises is tipped from railway wagons or from conveyors. The tipping and storage areas are the ones where fugitive coal-dust escapes in the immediate neighbourhood, especially when these operations take place in the open, under dry-weather conditions.

Crushing of coal and conveyance of fine coal to furnaces is the next stage of fugitive dust emission. Combustion of coal for energy production then takes place, where generation of ash and pollutant gases takes place. A substantial amount of energy also escapes at the same time. Under the present technological scenario, a large proportion of all the three are captured and sought to be nullified, detoxified or ameliorated, from environmental point of view. Considering the magnitude of energy production however, even small proportion of the pollutant output proves to be a major environmental hazard. e.g. A 500 MW TPP using Indian coal (0.5% S, 40% mineral matter) generates 3537 tons of ash, 76 tons of SO₂, every day of its full capacity working. Pollution abatement measures of good capacities (99.8% in respect of dust capture) still permit around 884 g SO₂ and 66 g dust to emit from the high stack, every second. Ash captured before emission from stacks is deposited in pits, valleys or even on flat grounds. It finds its way in air by wind erosion and in water bodies by surface run off. Where deposited, the land by itself is unfit for any primary production process.

Covering of ash dumps

The large proportion of ash (40-47% in Indian coals) is conveyed to deposition areas in pipelines in the form of slurry. Receiving grounds are valleys, flat-lands or pits dug for the purpose. On decantation, or after infiltration of water into the ground, the ash stands exposed to elements - winds and rains. Ash gets blown on winds to get deposited downwind on croplands or on other types of vegetation, smother plants and affects yields (Rao, 1971; Bradshaw and Chadwick, 1980). Ash carried by run-off water forms sediments in nearby waterways causing turbidity problems for aquatic organisms, reduces water quality for drinking or even for irrigation. Cases of accumulation of toxic heavy metals in sediments of rivers are also reported (Evans and Geisey, 1979). Stabilization of ash deposits, hence, is always an urgent necessity.

Examples of successful stabilization of ash dumps and covering the same with plants can be cited (Bradshaw and Chadwick, 1980). Use of stabilized grounds formed by ash deposits for agricultural production has also been done.

The picture in India however, is far from encouraging so far. Though attempts appear to have been made for covering ash by plants, failure of the same was seen in the form of 2-3 year old plants getting chlorotic, bronzed or copper coloured and eventually dyeing. In one reasonably successful operation, where a variety of trees grew successfully for 5-6 years without soil amendments (as reported by the staff), two drawbacks were observed - i) the tall trees (about 4-5 m in height) had started lodging and ii) ash between tree bases had blown away. It is hence necessary to emphasize that a holistic approach to the problem of ash stabilization is desirable. Location of ash dump 'vis a vis' other land-uses in the vicinity, landscaping of the dump, stabilization, detoxification and utilization of the ground created for productive and other purposes should be planned meticulously and simultaneously. The planning process obviously should involve many disciplines. The following suggestions are a part of the planning operation, with a stress on plantation. The suggestions are based on i) experience of countries where productive lands have been formed after ash deposition and ii) working with much more toxic and hazardous tailings with comparable physical properties, from zinc-lead, mines (Chaphekar 1989).

Suggested procedure for Plantation

Fly ash is deficient in plant nutrients like nitrogen and sometimes phosphorus and other minerals and contains toxic metals like copper, cadmium, cobalt, chromium, manganese, molybdenum, nickel, lead, zinc and boron (Tables 6.1 and 6.2). Amendment of ash with nutrients and agents to arrest toxicants are essential for covering it with plants. Some suitable and inexpensive soil additives are given in Table 6.3, along with their properties. Nutrient contents of some commonly used organic manures are given in Table 6.4.

Mixing of farmyard manure (FYM) in 1:4 proportion should serve well as was found with zinc mine tailings (Chaphekar, et al., 1986). For growing grasses, this mix need be in the top soil (upto 15 cm) only, while for tree saplings, pits of suitable dimensions (60x60x60 or 90x90x90 cm) are required with similar mixtures. Watering regimes depend upon local climatic conditions, though in initial stages regular watering - daily for grass and 2-3 times a week for trees is a must.

Nothing compares favourably with the capacity of carpet forming grasses in holding soil in its place, e.g. *Cynodon dactylon* has conservation value index (CVI) of 94% (Ambasht, 1970). Cultivation of grasses with spreading habit stabilizes the ash surface effectively. Grasses with high turnover rate of shoots contribute substantially to the organic enrichment of the otherwise nutrient-poor silty ash. Weathered ash is reported to be substantially less toxic than the freshly deposited ash (Bradshaw & Chedwick, 1980). Cultivation of herbaceous legumes enriches the substratum with nitrogen. The stabilized ash then forms suitable ground for other planned utilities like woodland, fuel or fruit-yielding trees, etc. Tables 6.5 (Jha & Singh, 1994) and 6.6 give lists of plants considered suitable for growing on ash dumps for their stabilization. The plants listed are grasses, legumes and MPTs (multi-purpose trees) forming a comprehensive agroforestry system. Possibilities for development of different amenities are numerous, including parks for recreational or educational purposes. Testing of edible parts of plants for toxic heavy metal contents would help decision-making for deriving agricultural yield from stabilized ash dumps. Experience derived after practicing stabilization efforts along suggested lines, would prove valuable as guidelines for further efforts.

Precautions

There are several variables in the environment and the types in inputs leading to pollution stress. Major variation is in the set of biogeographical conditions - especially climate and topography, as a result of which corresponding modifications in planting strategies become necessary. A large variety of local (climatically adapted) plant species need to be tried in different regions of the country. In case of failure of any of the species to respond as expected, a thorough investigation (even post-mortem) into the causes of failures, is called for. Such investigations provide guidelines for corrective measures and modifications in plans.

Another important aspect of ameliorative action is evaluation of action taken. Minor drawbacks in execution of plans tend to get amplified with passage of time. Continuous monitoring of plant growth, immediate replacement of casualties, supplementation of nutrients, rescheduling of watering regimes, etc. are important.

Table 6.1 Chemical Composition of Fly-ash

Element	Concentration (Values in %)	Element	Concentration (Values in ppm)
Si	51.94	Co	21
Na	0.49	Ni	86
K	0.60	Cu	68
Mg	0.29	Mo	50
Ca	1.38	Zn	72
Fe	6.13	Cd	5
Al	23.94	As	36
P	0.22		

(Source: D.N.Rao, M.Agrawal, J.Singh, 1990)

Table 6.2 Concentration of Elements in Typical Indian Coal And Fly-Ash Samples

Elements	Concentration in ppm	
	Coal	Fly Ash
Na	300	1300
K	2075	18275
La	47.6	238
Ce	30.2	145
Hg	11.0	48
Pb	1.8	8.1
Th	5.3	25
Cr	62.8	404
Hf	7.1	32.6
Sc	22.9	106
Zn	540	2027
Fe	20890	106670
Ta	1.5	5.1
Co	33.4	128
Eu	1.0	5.6
Sm	0.065	2.29
Au	0.14	0.69

(Source : M.H.Fulekar & J.M.Dave, 1990)

Table 6.3 Soil additives and their properties

Material	pH	Durability	C:N	Application to soil tons ha ⁻¹		
				(a)	(b)	(c)
Hay	5.5	1 season	25:1	2	3	4
Manure	6.6	6-12 months	25:1	15	30	40
Sawdust	3.5-7.0	3-5 years	200:1 to 500:1	1	5	10
Leaves (composted)	6.5	1 season	40:1	3	4	5
Refuse	7.5	1 season	45:1 to 55:1	20	-	-
Compost	8.5					

(a) While seeding, (b) for erosion control, (c) around already established plants.

(Source : Bradshaw and Chadwick, 1980)

Table 6.4 Nutrient contents of some types of organic manures

Manure type	Nutrient contents %			Organic matter %
	N	P	K	
Farm yard manure	0.62	0.13	0.49	24
Pig slurry	0.21	0.10	0.18	5
Poultry manure	2.30	0.90	0.65	65
Sewage sludge	1.82	0.43	0.46	39
Mushroom compost	2.80	0.20	0.80	65
Domestic refuse	0.50	0.20	0.30	65
Straw	0.48	1.62	0.85	95

(Source : Juwarkar. et al., 1989).

Table 6.5 Suggested Multi-Purpose Trees (MPTs) Suitable for Revegetation of Mine Spoils and Degraded Habitats

Acacia catechu
Acacia nilotica
Acacia tortilis
Albizia lebeck
Albizia procera
Azadirachta indica
Casuarina equisetifolia
Dalbergia sissoo
Dendrocalamus strictus
Dichrostachys cinerea
Gmelina arborea
Holarrhena antidysenterica
Holoptelia integrifolia
Leucaena leucocephala
Madhuca indica
Melia azaderach
Phyllanthus emblica
Pongamia pinnata
Prosopis cineraria
Sesbania aegyptiaca
Shorea robusta
Syzygium cumini
Tamarindus indica
Tectona grandis
Terminalia arjuna
Terminalia bellerica
Zizyphus mauritiana

Adapted from (A.K. Jha & J.S.Singh. 1994)

Table 6.6 List of Grasses, Legumes And Multi-purpose Trees (MPTs) Suggested For Cultivation for Stabilization of Fly-Ash

Grasses

Bothriochloa intermedia
 Bothriochloa pertus
 Brachiaria mutica
 Cenchrus setigerus
 Chloris gayana
 Chrysopogon fulvus
 Cynodon dactylon
 Echinochloa colona
 Eragrostis cynosuroides
 Heteropogon contortus
 Paspalidium geminatum
 Sacharum bengalense
 Sehima nervosum
 Sporobolus airoides
 Sporobolus coromendelines

Herbaceous Legumes

Cajanus cajan
 Crotalaria juncea
 Crotalaria burhia
 Desmodium triflorum
 Medicago sativa
 Phaseolus mungo
 Stylosanthes hamata

Trees

Acacia albida
 Acacia auriculiformis
 Acacia catechu
 Acacia holosericea
 Acacia nilotica
 Acacia senegal
 Albizia amara
 Albizia lebbeck
 Azadirachta indica
 Dalbergia sissoo
 Eucalyptus hybrid
 Erythrina variegata
 Gliricidia sepium
 Grewia tenax
 Hardwickia binata
 Leucaena latisiliqua
 Pithecellobium dulce
 Zizyphus nummularia

(Source : A.K. Jha & J.S. Singh, 1994)

**Bioclimatic Zones of India Inclusive of Soil Types and Revenue Districts
I. Western Himalayan Region**

S. No.	Sub Zone	Rainfall (mm)	Climate	Soils	Districts
1.	High altitude temperate	165	Humid to cold arid	Hill soil mountain meadow, skeletal Tarai.	Chilas, Gilgit, Gilgit Wazarat, Jammu, Kashmir North (Baramula) Kashmir South (Anantnag, Pulwama, Srinagar, Badgam) Kathua, Ladakh (Kargil, Ladakh.) Mirpar, Muzaffarabad (Kupwara.) Poonch, Riasi (Rajauri) Tribal territory. Udampur (Udampur Doda) (J and K)
2.	Hill temperate	2000	Humid	Brown Hill	Bilaspur, Chamba Hamirpur, Kangra, Kinnaur, Kullu, Lahul and Spiti Mandi, Shimla Sirmour, Solan, Una (H.P)
3.	Valley temperate	400	sub Humid	sub Mountain, Mountain, Meadow, Skeletal	Chamoil, Dehra Dun Garhwal, Tehri Garhwal Pithoragarh, Almora, Nainital, Uttarkashi
4.	Sub-tropical	1030	Semi-arid to humid	Alluvial (Recent) Brown Hills	

II. Eastern Himalayan Region

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Himalayan Hills	2641	Perhumid to humid	Brown Hills	Darjeeling (W.B.) East sikkim, North Sikkim, South sikkim, West sikkim.
2.	NE, Hills	3528	Per humid to humid	Red sandy Laterite	Karbi Anglong, North Cachar Hills (Assam) Dibang valley, East Kameng, East Siang, Lohit, Lower Subansiri Tirap, Upper Subansiri, West Kameng (Tawang), West Siang (Ar.P) East Garo Hills, East Khasi Hills, Jaintia Hills, West Garo Hills, West Khasi Hills (Meghalaya) Kohima, Mok's kohung, Mon, Phek, Tuensong, Wokha, Zunhebota (Nagaland)
3.	Southern Hill	2052	Per humid to humid	Acidic soil	Bishnupur (Central Manipur) Churachandpur (South Manipur) Imphal (Central Manipur) Senapati (North Manipur) Tamenglong (West Manipur) Chandel (Tengnoupal) Thoubal (Central Manipur) Ukhrlul (East Manipur) North Tripura, South Tripura, West Tripura, Aizwal, Chhingtupui Lunmglei (Mizoram)

(Contd.....)

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
4.	Lower	1840	Per humid to humid	Alluvial Red loamy	Barpeta Dhubri, Darrang, Goalpara, Kaprup (Nalbari), Kokrajhar (Nagoan), Sonitpur Nowgong (Assam)
5.	Upper	2809	Humid to per Humid	Alluvial Red Loamy	Dibrugarh, Karbi Anglong, Jorhat, Karimgani, Lakhimpur, Sibsagar (Golaghat), Cachar (Silchar, Pragiyotishpur) (Assam), Jalpaiguti Koch Bihar (W.B.)

III. Lower Gangetic Plains (West Bengal)

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Barind Plains	1587	Moist sub humid and dry sub humid	Red and yellow alluvial	Mallah West Dinajpur
2.	Central Alluvial Plains	1449	Moist sub humid to dry sub humid	Red and yellow Deltaic Alluvium, Red Loamy	Bardhaman Haora, Hugli Medinipur (E&W) Murshidabad, Nadia
3.	Alluvial Coastal Saline Plains	1607	Dry sub humid to moist sub humid	Red and yellow deltaic Alluvial	Calcutta, Twenty Four Paragans (North and South)
4.	Rarh Plains	1302	Moist sub humid to Dry sub humid	Red and yellow red loamy	Bankura Birbham.

IV. Middle Gangetic Plains

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	North West Alluvial	1211	Moist sub humid to dry sub humid	Alluvial calcareous	Azamgarh, Bahraich, Ballia Basti, Faizabad, Gazipur, Gonda, Gorakhpur, Jaunpur, Mirzapur, Deoria, Varanasi (U.P.)
2.	North East Alluvial	1470	Dry Sub humid to Moist sub humid	Alluvial tatal	Aurangabad, Begusarai, Bhagalpur, Bhojpur, Darbhanga, Gaya, Gopalganj, Katihar, Khagaria, Madhepura, Mudhubani, Munger, Muzzaffarpur, Nalanda, Nawada, Poschim Champaran, Patna, Purba Champaran, Purnia, Rohtas, Saharsa, amsatipur, Saran, Sitamarhi, Siwan. Vaishali (Bihar)

V. Upper Gangetic Plainns (Uttar Pradesh)

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Central Plains	979	Dry sub humid to semi arid	Alluvial	Allahabad, Bara banki, Fatehpur, Hardoi, Kheri Lucknow, Pilibhit, Rae Bareli, Sitapur, Sultanpur, Unnao, Partapgarh
2.	North Western Plains	907	Dry sub humid to semi arid	Alluvial tarai	Bareilly, Bijmor Bulandshahar, Gaziabad, Meerut, Moradabad, Muzaffarnagar, Rampur, Saharanpur, Shahjahanpur
3.	South Western Plains	721	Semi arid	Alluvial	Agra, Aligarh, Badam Etah, Etawah, Farukhabad, Kanpur (Rural), Kanpur (Urban) Manipur, Mathura

VI. Trans Gangetic Plains

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Foot hills of Shivalik and Himalayas	890	Semi-arid to dry sub-humid	Alluvial (Recent) Calcareous	Gurdaspur, Hoshiarpur Rupnagar (Punjab) Ambala, Chandigarh (Haryana)
2.	Plains	561	Semi arid to dry sub humid	Alluvial (Recent) Calcareous	Amritsar, Jalandhar Kapurthala, Ludhiana, Patiala (Punjab), Faridabad, Gurgaon, Jind, Karnal, Kurukshetra, Rohtak, Sonapat (Haryana) Delhi
3.	Scarce Rainfall arid zone	360	Arid and Extreme arid	Calcareous Sierozemic Alluvial (Recent) Desert	Bathinda, Faridkot, Ferozpur, Sangrur (Punjab), Bhiwani, Hisar, Mahendragarh Sirsa (Haryana) Ganganagar (Rajasthan)

VII. Eastern Plateau and Hills

S. No.	Sub Zone	Rainfall (mm)	Climate	Soils	Districts
1.	Eastern Plain	1271	Dry sub humid	Medium to deep black red and yellow	Bolanagar, Dhenkanal Sambalpur (Orissa) Balaghat, Bilaspur, Durg, Raipur, Raj Nandgaon (M.P.) Bhandara, Chandrapur Garchiroli (Maharashtra)
2.	Eastern Highland	1436	Moist sub humid to dry sub-humid	Red sandy, Red and Yellow	Keonjhar, Mayurbhanj Sundargarh (Orissa) Rajgarh, Surguja, Shahdol (M.P.)
3.	North Central Plateau	1296	Moist sub humid to dry sub-humid	Red sandy Red and Yellow	Deogarh, Dhanbad, Giridih, Godda, Hazaribag, Sahibganj, Santhal Pargana (Dumka) (Bihar)
4.	Eastern Plateau	1369	Moist sub humid to dry sub humid	Red and Yellow, Red loamy	Puruliya (W.B.) Lahardaga, Palamau Ranchi, Singhbhum (Bihar)
5.	Tribal	1338	Moist sub humid to dry sub humid	Red sandy Red and Yellow, Red loamy	Kalahandi, Koraput Phulbani (Orissa) Bastar (M.P.)

VIII. Central Plateau and Hills

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Bundelkhand	780	Dry sub humid to dry arid	Mixed red and black	Banda, Jalaun, Jhansi, Lalitpur, Hamirpur(U.R.)
2.	Bundelkhand (M.P.)	700	Dry sub humid to semi arid	Mixed red and black	Chhatarpur, Datia, Tikamgarh (M.P.)
3.	North Hills	1570	Moist sub humid to dry sub humid	Red and Yellow	Mandla (M.P.)
4.	Kymore Plateau and Satpura Hills	1100	Dry sub humid	Red & Yellow Medium black	Jabalpur, Panna, Rewa, Satna, Seoni, Sidhi (M.P.)
5.	Vindhya Plateau	1130	Dry sub humid	Medium black	Bhopal, Damoh, Raisen, Sagar, Sehore, Vidisha (M.P.)
6.	Satpura	1220	Dry sub humid	Shallow black Mixed Red and black	Chhindwara, Betul (M.P.)
7.	Central Narmada vally	1300	Dry sub humid	Deep black skeletal	Hoshangabad, Narsimhapur (M.P.)
8.	Gird	670	Semi arid (half drier)	Medium black, Alluvial	Bhind, Guna, Gwalior, Morena (M.P.)
9.	South eastern Plains	760	Semi arid (half drier and water half)	Medium black	Bundi, Kota (Rajasthan)
10.	Southern Plains	760	Semi arid (Water half)	Medium red and grey, brown	Banswara, Dungarpur (Rajasthan)
11.	Transitional Plains	490	Semi arid to arid	Desert soil Grey brown	Pali, Sirohi (Rajasthan)
12.	Southern Plains Aravalli Hills	500	Semi arid (Water Half)	Red and Yellow Grey brown	Bhilwara, Chandigarh, Udaipur (Rajasthan)

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
13.	Semi-arid Eastern Plains	500	Semi arid (drier half)	Alluvial	Ajmet, Jaipur, Tonk (Rajasthan)
14.	Flood Prone Eastern Plains	500	Semi arid (Drier half)	Alluvial (Recent)	Alwar, Bharatpur, Sawai Madhopur, Dhaulpur (Rajasthan)

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Hill zone	988	Semi-arid	Medium to deep black Shallow red Red loamy	Kalhapur, Nasik, Pune, Satara (Maharashtra) Jhabua (M.P.)
2.	Scarcity zone	602	Semi-arid	Medium black, deep black	Ahmednagar, Dhule, Sangli, Sholapur (Maharashtra)
3.	Plateau zone North	874	Semi-arid (Eetter half)	Medium black, deep black, Mixed red & black Shallow red	Akola, Amaravati, Aurangabad, Beed, Buldana, Jalgaon, Jalana, Latur, Osmanabad, Parbhani (Maharashtra) Dewas, Dhar, East Nimar, Indore, Mandsaur, Rajgarh, Ratlam, Shajapur, Ujjain, West Nimar (M.P.) Jhalawar (Rajasthan)
4.	Plateau zone South	1040	Semi-arid to dry sub humid	Medium black, Shallow, black	Nagpur, Nanded, Warsha, Yavatma (Maharashtra)

X. Southern Plateau and Hills Region

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Sub zone-1	769	Semi-arid & arid	Medium black, Laterite deep black, Red loamy	Belgaum, Ballary, Bidar, Bijapur, Dharwad, Gulbarga, Raichur (Karnataka)
2.	Sub zone-2	677	Semi-arid	Red loamy medium black, Red sandy, coastal alluvium, laterite	Anantpur, Chittor, Cuddapah, Kurnool (A.P.) Bangalore, Chitradurga, Kolar, Tumkur (Karnataka)
3.	Sub zone-3	725	Semi-arid & arid	Red sandy, Medium to deeo black	Hyderabad, Mahbubnagar, Nalgonda, Rangareddi (A.P.)
4.	Sub zone-4	1001	Semi-arid (Wetter hatf)	Deep black, Medium black	Adilabad, Karimnagar, Khammam, Medak, Nizamabad, Warangal (A.P.)
5.	Sub zone-5	865	Semi-arid	Red loamy, Red sandy	Mandya, Mysore (Karnataka) Dharmapuri (Tamilnadu) Hasan (Karnataka)
6.	Sub zone-6	841	Semi-arid to dry sub humid	Mixed red & black red loamy, Deltaic alluvium	Coimbatore, Madurai (Anna) Tiruchirapalli, Periyar, Pudukkotai (Tamil Nadu)

XI. East Coast Plains and Hills Region

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	North Orissa Coast	1287	Moist sub humid	Deltaic alluvial, Coastal alluvial Laterite, Red Loamy	Baleshwar, Cuttack Puri (Orissa)
2.	North coastal Andhra	1128	Dry sub humid	Red loamy Laterite, Medium black, red sandy, coastal alluvial	Srikakulam, Vishakhapatnam, Vizianagaram (A.P.)
3.	South coastal Andhra	996	Semi-arid	Deltaic, Alluvium Deep black Red sandy Red and black	East Godavari, Guntur, Krishna, Prakasam, West Godavari (A.P.) Yanam (Pondicherry)
4.	North coastal Tamil Nadu	1036	Semi-arid	Red loamy Red sandy, coastal alluvium	Nellore (A.P.) Chengalpattu, Madras, North Arcot, South Arcot (Tamil Nadu) Pondicherry)
5.	Tanjavur	1113	Semi-arid to dry sub humid	Deltaic alluvium Red loamy	Thanjavur (Tamil) Karaikal (Pondicherry)
6.	South coastal	780	Semi-arid (drier half)	Mixed Red & black coastal Alluvium	Karnarajar, Ramanathapuram Tirunelveli, P. Muthurama Lingam (Ramnathapuram) (Tamil Nadu)

XII. West Coast Plains and Ghat Region

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Coastal Hilly	3640	Per humid & humid	Laterite, Red, loamy Coastal	Uttarkannada (Karnataka) Greater Bombay, Ratnagiri Raigad (Kolaba) Sindhudurg Thane (Maharashtra) Goa
2.	Coastal Midland	3127	Dry sub humid & per humid	Red loamy, Coastal alluvium laterite	Alleppy, Cannanore, Ernakulam Kasargood, Kozhikode, Malappuram Quilion, Trichur, Trivandrum (Kerala) Kanniyakumari (Tamil Nadu) Dakshin Kannada (Karnataka)
3.	Midland	2727	Per humid	Laterite Coastal Alluvium	Kottayam, Palghat, Pathanamittitta (Kerala)
4.	Hilly	2226	Per humid	Red loamy, Mixed Red & black	Iddukki, Wayanad (Kerala), Chikmaglur Kodagur (coorg) Shimoga (karnataka) Nilgiri (Tamil Nadu)

XIII Gujarat Plains and Hill Regions

S. No.	Sub Zone	Rainfall (mm)	Climate	Soils	Districts
1.	South Gujarat	1793	Semi arid to dry sub humid	Deep black coastal alluvium	The Dangs, Valsad (Gujarat) Daman Dadra & Nagar Haveli
2.	South Gujarat	974	Semi arid to dry sub humid	Deep black coastal alluvium	Bharuch, Surat (Gujarat)
3.	Middle Gujarat	904	Semi arid	Medium black	Kheda, Ranch – Mahals Vadodara (Gujarat)
4.	North Gujarat	735	Arid to semi arid	Grey brown deltaic alluvium	Ahmedabad, Banaskantha, Mahesana, Sabarkantha (Gujarat)
5.	North West Arid	340	Arid to semi arid	Grey brown deltaic alluvium	Kachchh (Gujarat)
6.	North Saurashtra	537	Dry sub humid	Coastal alluvium Medium black	Amreli, Bhavnagar, Jamnagar, Rajkot, Surendranagar (Gujarat)
7.	South Saurashtra	844	Dry sub humid	Coastal alluvium Medium black	Junagadh

XIV. Western Dry Regions

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Western Dry	395	Arid to extremely arid	Desert soil, Grey Brown	Barmer, Bikaner, Churu, Jaisalmer, Jalor, Jhunjhunu, Jodhpur, Nagaur, Sikar (Rajasthan)

XV. The Island Regions

Andaman, Nicobar & Lakshadweep

(1)	(2)
1. Andaman	1. Laksjadweep
2. Nicobar	

This Appendix consists of names of plants recommended for Green Belts. Abbreviations and order of presentation used in this Appendix are as follows :

- No. - Serial number in the list, starting with first letter of the generic name.
- Latin name of the plant.
- Fam. - Family.
- C.N. - Common and vernacular name in different languages of India, Viz.
Beng - Bengali, Guj. - Gujrati,
Mar. - Marathi, Hin. - Hindi....etc.
- S/T - Sensitive/Tolerant, (to air pollution)
- HA - Habit.
- HT - Height.
- GR - Growth rate.
- R - Regeneration.
- E/D - Evergreen/Deciduous.
- DF - Duration of foliage.
- Flo.S. - Flowering season.
- CSA - Crown surface area (estimated).
- CS - Crown shape.
- LA - Leaf area.
- SI - Stomatal index.

- Fam. - Malvaceae
 C.N. - Country mallow; Beng. Jhampi; Guj. Khapat;
 Hin. - Kanghi; Kan - Srimudrigida; Mal. Jhonkaped;
 Mar - Chakrabhenda; Oriya - Nakochono;
 Tam - Thuttli; Tel - Botlabenda, Tuttilibenda;
 Assam - Jhapa; Goa - Petari.
- S/T - T
 HA - Shrub
 HT - 5m
 GR - Quick growing
 R - Through Seeds.
 E/D - Deciduous.
 Flos - Most of the year.
 CS - Oblong.

- Fam - Mimoseae
 C.N. - Australian Wattle, Beng - Akashmone.
 S/T. - T
 HA - Tree.
 HT - 16 m.
 GR - Quick growing.
 R - By seeds.
 E/D - Evergreen
 Flo.S. - June - Jan.
 CSA - 8548.22 m²
 CS - Oblong
 LA - .140.50 cm²
 SI - 10.9

Fam - Mimoseae

C.N. - The catch tree. Sonkhairi, Sans - Khadira,
Hin - Khair; Beng - Kuth; Tam - Karangalli,
Tel - Khadiram.

S/T - T

HA - Shrub

HT - 3m

GR - Quick growing

R - By seeds.

E/D - Evergreen.

Flo.S. - May - August

CSA - 108.42 m²

CS - Oblong.

LA - 109.98 cm²

SI - 8.24

No. A4

Acacia dealbata Link.

Fam - Mimoseae

C.N. - Silver wattle.

S/T - T

HA - Tree

HT - 15m

GR - Quick growing

R - By seeds

E/D - Evergreen.

Flo.S. - April - June

No. A5

Acacia farnesiana Willd

Fam - Mimoseae

C.N. - The cassia flower.

Hindi - Gandh - babul, Beng - Guya babula,

Sans - Arimoedah; Mar - Deobabal,

S/T - T
 HA - Tree.
 HT - 5m.
 GR - Quick growing.
 R - By seeds.
 E/D - Evergreen
 Flo.S. - Aug - Mar.

No. A6

Acacia ferruginea DC

Fam - Mimoseae

C.N. - Safed khair.

Sans - Somasara; Tam - Velvelam; Tel - Ansandra.

S/T - T

HA - Tree.

HT - 3-4m.

GR - Quick growing.

R - By seeds

E/D - Evergreen

Flo.S. - Jan - Feb.

No. A7

Acacia leucophloea Willd.

Fam - Mimoseae

C.N. - Distiller's acocia; Beng - Safed bobul

Eng - White bobool; Guj. Haribavol;

Hindi - Safed bobul; Kan - Bilijal;

Mal - Pattacharayamaram; M.P - Viloyati babul;

Mar - Hewar; Raj - Arunj; Sans - Arimedoh;

Tam - Velvayalam; Tel - Tellotumma.

S/T - T

HA - Shrub.

HT - 3 m

GR - Quick growing

R - By seeds. 1635
E/D - Deciduous
Flo.S. - Jan.-Feb.
CSA - 8281.4 m²
CS - Oblong
LA - 132.52 cm²
SI - 12.01

85

No. A8 Acacia mearnsii de Wild.

Fam - Mimoseae.
C.N. - Black wattle, Tam - Chavukku
S/T - T
HA - Tree
HT - 20m
GR - Quick growing.
R - By seeds, Root suckers.
E/D - Evergreen
CS - Spreading.

No. A9 Acacia mellifera (Vahl) Beth.

Fam - Mimoseae
S/T - T
HA - Tree
HT - 8 -10m
GR - Quick growing
R - By seeds
E/D - Deciduous
Flo.S. - Twice in an year

No. A10 Acacia nilotica (Linn) Willd.

Fam - Mimoseae
C.N. - Indian Gum - Arabic tree, Beng, Hindi, Punjab and
M.P - Babul; Eng - Babul; Guj - Baval;

1636 86

Bihar - Babule; Kan - Karijauli, Mal - Karivelan,
Mar - Vedisaru, Oriya - Baubra;
Sans - Barburah, Vavari; Tam - Karuvelamaram;
Tel - Nallatumma.

S/T - T
HA - Tree
HT - 8m
GR - Quick growing
R - By seeds
E/D - Evergreen
Flo.S. - Aug - Jan.
CSA - 8293.74 m²
CS - Spreading.
LA - 135.70 cm²
SI - 11.23

No. A11 Acacia pennata Willd

Fam - Mimoseae
C.N. - Hin - Biswal; Kumaon - Agla; Beng - Kuchui;
Sans - Ari; Tam - Indu; Tel - Karusikaya.
S/T - T
HA - Shrub
HT - 8m
GR - Quick growing
R - By seeds
E/D - Evergreen
Flo.S. - June - Aug.
CS - Round

No. A12 Acacia polyacantha Willd.

Fam - Mimoseae
S/T - T
HA - Tree

HT - 10m
GR - Quick growing
R - By seeds
E/D - Semi - deciduous.
Flo.S. - May - June, Oct - Nov.
CS - Flat crown

1637

87

No. A13 Acacia senegal Willd.

Fam - Mimoseae
C.N. - Sans - Svetakhadira; Rajasthan - Kumta
S/T - T
HA - Tree
HT - 5m
GR - Quick growing
R - By seeds.
E/D - Deciduous
Flo.S. - Aug - Mid Sept, Nov. - Mar.
CS - Feathery spreading crown

No. A14 Acacia sinuata (Lour) Merrill

Fam - Mimoseae
C.N. - Beng - Banritha; Guj and Mar - Shikakai;
Hin - Kochi; Kan - Sige; Mal - Chikaka;
Tam - Shikakai; Tel Sikaayai.
S/T - T
HA - Tree
HT - 10m
GR - Quick growing.
R - By seeds.

No. A15 Acacia tortilis Hayne

Fam - Mimoseae
C.N. - The Umbrella thorn tree.

S/T - T
 HA - Tree
 HT - Bm
 GR - Quick growing.
 R - By seeds.
 E/D - Evergreen

No. A16 Acer campbellii Hook F. and Thoms.

Fam - Aceraceae.
 C.N. - Himalayan maple. Beng - Kabashi Lepcha - Daom,
 Yatlikung.
 S/T - S
 HA - Tree
 HT - 12m
 GR - Quick growing.
 R - By seeds.
 E/D - Deciduous.
 CS - Spreading

No. A17 Acer negundo Linn

Fam - Aceraceae
 C.N. - Ash - leaved maple, Boxeldes.
 S/T - S
 HA - Tree
 HT - 12m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.
 CS - Spreading

No. A18 Achras sapota Linn

Fam - Sapotaceae.
 C.N. - Sapota; Tam - Shimai - elluppai Mar - Chikoo

S/T	-	T	1639	89
HA	-	Tree.		
HT	-	10m		
GR	-	Slow growing during early stages.		
R	-	Grafting.		
E/D	-	Evergreen		
Fla.S.	-	Round the year in coastal districts. Sept. - Dec. in other areas.		
CSA	-	309.021 m ²		
CS	-	Spreading.		
LA	-	108.02 cm ²		
SI	-	25.78		

Na. A19 Actinodaphne angustifolia Nees.

Fam	-	Lauraceae.
C.N.	-	Mar - Pisa; Mal - Malavirinya, Tam - Tali
S/T	-	T
HA	-	Tree
HT	-	13m
GR	-	Slow
R	-	By seeds
E/D	-	Evergreen.
Fla.S.	-	May - June, Nov.
CS	-	Round

Na. A20 Adenanthera pavonina Linn.

Fam		Mimoseae
C.N.		Caral - ar red wood. Beng - Rakta Kambal; Guj - Badigumehi; Kan and Mal - Manjadi; Mar.- Tharligunj; Oriya - Girid; Sans - Kunchandana; Tam - Anaikundumani, Tel - Bandiguruvenda.
S/T	-	T

HA - Tree 1640
 HT - 20m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - Mar - Aug.
 CS - Spreading

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No. A21 Adina cordifolia Roxb.

Fam - Rubiaceae.

C.N. - Sons - Dhorakadamba; Hindi - Haldu; Beng - Keli,
 Kodam; Tam and Mal - Monja, Kadamba;
 Tel - Pasupa - Kadamba

S/T - T

HA - Tree

HT - 20m

GR - Slow growing

R - By seeds.

E/D - Deciduous

Flo.S. - June - Sept.

CSA - 148, 490.1 m²

CS - Oblong / Round.

LA. - 268.54 cm²

SI - 29.63

No. A22 Aegle marmelos (Linn) Correa.

Fam - Rutaceae.

C.N. - Beal tree, Holy fruit tree;

Beng, Hindi, Mar and Assam - Boel; Guj - Bili;
 Kan - Bilvo; Mal - Koovolom, Kukomlo.

Oriyo - Belo; Son - Bilva, vilvah; Tom - Vilvam,
 Kuvilom; Tel - Maaredu, Urdu - Bel.

S/T - T

HA - Tree
 HT - 12m
 GR - Slow growing
 R - By seeds, root cuttings.
 E/D - Evergreen
 Flo.S. - May - July
 CSA - 26547.19 m²
 CS - Oblong
 LA - 57.72 cm²
 SI - 24.08

1641

91

No. A23 Aesculus indica Hook

Fam - Sapindaceae
 C.N. - Himalayan chestnut, Indian Horse - chestnut;
 Hindi - Bankhar; Jaunsar Pu; Kashmir - Hanedun;
 Kumaun - Pangar; Punjab - Bankhar.
 S/T - S
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds, root suckers.
 E/D - Deciduous
 Flo.S. - Apr - June.
 CS - Spreading

No. A24 Ailanthus altissimo (Mill) Swingle

Fam - Simarubaceae.
 C.N. - Ailanto
 S/T - T
 HA - Tree
 HT - 12m
 GR - Quick growing
 R - By seeds.

C/D - Deciduous **1642**

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Flo.S. - Sept - Nov.

CS - Spreading

No. A25 Ailanthus excelsa Roxb.

Fam - Simarubaceae.

C.N. - Tree of Heaven. Mar. Maharuk Guj, Hindi,
Mar Maharakha, Kan - Hemaraheeramaru,
Mal - Mattipongilyam, Oriya - Mahala,
Sans - Madala arala; Tam - Perumarautta,
Tel - Peddamaanu.

S/T - T

HA - Tree

HT - 20m

GR - Quick growing

R - By seeds. shoot, root cuttings.

E/D - Deciduous.

Flo.S. - Feb - March

CSA - 152, 481.2 m²

CS - Round

LA - 167.47 cm²

SI - 13.01

No. A26 Alangium chinense (Lour) Harms

Fam - Alangiaceae.

C.N. - Beng - Bonipodo; Assam - Bhelu; Garo - Phagrany;
HP and Punjab - Budanar; Kashmir - Prot;
Khasi - Dieng - Mylliatlap; Kumaun - Garh.

S/T - T

HA - Tree

HT - 10m

GR - Quick growing

R - By seeds

E/D - Deciduous.

- Fam - Mimaseae
 C.N. - Mar - Tugli Lalai; Sans - Krishna sirisha;
 Tam - Turinjal; Tel - Sigara.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds, Root suckers
 E/D - Deciduous
 Fla.S. - April - June
 CS - Spreading

Na. A28 Albizia chinensis (Osbeck) Merrill

- Fam - Mimaseae
 C.N. - Beng - Chakua, Assam - Saukarai, Hindi - Siran;
 Gara - Bealphiu; Kan - Kalbage; Khasi - Dieng -
 phyneat; Mal - Pattavaga; Mar - Laeli;
 Tam - Pilivagei; Telkandachigera
 S/T - T
 HA - Tree
 HT - 10-12m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Fla.S. - April - June.
 CS - Spreading flat topped

Na. A29 Albizia lebbeck Benth

- Fam - Mimoseae.
 C.N. - The Siris tree. Beng - Sirish; Guj - Pilosarasio;
 Hindi - Siris, Kan - Bagemara; Mal - Vag.
 Nenmenivaka, Vaka; Mar. Sirisha; Sans - Srisah,

- S/T - T
- HA - Tree
- HT - 20m
- GR - Quick growing
- R - By seeds
- E/D - Deciduous
- Flo.S. - April - May
- CAS - 62,509.32 m²
- CS - Round / spreading.
- LA - 272.51 cm²
- SI - 19.72

No. A30 Albizia moluccana Mig.

- Fom - Mimoseae.
- C.N. - White popinoe, Lead tree, Guj - Losobovol;
 Hindi - Subobul, Vilaitiborol;
 Mal - Takoronnimarom; Oriyo - Rajokosundori;
 Tom - Nattuccovundol; Tel - Koniti.
- S/T - T
- HA - Tree
- HT - 15m
- GR - Quick growing
- R - By seeds
- E/D - Evergreen
- Flo.S. - July - Oct.
- CS - Oblong

No. A31 Albizia odoratissima Benth.

- Fom - Mimoseae.
- C.N. - Black siris; Beng - Kokur siris; Hin - Kola siris;
 Mar - Chikundo; Sons - Svetoshirisho;

S/T	-	T
HA	-	Tree
HT	-	18m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	April - June.
CS	-	Oblong

No. A32 Albizia procera Benth

Fam	-	Mimoseae
C.N.	-	White siris, Beng - Koroi; Assam - Korai Cachar - Jigring - bon - phayng; Kan - Bellate; Mol - Karunth - agora; Mar - Kinhai; Tom - Kondovogei; Tel - Tellochindugo
S/T	-	T
HA	-	Tree
HT	-	20m
GR	-	Quick growing
R	-	By seeds
E/D	-	Deciduous
Flo.S.	-	June - Sept.
CSA	-	28471.26 m ²
CS	-	Round / Oblong
LA	-	286.74 cm ²
SI	-	20.21

No. A33 Aleurites fordii Hemsl

Fom	-	Euphorbiaceae.
C.N.	-	Tungoil tree
S/T	-	T
HA	-	Tree

HT - 8m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Fla.S. - April - June.
 CS - Round

Na. A34 Alnus nepalensis D. Don

Fam - Betulaceae.
 C.N. - Indian or Nepalese Alder. Hin - Uits; Aru.P. - Udis;
 Chamba - Piak; Kumaun - Udish Lepcha - Kayal;
 Punjab - Kae.
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Fla.S. - Sept - Nov.

Na. A35 Alnus nitida Endl

Fam - Betulaceae
 C.N. - The west - Himalayan Alder; Kashmir - Seril;
 Punjab - Sharal; U.P. Kunis.
 HA - Tree
 HT - 20m
 GR - Quick growing after 1st year.
 R - By seeds
 E/D - Deciduous
 Fla.S. - August - October

Na. A36 Alstonia scholaris (Linn.) R. Br.

Fam - Apocynaceae.
 C.N. - Eng - Devil tree, shaitan wood, Hindi - Chatfiyan

1647 97
 saittan koijath, Mal - Elilampala, Yaksippala, Palai
 Daiva ppala; Mar - Satvin; Sans - Saptapamah,
 Saptachadah; Tam - Elilappalai, Palai

S/T - T
 HA - Tree
 HT - 15m
 Gr - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Dec - Mar.
 CSA - 241,680.5 m²
 CS - Round
 LA - 52.31 cm²
 SI - 15.23

No. A37 Anona squamosa Linn.

Fam - Anonaceae.
 C.N. - Custard apple, Sugar apple, Sweet sop.;
 Assam - Atakatal;
 Beng, Guj, Mar and Hindi - Seetaphal, Sharifa;
 Kan - Seethaphala; Mal - Sitappalam, Attaccakka;
 Oriya - Seethaaphola; Punjab - Sharifa;
 Sans - Seetaaphalam; Tam - Atta, Sitappalam
 Tel - Seetaaphalam.

S/T - T
 HA - Small tree
 HT - 10m
 GR - Fast growing
 R - By seeds, Grafting, Budding
 E/D - Evergreen
 Flo.S. - March - July extended upto sept.
 CSA - 2178.21 m²
 CS - Round.

LA - 53.86 cm²
SI - 26.19

No. A38 Anona reticulata Linn.

Fam - Anonaceae.
C.N. - Bullock's Heart; Beng and Hindi - Luvuni, nona;
Goa and Kokan - Anona;
Guj and Mar - Raamaphal;
Kan - Raamaphala; Mal - Raamappazham;
Oriya - Raamaphala; Sans - Lavani, Raamaphalam;
Tam - Manilvatta, raamsita; Tel - Raamaphalamu.
S/T - T
HA - Tree
HT - 10m
GR - Fast growing
R - By seeds
E/D - Evergreen
Flo.S. - June.
CSA - 2017.44 m²
CS - Round
LA - 50.91 cm²
SI - 17.24

No. A39 Anogeissus latifolia Wall.

Fam - Combretaceae.
C.N. - Axlewood, Button tree; Guj - Dhavdo;
Hindi - Dhaura; Kan - Bejjalu;
Mal - Maruka- njiram; Mar - Dabria;
Oriya - Dohu; Tam. Vekaynaga; Tel - Chirumaanu,
tellamaddi, Bihar - Bhanji; U.P., N.W. Himal - Bakli
S/T - T
HA - Tree
GR - Slow growing

R - By seeds,, Root suckers
 E/D - Evergreen
 Flo.S. - May - July
 CSA - 67542.82 m²
 CS - Round / oblong
 LA - 140.23 cm²
 SI - 18.72

1649

99

No. A40 Anthocephalus chinensis (Lamk.)

Fam - Rubiaceae.
 C.N. - Mar, Hin, Sans - Kadamba; Beng - Kadam;
 Tam - Vellai - cadama; Tel - Kadambama.
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous
 Flo.S. - Nov - Feb.
 CSA - 52,233.5 m²
 CS - Spreading
 LA - 106.72 cm²
 SI - 19.63

No. A41 Aphanamixis polystachya (Wall) Parker.

Fam - Meliaceae.
 C.N. - Rohituka tree; Hin - Harin - hara;
 Mal - Cemmaram; Sans - Rohitakah;
 Tam - Malampuluvan, Semmaram;
 Beng - Tiktaroj, Pittaraj, Tel - Chowamanu.
 S/T - T
 HA - Tree
 HT - 13m

GR - Slow growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - July.
 CSA - 10826.95 m²
 CS - Oblong / Round
 LA - 1566.4 cm²
 SI - 18.14

1650

100

No. A42 Artocarpus heterophyllus Lamk.

Fam - Urticaceae.
 C.N. - Jack fruit tree, Hin - Kathal, Cakki; Mar - Phannas;
 Mal - Palavu; Sana - Panasah; Tam - Pila, Palavu.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Slow growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Nov. - Jan.
 CSA - 196,419.1 m²
 CS - Oblong
 LA - 106.86 cm²
 SI - 19.05

No. A43 Artocarpus lacucha Buch

Fam - Urticaceae.
 C.N. - ~~Monkey Jack~~. Hindi Beng - Dahua;
 Mar - Wotomba; Sans - Lakucha; Tam - ilagusam;
 Tel - Kammaregu.
 S/T - T
 HA - Tree
 HT - 18m

GR - Quick growing
R - By seeds.
E/D - Deciduous
Flo.S. - Mar - April
CSA - 2113.20 m²
CS - Spreading / Round
LA - 104.32 cm²
SI - 18.95

1651

101

No. A44 Azadirachta indica A. Juss.

Fam - Meliaceae.
C.N. - Indian Lilac, Neem tree, Margosa tree;
Beng and Hin - Nim; Guj - Limbado;
Kan - Bevinamara; Mal - Veppu, Aruveppa;
Mar - Limba; Oriya - Nimba; Tam - Veppam;
Tel - Veepachettu.
S/T - T
HA - Tree
HT - 20 m
GR - Quick growth after 1st season
R - By seeds
E/D - Evergreen
Flo.S. - Jan - March, Aug. - Sept.
CSA - 300,445.3 m²
CS - Spreading.
LA - 83.89 cm²
SI - 29.2

No. B1 Balanites roxburghii Planch

Fam - Balanitaceae.
C.N. - Desert - Date; Beng. Hingol; Guj - Ingoriyo;
Hin and Mar - Hingon; Kan - Ingalore,
Mal - Nanjuntto;

Tam - Nanjundan; Tel - Garo; Raj - Hingorni

S/T	-	T
HA	-	Tree
HT	-	9m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Evergreen
Flo.S.	-	April - June.
CS	-	Spreading

No. B2 Bambusa arundinocia (Retz) Roxb

Fam	-	Poaceae
C.N.	-	Thorny Bamboo; Beng - Bans; Guj - Wans; Hin - Kantabans; Kan - Andebiduru; Mal - Illi; Mar - Bambu; Oriya - Bendo; Sans - Bahupallava vansa; Tam - Mullumungil; Tel - Mullabongu; Assam - Banho; H.P. Kallabans; Jammu - Lambert; Kashmir - Billawar; Punjab - Magar bang.
S/T	-	T
HA	-	Shrub.
HT	-	20m
GR	-	Quick growing
R	-	By cuttings.
E/D	-	Deciduous.
CS	-	Oblong.

No. B3 Bambusa vulgaris Schrad.

Fam	-	Poaceae
C.N.	-	The Golden bamboo; Beng - bans; Mar - Kolaka; Oriya - Sundragai; Tam & Mal - Ponungile.
S/T	-	T
HA	-	Shrub/tall perennial grasses.

HT - 15m **1653**
GR - Quick growing
R - Cutting.
E/D - Deciduous.

103

No. 84 Barringtonia acutangula (L) Goertn.

Fom - Borringtonioceae.
C.N. - Indian Oak. Assam - Konopo; Beng, Hin - Hijol;
Guj-Somudrophol; Kon - Holekouvo;
Mol - Attompu, Attupelu, Mar - Dattephol;
Oriyo - Hinjolo; Tom - Adompo, somuttiroppolom;
Tel - Kanopochettu; Sons - Somudropholoh.
S/T - T
HA - Tree
HT - 9-12 m
GR - Quick growing
R - By seeds
E/D - Evergreen
Flo.S. - March - May, Sept - Oct.
CS - Spreading

No. 85 Barringtonia racemosa Roxb

Fom - Borringtonioceae.
C.N. - Beng - Somudrophol; Hin - Ijjut;
Kon - Konoginetera; Mol - Katampu; Mar - Nivar;
Tom - Arottam; Tel - Konopo.
S/T - T
HA - Tree.
HT - 6-8m
GR - Fast growing.
R - By seeds.
E/D - Evergreen
Flo.S. - Throughout the year.

Na. B6 Bauhinia acuminata Linn.

Fam	-	Caesalpinaceae.
C.N.	-	Kanchan
S/T	-	T
HA	-	Shrub.
HT	-	3m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Deciduous
Fla.S.	-	June
CSA	-	109.8 m ²
CS	-	Oblong / Round.
LA	-	69.46 cm ²
SI	-	22.31

Na. B7 Bauhinia purpurea Linn.

Fam	-	Caesalpinaceae
C.N.	-	Butterfly tree, Mountain ebony. Beng - Dev kanchan; Hin - Khairwal; Kan - Baswanapada; Mal - Chuvanna - Mandaram, Mar- Rakta Kaanchan; Tam - Mandari; Tel - Kaanchanamu.
S/T	-	T
HA	-	Tree
HT	-	7 m
GR	-	Quick growing
R	-	Through seeds
E/D	-	Deciduous
Fla.S.	-	Sept - Nov.
CSA	-	625.2 m ²
CS	-	Oblong
LA	-	107.3 cm ²
SI	-	23.58

- Fam - Caesalpinaceae
 C.N. - Beng - Banraj; Guj - Asundro; Hin - Astha;
 Kan - Banne; Mal - Kotapuli; Mar - Apta;
 Oriya - Omborodo; Sans - Swetakanchanamu;
 Tam - Araivattatthi; Tel - Ari; Punjab - Kosundra.
- S/T - T
 HA - Small tree
 HT - 5m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - Mar - June
 CSA - 136.9 m²
 CS - Oblong
 LA - 73.4 cm²
 SI - 25.68.

No. B9

Bauhinia semla Wanderlin

- Fam - Caesalpinaceae
 C.N. - Hin - Semla; Mar - Koilar; Tel - Nirpa. H.P. - Karalla;
 Punjab - Kural.
- ST - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S - Sept - Nov.
 CS - Round.

No. B10

Bauhinia variegata Linn.

- Fam - Caesalpinaceae.

C.N.	-	Budhist baubinia, Mauntain Ebony, Beng - Raktakanchan; Guj - kavindara; Hin - Kachnar; Kan - Arisinatige; Mal - Mandaram, Kannu; Malayakatti; Mar - Kanchan, Sans - Kavidarah; Tam - Shemmandarai; Tel - Devakanchanamu.
S/T	-	T
HA	-	Tree
HT	-	5m
GR	-	Quick grawing
R	-	By seeds
E/D	-	Deciduous
Fla.S.	-	Nav.
CSA	-	1769.52 m ²
CS	-	Oblang
LA	-	53.2 cm ²
SI	-	27.41

Na. B11 Betula alnoides Buch-Ham.

Fam	-	Betulaceae
C.N.	-	Indian birch. Nagabirch. Beng - Halasunli; Guj - Bhajpatra; Hin - Bhujpatra; Sans - Bhurja patram; Tel - Bhajapatramu; Urdu - Bhurjapatra; Assam - Dieng - ling; Garhwal - Sauer; Kumaun - Banutis; Nagaland Teri-ching's; Punjab - Shagru.
S/T	-	S
HA	-	Tree
HT	-	15m
GR	-	Quick grawing after 1st yr.
R	-	By seeds, cutting.
E/D	-	Deciduous (Winter)

Flo.S. - Nov. - Jan.

CS - Oblong

1657

107

No. B12 Bischofia javanica Blume.

Fam - Bischofiaceae.

C.N. - Bishopwood; Beng - kainjal; Hin - Paniala;
Kan - Gobranerale; Mal - Nira; Mar - Boke;
Oriya - Dingiri; Tam - Thondi; Tel - Nalupumusti;
Andaman - Ye - badauka; Assam - Urian;
Megh - Deing. Soh - Tug.

ST - T

HA - Tree

HT - 15m

GR - Quick growing

R - By seeds, cuttings.

E/D - Semi - deciduous.

Flo.S. - April - Sept

CS - Oblong.

No. B13 Bougainvillea spectabilis Willd.

Fam - Nyctaginaceae.

C.N. - Bougainvillea

S/T - T

HA - Shrub

HT - 8m

GR - Quick growing

R - By cutting

E/D - Evergreen

Flo.S. - Throughout the year.

CSA - 939.25 m²

CS - Oblong / Round.

LA - 33.15 cm²

SI - 32.53

- No. B14 Bridelia squamosa Lam. **1658**
- Fam - Eupharbiaceae
- C.N. - Hin - Khaja; Beng - Geia, Kantakai;
Mal - Mukkayini; Mar - Asanai;
Sans - Mahavira; Tam - Mullavengai;
Tel - Bantha-yepi.
- S/T - T
- HA - Tree
- HT - 10m
- GR - Quick growing
- R - By seeds, Root suckers.
- E/D - Deciduous.
- Fla.S.- May - Oct.
- CSA - 58,432.1 m²
- CS - Spreading
- LA - 168.09 cm²
- SI - 25.1

- No. B15 Broussonetia papyrifera L. Nerit
- Fam - Maraceae
- C.N. - Paper mulberrys, Hin - Jangli taat;
Kan - Kaagaduppunaeralae.
- S/T - T
- HA - Tree
- HT - 12m
- GR - Quick growing
- R - By seeds, cuttings, air-layering.
- E/D - Deciduous
- Fla.S. - Aug - Nov.
- CS - Oblang.

- No. B16 Buchanania lanzan Spreng.
- Fam - Anacardiaceae.

- C.N. - Almondette tree; Beng - chironji;
 Guj and Mar - Charoli; Hin - Achar;
 Kan - Murkali; Mal-Mungapera;
 Oriya - Charu; Sans - Priyalam; Tam - Morala;
 Tel - Mortichettu or Saara.
- S/T - T
 HA - Tree
 HT - 13m
 GR - Quick growing
 R - By seeds, root suckers.
 E/D - Evergreen
 Flo.S. - Jan - Mar.
 CS - Round.

No. B17 Buteo monosperma Lamk.

- Fam - Fabaceae
- C.N. - Flame of the forest; Beng. Mal, Mar - Palas;
 Guj - Khakharo; Hin - Kashmir. Dhak ;
 Kan - Muttuga; Oriya - Porasu; Punjab -chichra;
 Sans - Palaasa; Tam - Taraso; Tel - Mooduga,
 Palaasamu.
- S/T - T
 HA - Tree
 HT - 10m
 GR - Slow growing
 R - By seeds
 E/D - Deciduous.
 Flo.S. - Jan - April
 CSA - 38,592.1 m²
 CS - Oblong / Ovoid
 LA - 448.6 cm²
 SI - 29.43

No. C1

Caesalpinia pulcherrima Swartz.

1660

110

- Fam - Cesalpinaceae.
C.N. - White gold mahur; Kan - Kempukenjiga;
Mar - Sankasura; Tam - Vadanarayana;
Tel - Sankesula, Vatanarayana.
S/T - T
HT - 4m
GR - Quick growing
R - By seeds, cuttings.
E/D - Evergreen.
Fla.S. - Throughout the year.
CSA - 639.32 m²
CS - Spreading.
LA - 246.4 cm²
SI - 29.09

No. C2

Callistemon citrinus (Curtis) stapf.

- Fam - Myrtaceae
C.N. - Battle brush, scarlet battle brush.
S/T - T
HA - Small tree
HT - 5m
GR - Slow growing
R - By seeds, cuttings
E/D - Evergreen
Fla.S. - Throughout the year esp. April.
CSA - 45,997.2 m²
CS - Conical
LA - 214.01 cm²
SI - 12.749

No. C3

Calophyllum inophyllum Linn

- Fam - Clusiaceae

C.N.	-	Alexandrian laurel, Beng and Hin - Sultanachampa; Guj - Udi; Kan - Hanne; Mal - Punnai; Mar - Surangi; Oriya - Paanang, Sans - Punnagah; Tam - Punnai, Punnagam; Tel - Pannachettu.
S/T	-	T
HA	-	Tree
HT	-	18m
GR	-	Slow growing
R	-	By seeds.
E/D	-	Evergreen
Flo.S.	-	Dec - Jan.
CSA	-	21,426.3 m ²
CS	-	Round / spreading
LA	-	130.51 cm ²
SI	-	28.43

No. C4 Calotropis gigantea R.Br (Linn)

Fam	-	Asclepiadaceae
C.N.	-	Gigantic swallow wart; Beng - Akand; Mar - Rui; Mal - Erukku; Tam - Erukkam; Tel - Peddajilleedu
S/T	-	T
HA	-	Shrub
HT	-	5m
GR	-	Quick growing
R	-	By seeds, cuttings
E/D	-	Evergreen
Flo.S.	-	Feb - July
CSA	-	47.5 m ²
CS	-	Oblong / Round
LA	-	48.58 cm ²
SI	-	9.93

- No. C5 Calotropis procera (R.Br.) Mill.
- Fam - Asclepiadaceae.
- C.N. - Swallow wort; Hin - Akada, Mar - Mandare, Rui; Oriya - Orkho; Sans - Alkarka; Tam - Velleruku; Tel - Chinnajilleedu.
- S/T - T
- HA - Shrub
- HT - 6m
- GR - Quick growing
- R - By seeds, cutting
- E/D - Evergreen
- Flo.S. - December
- CSA - 87.7 m²
- CS - Oblong / Round
- LA - 50.06 cm²
- SI - 10.32

- No. C6 Carissa spinarum Linn.
- Fam - Apocynaceae
- C.N. - Hin - Karaunda; Mar - Karwand; Oriya - Anka; Tam - chiru; Tel - Kalivi; Kashmir - Garunda; Punjab - Janglikarunda
- S/T - T
- HA - Shrub
- HT - 3m
- GR - Quick growing
- R - By seeds, root suckers.
- E/D - Evergreen
- Flo.S. - Mar - May
- CS - Round

- No. C7 Cassia fistula Linn
- Fam - Caesalpinaceae.

C.N. - Golden showy Indian laburnum; Beng and 113
Hin, Jammu - Amaltas; Guj, Mar - Garmala,
Bahwa; Kan - Arogena; Mal - Svarnaviram;
Oriya - Sunari; Punjab - Alash; Son - Saraphala;
Tam - Arakkuvadam;
Tel - Reelachettu, VKaalapanna

S/T - T
HA - Tree
HT - 12m
GR - Quick growing
R - By seeds, suckers
E/D - Deciduous
Fla.S. - March - May
CSA - 2957.11 m²
CS - Round
LA - 130.51 cm²
SI - 20.4

Na. C8 Cassia javanica Linn.

Fam - Caesalpinaceae.
S/T - T
HA - Tree
HT - 12m
GR - Quick growing
R - Through seeds.
E/D - Deciduous
Fla.S. - May - June
CS - Round

Na. C9 Cassia pumila Lamk.

Fam - Caesalpinaceae.
C.N. - Yellow Cassia; Mar - Sarmal; Tel - Nallojiluga;
Kan - Nelatogache.

S/T	-	T
HA	-	Tree
HT	-	10-12m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
CSA	-	13,273.7 m ²
CS	-	Round
LA	-	118.47 cm ²
SI	-	19.84

Na. C10 Cassia renigera Wall ex. Benth.

Fam	-	Caesalpinaceae
C.N.	-	Pink Cassia
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seeds
E/D	-	Deciduous .
Fla.S.	-	May - June
CSA	-	9,432 m ²
CS	-	Round / spreading
LA	-	115.2 cm ²
SI	-	17.21

Na. C11 Cassia siamea Lamk.

Fam	-	Caesalpinaceae.
C.N.	-	Iran wood tree; Beng - Minjri; Guj - Kaisid; Kan - Hiretangad, Mar - Kassad, Tam - Manja- Kannai; Tel - Seematangeedu.
S/T	-	T
HA	-	Tree

HT	-	10-12m
GR	-	Fast growing
R	-	By seeds.
E/D	-	Evergreen
Flo.S.	-	Aug - May.
CSA	-	3927.36 m ²
CS	-	Oblong
LA	-	138.32 cm ²
SI	-	21.2

No. C12 Casuarina equisetifolia Linn.

Fam	-	Casuarinaceae
C.N.	-	Australian or Whistling pine; Beng - Jau; Guj and Hin - Jangli saru; Kan - Chabaku; Mal - Chavukku; Mar - Suru; Tam - Savukku; Tel - Saravi Sarugudu.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Feb - April, Sept - Oct
CS	-	Oblong

No. C13 Ceiba pentandra (Linn) Gaertn.

Fam	-	Bambacaceae
C.N.	-	Kapok
S/T	-	T
HA	-	Tree
HT	-	15m
GR	-	Quick growing
R	-	By seeds

E/D	-	Deciduous
Fla.S.	-	March - July
CSA	-	3126.98 m ²
CS	-	Oblong
LA	-	135.07 cm ²
SI	-	18.21

Na. C14 Celtis australis Linn

Fam	-	Ulmaceae.
C.N.	-	European Nettle tree; Assam - Mahita; Cachar - Banridu; Kashmir - Brimij, Khasi - Dieng - sah - thong - chi; Punjab - Batkar.
S/T	-	T
HA	-	Tree
HT	-	12m
GR	-	Quick growing
R	-	By seeds, stump - planting.
E/D	-	Deciduous

Na. C15 Citrus aurantium Linn

Fam	-	Rutaceae
C.N.	-	Beng - Nebu; H - Limu - Niba, Khatta; Mal - Karna; Tel - Mallikarangi; Tam - Narattai
S/T	-	T
HA	-	Tree
HT	-	5m
GR	-	Quick growing
R	-	By cutting, Grafting
E/D	-	Evergreen
Fla.S.	-	Sept - Nov
CSA	-	494.9 m ²
CS	-	Round / Oblong
LA	-	20.23 cm ²
SI	-	35.81

No. C16 Citrus limon (Linn) Burm

1667

117

- Fam - Rutaceae
C.N. - Lime of India. (Limbu.); Beng - Bara nebu, Gora nebu; Hin - Bara nimbu. Pahari nimbu;
Sans - Mala nimbu; Tam - Periya; Yelumichai;
Tel - Bijopuram.
- S/T - T
HA - Shrub
HT - 3m
GR - Slow growing
R - By cutting, Grafting
E/D - Evergreen
Flo.S. - Nov - Jan
CSA - 583.72 m²
CS - Oblong
LA - 18.55cm²
SI - 32.5

No. C17 Clerodendrum inerme (Linn) Gaertn.

- Fam - Verbenaceae
C.N. - Beng - Banjai, Hin - Vanjai; Kan - Kundali;
Mal - Cheruchinna, Mar - Vanajai; Kadumendi;
Tam - Pinarichangan-guppi; Tel - Etipshinika.
- S/T - T
HA - Shrub
HT - 5m
GR - Quick growing
R - By seeds, cutting
E/D - Evergreen
Flo.S. - Nov - Jan.
CSA - 723.43 m²
CS - Round
LA - 42.34 cm²
SI - 18.02

No. C18 Clerodendrum infortunatum Linn (auct), Wight.

1668

118

Fam - Verbenaceae
C.N. - Hin and Beng - Bhant, San - Bhantaka;
Tam -Perugilai; Tel - Gurrapukattiyaku;
Mal - Peruku.
S/T - T
HA - Shrub
HT - 3-4m
GR - Quick growing
R - By seeds, cutting
E/D - Evergreen
Flo.S. - Oct - Jan
CSA - 854 m²
CS - Round
LA - 47.9 cm²
SI - 19.07

No. C19 Cocos nucifera Linn

Fam - Arecaceae
C.N. - Coconut tree; Beng - Dab, Narikel;
Hin -Nariyal; Mal - Narikelam; Mar - Naral;
Sans - Narikela; Tam - Tenkai; Tel - Narikelamu.
S/T - T
HA - Tree
HT - 10-15m
GR - Slow growing
R - By seeds
E/D - Evergreen
Flo.S. - Throughout the year
CSA - 109,347.4 m²
CS - Round
LA - 1635 cm² per leaflet
SI - 9.31

Na. C20 Cordia dichotoma Forst 1669

119

- Fam - Cardiaceae
C.N. - Seb estan fruit tree. Beng - Bahubara;
Guj- Bargunda; Hin - Chata - lasara;
Kan - Chikka challe; Mal - Cheruviri;
Tam - Naruvili; Tel - Chinn - anakkeru.
S/T - T
HA - Tree
HT - 10m
GR - Quick growing after 1st yr.
R - By seeds, stem cutting
E/D - Evergreen
Fla.S. - March - April
CS - Raund / Oblang

Na. C21 Cariaria nepalensis Wall

- Fam - Cariaceae
C.N. - Mussarie berry tree; Hin - Masuri;
Kashmir - Bale!
S/T - S
HA - Shrub
HT - 5m
GR - Quick growing
R - By seeds.
E/D - Deciduous
CS - Raund

Na. C22 Corylus colurna Linn

- Fam - Betulaeae
C.N. - Turkish Hazel, Hin- Sharali; Kashmir - Virin;
Kumaun - Bhatia, badam; Punjab - Thangi
S/T - S
HA - Tree

HT	-	10m
GR	-	Quick growing
R	-	By seeds
E/D	-	Deciduous

No. D1 Dalbergia latifolia Roxb.

Fam	-	Fabaceae.
C.N.	-	Black wood, Indian Rose wood. Beng - Sitsol; Guj, Hin and Mar - Shisham; Kan - Bite; Mal and Tam - Itti; Oriya - Sisua; Tel - Irugudu, cittegi.
S/T	-	T
HA	-	Tree
HT	-	20m
GR	-	Quick growing
R	-	By seeds, stem, root cuttings.
E/D	-	Semideciduous
Flo.S.	-	August - Sept
CSA	-	21,723.2 m ²
CS	-	Round
LA	-	187.9 cm ²
SI	-	10.12

No. D2 Dalbergia sisoo Roxb.

Fam	-	Fabaceae.
C.N.	-	Sissoo; Beng, Mar. Oriya and Assam - Sissu; Guj - Sisam; Hin - Shisham; Kan - Agar;u; Mal - Iruvil; Tam - Sissuitti; Tel - Errasissoo; Punjab - Tali.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Moderate during 1st yr. and rapid afterwards.

R	-	By seeds, Root and Stem cuttings.
E/D	-	Evergreen
Flo.S.	-	March - April - June
CSA	-	5,848.5 m ²
CSA	-	Round
LA	-	190.84 cm ²
SI	-	18.72

No. D3 Delonix regia (Bojer) Rafin.

Fam	-	Caesalpinaceae.
C.N.	-	Flameboyant, Flametree, Gulmohur; Tam - Mayarum; Tel - Seemasantkesula.
S/T	-	S
HA	-	Tree
HT	-	15m
GR	-	Quick growing
R	-	By seeds, cuttings
E/D	-	Deciduous
Flo.S.	-	Aprill - June
CSA	-	44,209.23 m ²
CS	-	Spreading / Flat topped.
LA	-	358.32 cm ²
SI	-	14.38

No. D4 Dendrocalamus strictus Nees

Fam	-	Poaceae
C.N.	-	Solid Bamboo: Beng - Karail; Guj - Nakorvans; Hin - Banskaban; Kan - Kiribiduru; Mal & Tom - Kalmungil; Mar - Bhariyel; Oriya - Saliabanso; San - Vansha; Tel - Saadhoranapoveduru.
S/T	-	T
HA	-	Shrub / tall perennial grass.

HT - 12m **1672**
 GR - Quick growing
 R - By seeds, stem, rhizome cutting, layering
 E/D - Deciduous

122

No. D5 Derris indica (Lam.) Bennett.

Fam - Fabaceae.
 C.N. - Pongam - Oil Tree, Karanj, Indian Beech;
 Assam - Karchaw; Beng, Guj, Hin, Kumoun,
 Mar & Punjab - Karanja; Kan - Honge;
 Mal - Pungu. Oriya - Karanjo;
 Tam - Ponga, Pongam;
 Tel - Gaanugachettu, Punguchettu.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen
 Flo.S. - April - June
 CSA - 6,278.1m²
 CS - Round
 LA - 79.6cm²
 SI - 25.20

No. D6 Diospyros melanoxylon Roxb.

Fam - Ebenaceae.
 C.N. - Ebony, Coromandel Ebony - Persimmon.
 Beng - Kend; Guj - Tamrag;
 Hin and Mar - Tendu; Kan - Abanasi;
 Mal - Kari; Oriya - Kendu; Tam - Karai;
 Tel - Tumki.
 S/T - T

HA - Tree
 HT - 10m
 GR - Slow growing
 R - By seeds, root suckers.
 E/D - Deciduous
 Flo.S. - Feb - April
 CSA - 324,355.2m²
 CS - Oblong
 LA - 167.78 cm²
 SI - 17.89

1673

123

No. D7 Dryptes roxburghii (Wall)

Fam - Euphorbiaceae.
 C.N. - Putronjiva. Sans, Hin and Beng - Putronjivo;
 Pun - Jiyaputra; Kan - Putrajivo;
 Mal - Pongalam; Tam - Karupali; Tel - Kudurujiivi
 S/T - T
 HA - Tree
 HT - 15m
 GR - Slow growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Mar - May
 CSA - 3445.32 m²
 CS - Round
 LA - 144.37 cm²
 SI - 19.81

No. D8 Duranta repens L

Fam - Verbenaceae.
 S/T - T
 HA - Shrub
 HT - 3m

GR	-	Quick growing
R	-	By seeds 1674
E/D	-	Evergreen
Flo.S.	-	Throughout the year
CSA	-	60.47 m ²
CS	-	Spreading
LA	-	62.7 cm ²
SI	-	21.5

124

No. E1 Emblica officinalis Gaertn.

Fam	-	Eupharbiaceae.
C.N.	-	Gooseberry, Emblic myrobalan. Beng and Hin - Amla; Guj - Amali; Kan - Amalaka, nelli; Mal and Tam - Nelli; Mar - Awala; Son - Amaloka; Tel - Amalakama, rootausirika
S/T	-	T
HA	-	Tree
HT	-	5m
GR	-	Quick growing
R	-	By seeds, cutting. Budding, inarching.
E/D	-	Deciduous
Flo.S.	-	June - July also in Feb, Mar - May.
CSA	-	17,381.2 m ²
CS	-	Oblong
LA	-	140.64 cm ²
SI	-	11.62

No. E2 Embryopteris peregrina Goertn.

Fam	-	Ebenaceae.
S/T	-	T
HA	-	Tree
HT	-	10m

GR - Quick growing
R - By seeds
E/D - Deciduous
Flo.S. - Mar - May
CSA - 28,609.1 m²
CS - Spreading
LA - 84.07 cm²
SI - 12.84

1675

125

No. E3 Erythrina variegata Linn

Fam - Fabaceae.
C.N. - Indian coral tree; Beng - Polito mandar;
Guj - Bangoro; Hin - Dadap; Kan - Horivana
Mal and Tam - Kalyanamurkku;
Mar - Mondor, Pangara;
San - Mandara; Tel - Baadita, Moduga.
S/T - T
HA - Tree
HT - 10m
GR - Quick growing
R - By seeds, stem cuttings
E/D - Deciduous
Flo.S. - Feb - May
CSA - 22,903.7 m²
CS - Oblong
LA - 168.94 cm²
SI - 31.76

No. E4 Eucalyptus citriodora Hook.

Fam - Myrtaceae
C.N. - Lemon scented gum
S/T - T
HA - Tree

HT	-	20m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Feb - April. Oct - Dec.
CSA	-	52,447.63 m ²
CS	-	Conical
LA	-	48.37 cm ²
SI	-	12.0

No. E5

Eucalyptus hybrid

Fam	-	Myrtaceae
C.N.	-	Mysore gum
S/T	-	T
HA	-	Tree
HT	-	20m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Feb. - April., Oct. - Dec.
CSA	-	50,047.33 m ²
CS	-	Conical
LA	-	50.37 cm ²
SI	-	12.91

No. E6

Exbucklandia populnea (R.Br) R.W.Br.

Fam	-	Hamamelidaceae
C.N.	-	Beng - Bipli; Khasi - Dieng - doh; Trade - Pipli.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Slow growing
R	-	By seeds

E/D - Evergreen
 Flo.S. - Nov. - Dec.
 CS - Round

No. F1 Ficus benghalensis Linn

Fam - Moraceae
 C.N. - Banyan Tree, Beng - Bar; Guj - Vad;
 Hin - Bargad; Kan - Ala; Mal - Ala, Vatam;
 Mar - Vad; Sans - Bahupada; Tam - Al;
 Tel - Peddamarri
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By cutting, seeds
 E/D - Evergreen
 Flo.S. - April - June
 CSA - 2,36,493.67 m²
 CS - Spreading
 LA - 119.10 cm²
 SI - 21.72

No. F2 Ficus benjamina Linn

Fam - Moraceae
 C.N. - Assam - Chilubor; Beng - Pakur; Mar - Pimpri;
 Tam - Putrajivi
 S/T - T
 HA - Tree
 HT - 12m
 GR - Quick growing
 R - By seeds, cutting
 E/D - Evergreen
 Flo.S. - Sept - Nov

CSA	-	87,326.12 m ²
CS	-	Spreading
LA	-	29.27 cm ²
SI	-	18.62

No. F3

Ficus elastica Roxb

Fam	-	Moraceae
C.N.	-	Indian Rubber tree
S/T	-	T
HA	-	Tree (Epiphytic)
HT	-	12m
GR	-	Quick growing
R	-	By cutting
E/D	-	Evergreen
CSA	-	6028.18 m ²
CS	-	Spreading / Round
LA	-	94.20 cm ²
SI	-	19.43

No. F4

Ficus gibbosa Blume

Fam	-	Moraceae
C.N.	-	Mar - Datir; Garhwal - Chenchri; Sans - Udumbber; Tom - Irodgam; Tel - Tella - bariniko; Orissa - Korotosani
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By cuttings, seeds
E/D	-	Evergreen
Flo.S.	-	April - May
CSA	-	223,45.4 m ²
CS	-	Spreading

LA - 40.1 cm²
SI - 19.81

1679

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Na. F5

Ficus glomerata Roxb

Fam - Maraceae

C.N. - Beng - Dumur; Hin - Gular; Kan, Mal,
Tam - Athi; Mar - Umbar; Oriya - Dimra;
Tel - Atti, medichettu.

S/T - T

HA - Tree

HT - 15m

GR - Quick growing

R - By seeds, cutting

E/D - Deciduous

Fla.S. - Aug - Oct, Dec - Feb

CSA - 2,18,769.8 m²

CS - Spreading

LA - 47.28 cm²

SI - 13.58

Na. F6

Ficus hispida (L.) F.

Fam - Maraceae

C.N. - Kala - umbar, Beng - Kakdumur;
Assam - Khaskadumar; Hin - Kanea dumbar;
Punjab - Rumbal; Sans - Kakadumbura;
Tam and Mal - Peyatti; Tel - Vettiati.

S/T - T

HA - Tree

HT - 10m

GR - Quick growing

R - By seeds, cuttings

E/D - Evergreen

Fla.S. - April - July

CSA	-	46942.02 m ²
CS	-	Spreading
LA	-	45.23 cm ²
SI	-	17.21

No. F7 Ficus religiosa Linn

Fam	-	Moraceae
C.N.	-	Peepal tree; Beng and San - Ashthwa; Guj - Pipro; Hin - Pipal; Kan - Arali Ashwatha; Mar - Pimpala; Tam - Arasu; Tel - Ashavathamu, Raavichettu
S/T	-	T
HA	-	Tree
HT	-	20m
GR	-	Grows slow in early stages later grows fast
R	-	Through seeds, cutting.
E/D	-	Evergreen
Flo.S.	-	Jon. - May.
CSA	-	1,44,868.7 m ²
CS	-	Round/Oblong.
LA	-	114.15 cm ²
SI	-	18.70

No. F8 Ficus semicordata Buch Ham.

Fam	-	Moroceae
C.N.	-	Beng - Jagya Dumur; Hin - Jahephali; Kan - Gargaso; Mol - Perina; Mar - Porodumer; Tom - Torodi; Tel - Bommamorri.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing.
R	-	Through seeds.

E/D	-	Evergreen.	1681
Flo.S.	-	Throughout the year.	
CSA	-	52,809.61 m ²	
CS	-	Round	
LA	-	84.50 cm ²	
SI	-	17.38	

No. F9

Ficus virens Ait

Fam	-	Moraceae
C.N.	-	Hin and Punjab - Pilkhan; Ben - Pakar; Mal - Pepar, Mar - Pipli; Sans - Plaksha; Tam - Kurugu; Tel- Badiju
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Grows slowly in early stages later grows fast
R	-	By seeds, cutting
E/D	-	Evergreen
Flo.S.	-	Jan - May
CSA	-	1,97, 838.2 m ²
CS	-	Oblong
LA	-	43.3 cm ²
SI	-	15.91

No. G1

Gorcinia indica Chosis.

Fam	-	Guttiferaceae
C.N.	-	Hin and Mar - Kokam; Mal - Punampuli; Tam - Murgal
S/T	-	T
HA	-	Tree
HT	-	8m
GR	-	Slow growing (1 st yr).
R	-	Through seeds

E/D - Evergreen
 Flo.S. - Nov - Feb
 CSA - 210.748 m²
 CS - Oblong
 LA - 82.1 cm²
 SI - 22.03

No. G2 Garcinia talbotii Raizada.

Fam - Guttiferaceae
 S/T - T
 HA - Tree
 HT - 7m
 GR - Slow growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Nov.
 CSA - 193.02 m²
 CS - Round
 LA - 78.9 cm²
 SI - 21.7

No. G3 Gardenia jasminoides Eills.

Fam - Rubiaceae
 C.N. - Sans - Anant. Gandharaj. Tam - Karinga
 S/T - T
 HA - Tree
 HT - 5m
 GR - Quick growing
 R - By seeds, stem cutting
 E/D - Evergreen
 Flo.S. - April - Aug extended upto Sept.
 CSA - 265.87 m²
 CS - Oblong

LA - 57.51 cm
SI - 19.21

No. G4 Gardenia resinifera Roth

Fam - Rubiaceae
C.N. - Hin and Mar - Dikamali; Sans - Jantuka;
Tam - Tikkamalli; Tel - Erubikki
S/T - T
HA - Tree
HT - 5m
GR - Quick growing
R - By seeds, cutting
E/D - Deciduous
Flo.S. - Mar - June
CSA - 572.36 m²
CS - Oblong
LA - 61.17 cm²
SI - 19.73

No. G5 Gliricidia sepium (Jacq) Kunth ex Walp.

Fam - Faboaceae
C.N. - Mother - of - cocoa, Mexican lilac.
S/T - T
HA - Tree
HT - 10m
GR - Quick growing
R - By seeds and large cutting
E/D - Deciduous
Flo.S. - Jan - March
CSA - 13412.6 m²
CS - Oblong / Round
LA - 136.46 cm²
SI - 12.79

- Fam - Proteaceae.
 C.N. - Silvery or silky oak, Tam - Savukkamaram
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Feb - April
 CS - Oblong

No. G7 Grewia elastica Royle.

- Fam - Tiliaceae
 C.N. - Beng - Dhamni; Hin and Punjab - Dhaman;
 Oriya - Mirgi chara; Mal - Satachi;
 Mar - Dhaman; Tam - Tarra; Tel - Charachi;
 Sans. - Dharmana.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - May - Aug
 CS - Round

No. G8 Grewia subinequalis DC.

- Fam - Tiliaceae.
 C.N. - Beng, Guj Hin, Mar and Punjab. Phalsa;
 Kan - Bhuttiyadippe; Oriya - Pharasakoli;
 Tam- Palisa; Tel - Nollajano.
 S/T - T

HA	-	Shrub.
HT	-	7m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Apr - June
CS	-	Round

No. G9 Guazma ulmifolio Lamk.

Fam	-	Sterculiaceae
C.N.	-	Son, Tam, Tel and Mal - Rudraksha, Hin - Rudraki, Beng - Rudranya; Mar - Rudroksh.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Mar - August.
CSA	-	30279.8 m ²
CS	-	Round / Spreading
LA	-	85.21 cm ²
SI	-	13.31

No. H1 Hamelia patens Jacq.

Fam	-	Rubiaceae
C.N.	-	Scarlet bush
S/T	-	T
HA	-	Shrub
HT	-	3m
GR	-	Quick growing
R	-	By seeds, cuttings

E/D	-	Evergreen
Fla.S.	-	Oct - Jan
CSA	-	824.06 m ²
CS	-	Round
LA	-	47.2 cm ²
SI	-	19.07

Na. H2 Heterophragma roxburghii DC.

Fam	-	Bignaniaceae
C.N.	-	Mar, Guj, M.P. - Warras; Kan - Bechadi; Tel - Barukaligattu.
S/T	-	T
HA	-	Tree
HT	-	18m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Fla.S.	-	Feb - April
CSA	-	155217.7 m ²
CS	-	Round / Oblang
LA	-	34.7 cm ²
SI	-	14.2

Na. H3 Hibiscus rosa-sinensis Linn

Fam	-	Malvaceae
C.N.	-	Jasud. Chinese Hibiscus; Sans and Beng - Jaba; Hin - Jasum; Mar - Jasavanda; Tam - Sapattuppu; Tel - Dasanam.
S/T	-	T
HA	-	Shrub
HT	-	3m
GR	-	Quick growing
R	-	By cutting

E/D	-	Evergreen
Flo.S.	-	Throughout the year
CSA	-	61.47 m ²
CS	-	Round / Oblong
LA	-	44.7 cm ²
SI	-	23.32

No. H4 Hippophae rhamnoides Linn

Fam	-	Elaeagnaceae
C.N.	-	Common seabuckthorn; Ladakh and H.P. - Sirma; Punjab - Kalabisa, Serma; U.P. - Chuma.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seed, stem cuttings, suckers
E/D	-	Deciduous
Flo.S.	-	Mar - May

No. H5 Holoptelia integrifolia, (Roxb) DC.

Fam	-	Ulmaceae
C.N.	-	Indian Elm. Kanju; Guj - Khanjho; Hin and Kumaun - Kanju; Kan - Thavasai; Mal - Aval; Oriya - Dauranja; Sans - Chirabilva; Tam - Ayal; Tel - Thapass; M.P - Karanjalam; Punjab - Rajain. Mar - Papdi
S/T	-	T
HA	-	Tree
GR	-	Quick growing
R	-	By seeds, stem cutting
E/D	-	Deciduous
Flo.S.	-	Feb - April

CSA - 29443.5 m²
CS - Oblong
LA - 67.30 cm²
SI - 31.03

1688

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No. 11 Ixora arborea Roxb

Fam - Rubiaceae
S/T - T
HA - Tree
HT - 6m
GR - Quick growing
R - By cutting
E/D - Evergreen
Flo.S. - Throughout the year
CSA - 57.04 m²
CS - Oblong to spreading
LA - 54.2 cm²
SI - 17.3

No. 12 Ixora chinensis

Fam - Rubiaceae
S/T - T
HA - Shrub
HT - 6m
GR - Quick growing
R - By cutting
E/D - Evergreen
Flo.S. - March
CS - Oblong

No. 13 Ixora coccinea L

Fam - Rubiaceae
C.N. - Beng and Hin - Rangan. Mar - Pendgul;

S/T	-	T
HA	-	Tree
HT	-	6m
GR	-	Quick growing
R	-	By cutting
E/D	-	Evergreen
Fla.S.	-	Throughout the year
CSA	-	183.26 m ²
CS	-	Oblang
LA	-	69.70 cm ²
SI	-	23.30

Na. 14

Ixora rosea

Fam	-	Rubiaceae
S/T	-	T
HA	-	Tree
HT	-	6m
GR	-	Quick growing
R	-	By cutting
E/D	-	Evergreen
Fla.S.	-	More or less throughout the yr.
CSA	-	296.03 m ²
CS	-	Oblang
LA	-	62.21 cm ²
SI	-	20.30

Na. 15

Ixora undulata

Fam	-	Rubiaceae
S/T	-	T
HA	-	Tree
HT	-	6m

GR - Quick growing
R - By cutting
E/D - Evergreen
Flo.S. - March - April
CS - Oblong

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1690

No. J1 Jacaranda mimosaeifolia D.Don.

Fam - Caesalpinaceae
C.N. - Nil - gulmohur
S/T - S
HA - Tree
HT - 10m
GR - Quick growing
R - By seeds
E/D - Deciduous
Flo.S. - March - April
CSA - 7148.54 m²
CS - Round
LA - 46.4 cm²
SI - 19.0

No. J2 Juniperus communis

Fam - Pinaceae
C.N. - Common juniper; Beng - Havasha;
Hin - Aaraar; Mar - Hoshia; Kumaun - Chichia;
Punjab and Kashmir - Betar.
S/T - S
HA - Shrub
HT - 10m
GR - Quick growing
R - By seeds
E/D - Evergreen
Flo.S. - March - April
CS - Round / Oblong

No. K1 Kigelia africana Lamk 1691

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Fam - Bignoniaceae
C.N. - Sausage tree
S/T - T
HA - Small tree
HT - 10m
GR - Quick growing
R - By seeds
E/D - Evergreen
Flo.S. - Mar - June
CSA - 58432.21 m²
CS - Round / Oblong
LA - 267.6 cm²
SI - 12.90

No. L1 Lagerstroemia parviflora Roxb

Fam - Lythraceae
C.N. - Beng and Hin - Phurush; Mar - Dhayti;
Tam - Tindiyam; Tel - Chinagoranta.
S/T - T
HA - Tall tree
HT - 20m
GR - Quick growing
R - By seeds
E/D - Deciduous
Flo.S. - June
CSA - 67051.42 m²
CS - Round / Oblong
LA - 84.12 cm²
SI - 17.01

No. L2 Lagerstroemia speciosa (Linn)

Fam - Lythraceae

C.N.	-	Queen creeper, Mistle. Beng and Hin - Punjab Jaraal; Kan - Haledasavala; Mal - Manimaruthu; Mar -Taman; Oriya - Patali; Tam - Kadali; Tel - Varagaagu.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Fla.S.	-	April - June
CSA	-	72569.31 m ²
CS	-	Oblang
LA	-	87.62 cm ²
SI	-	13.9

No. L3

Lantana camara Linn.

Fam	-	Verbenaceae
C.N.	-	Lantana, Wildsage; Kan - Natahugide; Mal - Arippu; Mar - Ghaneri, Chadurang; Tam - Unniched; Tel - Puulikampa; M.P. - Raimuniya.
S/T	-	T
HA	-	Shrub
HT	-	3m
GR	-	Quick growing
R	-	By seeds, cutting
E/D	-	Evergreen
Fla.S.	-	Throughout the year
CSA	-	324.58 m ²
CS	-	Spreading
LA	-	48.69 cm ²
SI	-	12.13

- Fam - Lythraceae
 C.N. - Henna; Beng - Mehedi; Guj - Medi; Hin, Mar
 and Punjab - Mehndi; Kan - Mayilanchi,goranta;
 Mal - Mailanchi; Oriya - Benjat,
 Sans - Mendika; Tam - Marithondi;
 Tel - Gorinta; Kashmir -Mohuz.
 S/T - T
 HA - Shrub
 HT - 5m
 GR - Quick growing
 R - By seed and cutting
 E/D - Evergreen
 Flo.S. - April - July
 CSA - 71.85 m²
 CS - Round
 LA - 77.8 cm²
 SI - 17.0

- Fam - Sopotaceae
 C.N. - The Indian butter - Tree; Beng - Gophol;
 Hin - Phulwara, Chiuro
 S/T - T
 HA - Tree
 HT - 15m
 GR - Quick growing
 R - By seeds
 B/D - Deciduous
 Flo.S. - June - July
 CS - Spreading

No. M2 Madhuca longifolia (Koen)

Fam - Sapotaceae

C.N. - The Butter tree; Beng Hin and Mar - Mahwa,
Guj - Mahudo; Kan - Hippe; Mal - Ilupu,
Poonam; Oriya - Mahula; Tam - Illupei;
Tel - Ippa.

S/T - T

HA - Tree

HT - 15m

GR - Quick growing

R - By seeds

E/D - Deciduous

Flo.S. - Feb - April

CSA - 30,463.7 m²

CS - Round / Oblong

LA - 86.96 cm²

SI - 22.18

No. M3 Mallotus philippensis (Lour) Muell, Arg.

Fam - Euphorbioceoe

C.N. - Hin and Bengal - Kamala, Kamila,
Assam - Puddum; Mal - Tavitu, Mar - Kamala,
Shendri; Tam - Kamala; Tel - Sinduri;
Sans - Rechonaka.

S/T - T

HA - Tree

HT - 12m

GR - Slow growing

R - By seeds

E/D - Evergreen

Flo.S. - Nov - Jan

CSA - 30497.8 m²

CS - Oblong / Round

LA - 58.3 cm²
 SI - 19.0

No. M4 Mammea suriga (Buch - Ham. ex. Roxb.)

Fam - Guttiferaceae
 C.N. - Hin and Beng - Nagkesar; Kan - Surungi;
 Mar - Suringi; Mal - Surampunna;
 Tam - Surabunnai; Tel - Surampunnagamu;
 Sans - Punnag.
 S/T - T
 HA - Tree
 HT - 18m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Feb - Mar
 CSA - 27,865.1 m²
 CS - Spreading
 LA - 46.83 cm²
 SI - 20.1

No. M5 Mangifera indica Linn

Fam - Anacardiaceae
 C.N. - The mango tree, Beng and Hin - Am;
 Guj - Amri; Kan - Maavu; Mal - Aamram,
 maavu; Mar - Amba; Tam - Maanga, Maavu;
 Tel - Maamidichettu, Maavi.
 S/T - S
 HA - Tree
 HT - 15m
 GR - Quick growing after 1 st year
 R - By seeds, transplanting, grafting, budding, air
 lalyering, root cutting and marcotting.

E/D	-	Evergreen
Flo.S.	-	South India - Jan - Mar; North India - Feb. - Apr.
CSA	-	69,004.67 m ²
CS	-	Round / Oblong
LA	-	85.27 cm ²
SI	-	30.77

No. M6 Melaleuca leucadendron Linn

Fam	-	Myrtaceae
C.N.	-	Cajaput tree; Beng, Hin Mar - Cajaputte, Tam - Kaiyappudai
S/T	-	T
HA	-	Tree
GR	-	Quick growing
R	-	By seeds, cuttings
E/D	-	Evergreen
Flo.S.	-	Sept - Nov
CSA	-	21,435.38 m ²
CS	-	Oblong
LA	-	83.57 cm ²
SI	-	18.67

No. M7 Melia azadirach Linn

Fam	-	Meliaceae
C.N.	-	The Persian lilac, Beng - Mahanim; Guj - Bakamlimbodo; Hin - Bakain; Kan - Arebv, Hutchuburi; Mal - Karin, Vembu; Mar - Pejri; Tam - Malaivembu; Tel - Turakaveepa, Verriveepa.
S/T	-	T
HA	-	Tree
HT	-	20m

GR	-	Quick growing
R	-	By seeds, stem, root, cutting, root sucker.
E/D	-	Evergreen
Flo.S.	-	March - May
CSA	-	38964.16 m ²
CS	-	Oblong
LA	-	83.79 cm ²
SI	-	(23.53) 23.53

No. M8

Milletia peguensis Ali

Fam	-	Fabaceae
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Evergreen
Flo.S.	-	Aug. - Oct.
CSA	-	42311.52 m ²
CS	-	Round/oblong
LA	-	167.2 cm ²
SI	-	12.2

No. M9

Millingtonia hortensis L.f.

Fam	-	Bignoniaceae
C.N.	-	Indian cork - tree, Buch.
S/T	-	S
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seeds, cutting
E/D	-	Evergreen
Flo.S.	-	Oct. - Dec.

CSA	-	22439.17
CS	-	Oblong / Round
LA	-	139.2 cm ²
SI	-	18.11

No. M10 Mimusops elengi Linn

Fam	-	Sapotaceae
C.N.	-	Bakuli; Hin and Beng - Bakul; Mar - Borsati; Sans - Bakula; Punjab - Maulsari; Tam - Magilam; Tel - Vakulamu.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Jan. - Mar.
CSA	-	13,385.2 m ²
CS	-	Oblong / Round
LA	-	105.11 cm ²
SI	-	22.31

No. M11 Mimusops hexandra Roxb.

Fam	-	Sapotaceae
C.N.	-	Beng - Khirkhejur; Hin - Khirni; Mar - Rajan; Sans - Rajadani; Mals, Tam, and Tel - Pala.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By cutting
E/D	-	Evergreen
Flo.S.	-	Sept. - Nov.

CSA	-	4063.1 m ²
CS	-	Oblong / Round
LA	-	89.32 cm ²
SI	-	20.4

No. M12 Moringa oleifera Lomk.

Fom	-	Moringocee
C.N.	-	Drumstick tree, Horse Radish tree, Beng, Hin, Oriyo, Assam and Punjob - Sojino; Guj - Midho sorogovo; Kon - Nugge; Mol - Moringo; Mar - Shevgo; Sons - Shobhonjono; Tom - Murugoi, Tel - Mulogo.
S/T	-	S
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seeds, cutting
E/D	-	Deciduous
Flo.S.	-	Jon. - Apr.
CSA	-	23450.1 m ²
CS	-	Oblong
LA	-	14730 cm ²
SI	-	28.2

No. M13 Morus alba Linn.

Fom	-	Morocee.
C.N.	-	Tuti. Mulberry - Beng, Hin, Mar - Kashmir and Punjob - Tut. Guj - Shetur; Kon - Hipnerle; Oriyo - Tuto; Tom - Mosukette; Tel - Reshmechettu, Pippoliponduchettu.
S/T	-	S
HA	-	Tree
HT	-	8m

GR	-	Quick growing
R	-	By seeds, cutting, grafting, budding
E/D	-	Evergreen
Flo.S.	-	Feb. - June.
CSA	-	1047.62 m ²
CS	-	Oblong
LA	-	285.3 cm ²
SI	-	17.4

No. M14 Murraya paniculata Linn

Fam	-	Rutaceae.
C.N.	-	Beng - Kamini; Hin - Marchula; M.P. and Guj - Chulajuti; Kan - Pandry, Tam - Simaikkonji; Tel - Nagagolunga.
S/T	-	T
HA	-	Shrub
HT	-	5m
GR	-	Quick growing
R	-	By seeds, cutting
E/D	-	Evergreen
Flo.S.	-	June. - Oct.
CSA	-	1354.61m ²
CS	-	Round
LA	-	35.3cm ²
SI	-	10.31

No. N1 Nerium indicum Mill.

Fam	-	Apocynaceae
C.N.	-	Pink oleander; Hin and Punjab - Kaner; Beng - Karabi; Mal - Karaviram; Mar - Kanhera; Tam, Tel- Karaviram
S/T	-	T
HA	-	Shrub

HT	-	5m	1701
GR	-	Quick growing	
R	-	By cutting	
E/D	-	Evergreen	
Flo.S.	-	Throughout the year	
CSA	-	5747.63 m ²	
CS	-	Oblong / Round	
LA	-	32.62 cm ²	
SI	-	15.7	

No. N2 Nyctanthus arbor-tristis Linn

Fam	-	Oleaceae
C.N.	-	Hin, Beng and Punjab -Harsinghar; Guj - Harsingara; Mar - Parijatak; Mal - Mannapu; San - Sephalika; Tam - Pavala - malligai; Tel - Sepali.
S/T	-	T
HA	-	Shrub
HT	-	5m
GR	-	Quick growing
R	-	By seeds, cutting
E/D	-	Deciduous
Flo.S.	-	More or less throughout the year
CSA	-	546.3 m ²
CS	-	Oblong / Round
LA	-	88.1 cm ²
SI	-	14.73

No. O1 Ouginia oojeinensis (Roxb). Hochr.

Fom	-	Fabaceae
C.N.	-	Beng - Tinis; Guj - Tonoch; Hin - Sandon; Kan - Kari - Honne; Mal - Molavonno; Mar - Kalaphulos; Oriyo - Banjar;

Tam - Narva; Tel - Tellamoduga;
M.P. - Tinsa; Bihar - Ruta; Trade - Sandan.

S/T - T
HA - Tree
HT - 12m
GR - Quick growing
R - By seeds, Root cutting
E/D - Deciduous
Flo.S. - Feb. - March

No. P1 Peltophorum pterocarpum (DC) Backer.

Fam - Caesalpinaceae.
C.N. - Copper pod tree.
S/T - T
HA - Tall tree
GR - Quick growing
R - By seeds.
E/D - Evergreen.
Flo.S.- May - Sept
CSA - 231045.3 m²
CS - Oblong/Round.
LA - 370.7 cm²
SI - 16.68

No. P2 Phoenix sylvestris (L) Roxb.

Fam - Arecaceae.
C.N. - The Wild datepalm; Beng & Hin - Khajur.
Guj - Kharak; Kan - Ichalu; Mar - Shindi;
Oriya - Khajuri; Tam - Icham; Tel - Peddaetta.
S/T - T
HA - Tree
HT - 10m
GR - Slow growing

1703

R	-	By seeds.
E/D	-	Evergreen.
Flo.S.	-	Jan. - Feb.
CSA	-	546.1 m ²
CS	-	Round.
LA	-	411.32 cm ²
SI	-	12.4

No. P3 Phyllanthus acidus (L)

Fam	-	Euphorbiaceae.
C.N.	-	Country gooseberry; Beng - Hariphol, Noari; Hin - Harfarauri; Guj., M.P. - Harporawari; Tam - Kadalai; Tel - Sanagalu; Sans - Chanako.
S/T	-	T
HA	-	Tree
HT	-	8 m
GR	-	Quick growing
R	-	By seeds, Cutting, Budding.
E/D	-	Deciduous.
Flo.S.	-	Feb. - May.
CSA	-	5647.5 m ²
CS	-	Oblong.
LA	-	543.03 cm ²
SI	-	11.78

No. P4 Pinus khasiana

Fam	-	Pinaceae.
C.N.	-	Khasipine.
S/T	-	S
HA	-	Tree
HT	-	10m
GR	-	Slow growing
R	-	By seeds.

E/D - Evergreen.
 Flo.S.- May - June, Sept. - Oct.
 CS - Round.

No. P5

Pinus roxburghii

Fam - Pinaceae.
 C.N. - Hin - Chilgozo; N.W.H.P. - Chiri.
 S/T - S
 HA - Tree
 HT - 10m
 GR - Slow growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - May - June, Sept. - Oct.
 CS - Round.

No. P6

Pinus wallichiana A.B.Jackson

Fam - Pinaceae.
 C.N. - Chir pine.
 S/T - S
 HA - Tree
 HT - 12m
 GR - Slow growing
 R - By seeds.
 E/D - Evergreen.
 Fla.S. - May - June, Sept. - Oct.
 CS - Round.

No. P7

Pithecellobium ducle (Roxb.) Benth

Fam - Mimosaceae.
 C.N. - Manila tamarind, Madras thorn;
 Beng - Dekhani babul, Hin - Vilayatimili;
 Jungle jalebi; Kan - Kottampuli;

Mal - Karukkalpuli; Mar - Vilayati chinat;
 Tam - Kadukkaapuli; Tel - Seema chinta.

S/T	-	T
HA	-	Tree
HT	-	8 m
GR	-	Quick growing
R	-	By seeds, Branch cutting.
E/D	-	Evergreen.
Fla.S.	-	Jan. - Feb.
CSA	-	2564.75 m ²
CS	-	Oblang.
LA	-	182.6 cm ²
SI	-	11.78

No. P8 Painciana pulcherrima Linn (R. Grah.)

Fam	-	Caesalpinaceae.
C.N.	-	Beng - Krishnachura; Hin - Guletura; Guj - Sandheshara; Mar. - Shankasur; Sansa & Tel - Ratnagandhi; Mal. - Settimandaram; Tam - Mayuram; Tel - Ratnagandhi.
S/T	-	T
HA	-	Shrub
HT	-	3 m
GR	-	Quick growing
R	-	By cutting.
E/D	-	Evergreen.
Fla.S.	-	Oct. - Jan.
CSA	-	8034.67 m ²
CS	-	Oblang.
LA	-	214.01 cm ²
SI	-	13.4

- Fam - Anonaceae.
 C.N. - Hin & Beng - Devdaru; Guj - Asupala;
 Mar - Ashok; Kan - Putrajivi; Mal - Ashokam;
 Tam - Asogam; Tel - Asokamu.
 S/T - S
 HA - Tree
 HT - 15 or 5 m
 GR - Quick growing
 R - Through seeds (fresh).
 E/D - Evergreen.
 Flo.S. - April - June.
 CSA - 10,976.62 m² rounded crown.
 CS - Conical or Rounded
 LA - 55.06 cm²
 SI - 22.27

No. P10

Populus alba Linn

- Fam - Salicaceae.
 C.N. - White poplar; N.W. Himal - Chitta bagnu;
 Jangli frost. Kashmir - Fras.
 S/T - S
 HA - Tree
 HT - 15 m
 GR - Quick growing
 R - By seeds, stem, root cutting, root sucker.
 E/D - Deciduous.
 CS - Oblong.

No. P11

Populus ciliata Wall.

- Fam - Salicaceae.
 C.N. - Himalayan poplar; Beng - Bangikat;
 Jaunsar - biao, piplas, kumaun; Syan;

- 1707
- S/T - S
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds, stem, root cutting, root sucker.
 E/D - Deciduous.
 CS - Oblong.

No. P12 Populus deltoides Bartr.

- Fam - Salicaceae.
 C.N. - Carclone poplar, Eastern cottonwood Necklace polar.
 S/T - S
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds, stem, root cutting, root sucker.
 E/D - Deciduous.
 CS - Oblong.

No. P13 Populus euphratica Olivier

- Fam - Salicaceae.
 C.N. - Indian poplar. Punjab & N.W.H.P-Bahan, bhan; Ladakh - Hotung, hondung.
 S/T - S
 HA - Tree
 HT - 10 m
 GR - Quick growing
 R - By seeds, stem, root cutting, root sucker.
 E/D - Deciduous.
 CS - Oblong.

No. P14 Populus nigra Linn

- Fam - Salicaceae.
 C.N. - Lombardy - poplar; N.W.H.P. - Frost.
 S/T - S
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds, stem, root cutting, root sucker.
 E/D - Deciduous.
 CS - Conical.

No. P15 Prosopis chilensis (Malina) stuntz.

- Fam - Mimos eae.
 C.N. - Mesquite; Guj - Gandaa babul, Pardesi babul;
 Hin - Vilayati kikkar; Vilayati babul, Kabuli
 kikkar.
 S/T - T
 HA - Tree
 HT - 10 m
 GR - Quick growing
 R - By seeds, root suckers.
 E/D - Evergreen.
 Flo.S. - Dec. - April.
 CSA - 7950.68 m²
 CS - Spreading.
 LA - 51.05 cm²
 SI - 19.23

No. P16 Prosopis cineraria Linn.

- Fam - Mimos eae.
 C.N. - Beng & Oriya - Shami; Hin - Khejri;
 Guj - Sami, Khijado; Kan - Banni;
 Mal - Parampu, Tomba; Mar - Shami;

S/T	-	T
HA	-	Tree
HT	-	12 m
GR	-	Quick growing
R	-	By seeds, root suckers.
E/D	-	Evergreen.
Flo.S.	-	Dec. - April.
CSA	-	13,430.6 m ²
CS	-	Spreading.
LA	-	54.23 cm ²
SI	-	18.1

No. P17 Prosopis pallida (H & B ex Willd)

Fam	-	Mimos eae.
S/T	-	T
HA	-	Tree
HT	-	10 m
GR	-	Quick growing
R	-	By seeds, root suckers.
E/D	-	Evergreen.
Flo S.	-	Dec. - April.
CS	-	Spreading.

No. P18 Prosopis stephaniana Kunth.

Fam	-	Mimos eae.
S/T	-	T
HA	-	Shrub
HT	-	5 m
GR	-	Quick growing
R	-	By seeds, root suckers.
E/D	-	Evergreen.
Flo.S.	-	Dec. - Feb.
CS	-	Spreading.

No. P19 Prosopis tamarugo Fil. Phil.
 Fam - Mimos eae.
 S/T - T
 HA - Tree
 HT - 13 m
 GR - Quick growing
 R - By seeds, root suckers.
 E/D - Evergreen.
 Flo.S. - Dec. - April.
 CS - Spreading.

No. P20 Psidium guayava Linn.
 Fom - Myrtaceae.
 C.N. - Guava tree. Beng - Peyara;
 Hin & Punjab - Amrud; Guj - Perala;
 Sons - Mansola; Tam, Mal - Koyya;
 Tel - Goyya; Mar - Peru
 S/T - T
 HA - Tree
 HT - 5 m
 GR - Quick growing
 R - By cutting, seeds, Budding, Grafting.
 E/D - Evergreen.
 CSA - 9,243.1 m²
 CS - Oblong.
 LA - 53.66 cm²
 SI - 28.38

No. P21 Pterygota alata var. irregularis (W.W.Smith)
 Fom - Sterculioceae
 C.N. - Assam - Tula; Kan - Bekaro, Mol - Porutonti;
 Tam - Kodiottondi.
 S/T - T

HA	-	Tree	1711	161
HT	-	15 m		
GR	-	Quick growing		
R	-	By seeds, cuttings.		
E/D	-	Semi deciduous.		
Flo.S.	-	Mar. - April.		
CSA	-	179,320.8 m ²		
CS	-	Rround/Oblong		
LA	-	189.4 cm ²		
SI	-	22.04		
CS	-	Rround/Oblong		
LA	-	189.4 cm ²		
SI	-	22.04		

No. Q1 Quercus palustris

Fam	-	Fagaceae.
C.N.	-	Oak.
S/T	-	T
HA	-	Tree
HT	-	15 m
GR	-	Quick growing
E/D	-	Deciduous.
CS	-	Round.

No. Q2 Quercus petraea

Fam	-	Fagaceae.
C.N.	-	Oak.
S/T	-	T
HA	-	Tree
HT	-	15 m
GR	-	Quick growing
E/D	-	Deciduous.
CS	-	Round.

Fam	-	Fagaceae.
C.N.	-	Oak.
S/T	-	T
HA	-	Tree
HT	-	15 m
GR	-	Quick growing
E/D	-	Deciduous.
CS	-	Round.

No. R1

Ricinus communis Linn.

Fam	-	Euphorbiaceae.
C.N.	-	The castor; Beng - Bheranda; Guj - Divaligo; Hin & Mar. Erandi; Kan-Haralu; Mal - Avanakku; Tam - Amanakku; Tel - Aamudamuchettu.
S/T	-	T
HA	-	Shrub
HT	-	6 m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Evergreen.
Flo.S.	-	Sept. - Oct.
CSA	-	942.56 m ²
CS	-	Oblong.
LA	-	243.5 cm ²
SI	-	15.71

No. S1

Salix albo Linn.

Fam	-	Salicaceae.
C.N.	-	European willow; White willow. Kashmir - Butvir, Vivir; H.P. Punjab - Bisbhushan, Madnu, Malchang.
S/T	-	T

HA - Tree 1713
 HT - 20 m
 GR - Quick growing
 R - By stem cutting, root cutting.
 E/D - Deciduous.
 Flo.S. - Mar. - May.
 CS - Oblong/Round.

163

No. S2 Salix babylonica Linn.

Fam - Salicaceae.
 C.N. - Weeping willow. Garhwal - Gadhbanis;
 Kashmir - Biosa, Guir; Punjab - Biosa;
 Tel - Attuppalai,
 S/T - T
 HA - Tree
 HT - 10 m
 GR - Quick growing
 R - By stem, root cutting, suckers.
 E/D - Deciduous.
 Flo.S. - Mar. - May.
 CS - Round.

No. S3 Salix caprea Linn.

Fam - Salicaceae.
 C.N. - The sallow, goat willow
 Hin & Punjab - Bedmushk.
 S/T - T
 HA - Shrub
 HT - 5 m
 GR - Quick growing
 R - By cutting.
 E/D - Deciduous.

Flo.S. - Mar. - May
CS - Round/Oblong.

164

1714

No. S4 Salix fragilis Linn.

Fam - Salicaceae.
C.N. - Crack or Kashmir willow; H.P. Tilchang.
S/T - T
HA - Tree
HT - 18 m
GR - Quick growing
R - By seeds, cutting.
E/D - Deciduous.
Flo.S. - Mar. - May.
CS - Oblong/Round.

No. S5 Salix tetrasperma Roxb.

Fam - Salicaceae.
C.N. - Indian willow; Beng - Panijama; Hin - Bod.
jalma; Kan - Niravanji; Mal & Tam - Vanji;
Mar - Wallunj; Oriya - Baisi; Tel - Eetipoala;
Assam - Veh; Kashmir - Vir, bin;
Khasi -Jamyneri; M.P. Dhanie; Punjab - Bis, Bain
S/T - T
HA - Tree
HT - 15 m
GR - Quick growing
R - By cutting.
E/D - Deciduous.
CS - Round.

No. S6 Samanea samon Jacq.

Fam - Mimos eae.
C.N. - Rain Tree.

S/T	-	T
HA	-	Tree
HT	-	20 m
GR	-	Quick growing
R	-	By seeds cutting.
E/D	-	Evergreen.
Flo.S.	-	Mar. - June
CSA	-	99306.2 m ²
CS	-	Spreading/Round.
LA	-	282.6 cm ²
SI	-	15.64

No. S7 Sapindus emarginatus Vahl.

Fam	-	Sapindaceae.
C.N.	-	Soapnut; Assam - Haithaguti; Beng - Ritha; Mar- Ritha; Sans - Phenila.
S/T	-	T
HA	-	Tree
HT	-	10 m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Evergreen.
Flo.S.	-	Oct. - Dec.
CSA	-	43,789.24 m ²
CS	-	Oblong/Round.
LA	-	110.6 cm ²
SI	-	23.6

No. S8 Sapium sebiferum Roxb

Fam	-	Euphorbiaceae
C.N.	-	Makhan tree. Chinese Tallow Tree.
S/T	-	T
HA	-	Tree

HT	-	12 m	1716
GR	-	Quick growing	
R	-	By seeds.	
E/D	-	Deciduous.	
Fla.S.	-	June - Aug.	
CSA	-	24980.3 m ²	
CS	-	Raund.	
LA	-	74.2 cm ²	
SI	-	14.2	

Na. S9 Saraca asoka Roxb. De Wilde.

Fam	-	Caesalpinaceae.
C.N.	-	Hin & Mar - Ashak, Punjab & Beng - Asak; Mar - Asaka; Sans - Ashaka; Tam - Asagam; Tel - Asakamu.
S/T	-	T
HA	-	Tree
HT	-	5 m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Evergreen.
Fla.S.	-	Dec - May.
CSA	-	2295.2 m ²
CS	-	Spreading.
LA	-	68.8 cm ²
SI	-	17.93

Na. S10 Sesbania grandiflora Pers.

Fam	-	Fabaceae.
C.N.	-	Swamp - pea, Agathi; Kan - Agase; Mal- Mathi; Mar - Hadga, Agasta; Oriya - Ogasti; Tam - Agathi; Tel - Arise - chetta.
S/T	-	T

HA - Tree **1717**
 HT - 10 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Fla.S. - Sept. - Dec.
 CSA - 4694.87 m²
 CS - Oblang.
 LA - 130 cm²
 SI - 20.45

167

Na. S11 Sesbania sesban (Linn) Merrill.

Fam - Fabaceae.
 C.N. - Camman sesban; Beng & Hin - Jainti;
 Guj - Jayati; Kan - Arisinajeenangimera;
 Mal - Sempa; Mar - Jayanti, Shewarie;
 Oriya - Jayantei; Sans - Jayantika;
 Tam - Chittagathi; Tel - Samintha;
 Assam - Joyantri; Punjab - Joint.
 S/T - T
 HA - Shrub
 HT - 6 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Fla.S. - Aug. - Dec.
 CSA - 4563.7 m²
 CS - Oblang.
 LA - 118.3 cm²
 SI - 19.2

Na. S12 Sesbania speciosa Taub.

Fam - Fabaceae.

C.N.	-	Tam - Seemaiyothi.
ST	-	T
HA	-	Shrub
HT	-	4 m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Evergreen.
Fla.S.	-	Sept. - Dec.
CS	-	Oblang.

Na. S13 Soymida febrifuga A. Juss

Fam	-	Meliaceae.
C.N.	-	Indian Red wood, Beng & Hindi Mar - Rahan; Guj - Rahina; Kan - Suani; Oriya - Sahan; Tam - Shem; Tel - Sumi, Sanidamaanu.
S/T	-	T
HA	-	Tree
HT	-	15 m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Deciduous.
Fla.S.	-	Mar.
CSA	-	78325.4 m ²
CS	-	Raund/Oblang.
LA	-	49.7 cm ²
Sl	-	20.3

Na. S14 Spathodea campanulata Beauv.

Fam	-	Bignoniaceae
C.N.	-	Indian Tulip tree
S/T	-	T
HA	-	Tree
HT	-	12 m

1719

GR - Quick growing
 R - By seeds, cutting.
 E/D - Evergreen.
 Flo.S. - Nov. - Jan.
 CSA - 73,250.17 m²
 CS - Oblong / Round
 LA - 89.3 cm²
 SI - 24.84

169

No. S15 Spondias pinnata (L.f.)

Fam - Anacardiaceae.
 C.N. - Hin - Bemg & Mar - Amra; Kan - Ambate;
 San - Amratoka; Tam - Mabulichy;
 Tel - Amratakamul; Mal - Mapuli.
 S/T - T
 HA - Tree
 HT - 10 m
 Gr - Quick growing after 1st year.
 R - By seeds.
 E/D - Deciduous.
 Flo.S. - Feb. - Apr.
 CSA - 25587.31 m²
 CS - Round.
 LA - 130.64 cm²
 SI - 22.9

No. S16 Sterculia foetida Linn.

Fam - Sterculiaceae.
 C.N. - Jangli badam, Hin & Mar - Jangli badom;
 Kan - Penari; Tam & Mal - Pinari;
 Tel - Manjiponaku.
 S/T - T
 HA - Tree

HT - 15 m **1720**
GR - Quick growing
R - By seeds.
E/D - Deciduous.
Flo.S. - Mar. - May.
CS - Oblong/Round.

170

No. S17 Sterculia guttata Roxb.

Fam - Sterculiaceae.
C.N. - Kukur, Golder.
S/T - T
HA - Tree
HT - 15 m
GR - Quick growing
R - By seeds.
E/D - Deciduous.
Flo.S. - Jan. - Feb.
CS - Oblong/Round.

No. S18 Strychnos nux-vomica Linn

Fam - Loganiaceae.
C.N. - Beng & Punjab - Kuchila; Hin - Kuchla; Kan-
Kanjira; Mal - Kanniram; Mar - Kajra;
Sans - Visha - mushti; Tam - Etti; Tel - Mushti.
S/T - T
HA - Tree
HT - 12 m
GR - Quick growing
R - By seeds.
E/D - Deciduous.
Flo.S. - Mar. - April
CSA - 1067.441 m²
CS - Oblong/Round.

LA - 67.37 cm²

SI - 12.87

1721

171

No. S19 Syncarpia glomulifera Sm.

Fom - Myrtoceoe

C.N. - Turpentine tree.

S/T - T

HA - Tree

HT - 20 m

GR - Quick growing

R - By seeds.

E/D - Evergreen.

CS - Oblong/Round.

No. S20 Syzygium cumini Linn

Fom - Myrtoceoe.

C.N. - Block plum; Beng - Kolojom; Guj - Jombu;
Hin & Punjab - Jomon; Mar - Jombhul;
Kon - Nerole; Mol - Perinnorol; Oriyo - Jomo;
Tom - Neredum; Tel - Neereedu.

S/T - T

HA - Tree

HT - 20 m

GR - Quick growing

R - By seeds, cuttings. Grafting. Budding.

E/D - Evergreen.

Flo.S. - Mar. - May.

CSA - 112143.2 m²

CS - Oblong/Spreading.

LA - 77.82 cm²

SI - 20.60

No. T1 Tabernaemontana divaricata Linn.

172

- Fam - Apocynaceae.
C.N. - Beng, Mar, Hin & Sans - Tagar, Chandani;
Tam - Nandiyavattam; Tel - Gandhitagarapu.
S/T - T
HA - Shrub
HT - 3m
GR - Quick growing
R - By cutting.
E/D - Evergreen.
Fla.S. - Thraughout the year.
CSA - 128.67 m²
CS - Round.
LA - 47.81 cm²
SI - 30.2

No. T2 Tamarindus indica Linn.

- Fam - Caesapinaceae.
C.N. - The Tamarind tree; Beng - Anbli, Tentuli; Guj &
Kan - Amlī; Hin - Imli; Mal - Amlam, Puli;
Mar - Chinch; Oriya - Tentuli;
Tam - Amilam pul; Tel - Chintachettu;
Assam - Tetuli; Punjab - Imbli.
S/T - T
HA - Tree.
HT - 20 m
GR - Quick growing (Early)
R - By seeds.
E/D - Evergreen.
Fla.S. - April - Oct.
CSA - 276839.5 m²
CS - Spreading.

LA - 128.60 cm²
SI - 18.4

1723

173

No. T3 Tecoma stans Linn.

Fom - Bignoniaceae.
C.N. - Kon - Koreneklor; Tom - Sono - Patti;
Tel - Pochogotlo
S/T - T
HA - Shrub
HT - 5 m
GR - Quick growing
R - By seeds, cutting.
E/D - Evergreen.
Flo.S. - Feb. - April
CSA - 61.23 m²
CS - Oblong.
LA - 43.7 cm²
SI - 23.8

No. T4 Tectono grandis Linn.

Fom - Verbenaceae.
C.N. - Teak; Beng - Segun; Hin & Mar - Sogwon;
Guj- Sago; Kon - Tego; Mol & Tom - Thekku;
Oriyo - Singuru; Tel - Adoviteeku, Peddottek;
Assam - Chingjogu.
S/T - T
HA - Tree
HT - 20 m
GR - Quick growing
R - By seeds.
E/D - Deciduous.
Flo.S. - June - Sept.
CSA - 10272.14 m²

CS - Oblong/Round
LA - 790.37 m²
SI - 23.48

1724

174

No. T5 Terminalia alata Heyne ex Roth.

Fam - Combretaceae.
C.N. - Laurel; Beng - Asan; Guj - Sadar; Hin - Asan,
Sain, Saj; Kan - Sadada; Mar - Ain;
Oriya - Sahaju; Tam - Karramarda,
Tel - Nallamaddi.
S/T - T
HA - Tree
HT - 20 m
GR - Quick growing
R - By seeds, cutting.
E/D - Deciduous.
Flo.S. - May - July.
CS - Oblong/Round.

No. T6 Terminalia arjuna (Roxb) Wight & Arn.

Fam - Combretaceae.
C.N. - Arjun, Arjhan; Beng - Guj - Sadado; Hin &
Punjab - Arjuna; Kan - Maddi; Mar - Sadaru,
vellamarda; Oriya - Arjuno, sahaajo;
Tam - Vellamatta; Tel - Yerramaddi;
Assam - Orjun.
S/T - T
HA - Tree
HT - 15 m
GR - Quick growing
R - By seeds, cutting, air layering.
E/D - Deciduous.
Flo.S. - April - July.

CSA - 719,992.2 m²
CS - Oblong/Round
LA - 60.06 cm²
SI - 24.57

1725

175

No. T7 Terminalia bellerica (Gaertn) Roxb

Fam - Combretaceae.
C.N. - Belleric myrobalan; Beng Bhairah; Hin - Bahera;
Mal & Tam - Tani; Mar - Beheda;
Oriya - Bhara, Tel - Thandrakoaya.
S/T - T
HA - Tree
HT - 15 m
GR - Quick growing
R - By seeds, cuttings.
E/D - Deciduous.
Flo.S. - April - May.
CSA - 82813.9 m²
CS - Oblong/Round
LA - 63.20 cm²
SI - 19.06

No. T8 Terminalia catappa Linn.

Fam - Combretaceae.
C.N. - The Indian Almond tree; Beng - Badam;
Hin - Deshi badam; Mal - Adamarram;
Tam - Natvadam; Tel - Boadamuchettu, Vedam.
S/T - T
HA - Tree
HT - 10 m
GR - Quick growing
R - By seeds.
E/D - Deciduous.

Flo.S. - Oct.- Nov **1726**

176

CSA - 94367.4 m²

CS - Conical

LA - 62.01 cm²

SI - 20.9

No. T9 Terminalia chebula Retz.

Fam - Combretaceae.

C.N. - Chebulic myrobalan; Beng - Horitaki;
Guj - Hardo; Hin - Harra; Mar - Hirda;
Oriyo - Haridra; Tam - Kadukkai;
Tel - Karakkaaya; Assam - Silikha; Punjab - Har

S/T - T

HA - Tree

HT - 15 m

GR - Quick growing

R - By seeds.

E/D - Deciduous.

Flo.S. - Mar.- Oct.

CSA - 82,314.16 m²

CS - Round/Oblong.

LA - 60.60 cm²

SI - 19.06

No. T10 Thespesia populneoides (Roxb) Kastel.

Fam - Molvaceae.

C.N. - Umbrella tree, Indian Tulip tree, Beng - Dumbra,
porespipal; Guj - Paarsapeepala;
Hin & Punjab - Paraspipal; Kan - Hoovorase;
Mal - Poovarasu; Mar - Bhendi;
Oriya - Gunjausto; Sans - Gardhobhanda;
Tom - Chelanthi; Tel - Gangaraavichettu.

S/T - T

HA	-	Tree	1727
HT	-	10 m	
GR	-	Quick growing	
R	-	By seeds, cuttings.	
E/D	-	Evergreen.	
Flo.S.	-	Throughout the year.	
CSA	-	34,635.32 m ²	
CS	-	Round	
LA	-	184.39 cm ²	
SI	-	29.81	

177

No. T11 Thevetia peruviana (Pers.) Merrill.

Fam	-	Apocynaceae.
C.N.	-	Yellow oleoner; Beng - Koklaphul, Haldi korubi; Guj & Hin - Pila kaner; Kan - Kodukasi; Mal - Monjaareli; Mar - Pivola konhera; Bitti Oriya - Konyorphul; Tom - Pachoiyalari; Tel - Pochoganneru.
S/T	-	T
HA	-	Shrub
HT	-	6m
GR	-	Quick growing
R	-	By seeds, cutting.
E/D	-	Evergreen.
CSA	-	21,775.22 m ²
CS	-	Round / Oblong.
LA	-	11.08 cm ²
SI	-	27.8

No. T12 Thuja occidentalis Linn.

Fam	-	Cupressaceae.
C.N.	-	American Arborvitae, White cedar.
S/T	-	T

HA - Tree 1728
HT - 15 m
GR - Quick growing
R - By cutting.
E/D - Evergreen.
CS - Conical

178

No. T13 Thuja plicata D. Don.

Fam - Cupressaceae.
C.N. - Giant arborvitae, Western red cedar.
S/T - T
HA - Tree
HT - 20 m
GR - Quick growing
R - By cutting.
E/D - Evergreen.
CS - Conical

No. T14 Trema orientalis Blume

Fam - Ulmaceae.
C.N. - Charcoal tree. Indian nettle tree. Beng - Chikan;
Guj & Mar - Gol; Hin - Gio; Kan - Gorklu;
Mal - Ama; Oriya - Kharkas; Tam - Ambaratthi;
Tel - Bundamuru;
S/T - T
HA - Tree
HT - 6 m
GR - Quick growing
R - By seeds, stumps.
E/D - Evergreen.
Flo.S. - Throughout the year.
CSA - 42,5734.1 m²
CS - Round/Oblong.

LA - 65.7 cm²
SI - 27.30

1729

179

No. V1 Ulmus wallichiana Planch.

Fam - Ulmaceae.
C.N. - Hin - Mored pabuna; Kashmir - Brari;
Kumoun - Moral; Punjab - Kain.
S/T - T
HA - Tree
HT - 15 m
GR - Quick growing
R - By seeds.
E/D - Evergreen.
CS - Round

No. Z1 Zizyphus mauritiana Vor. Fruticoso

Fom - Rhomnoceoe.
C.N. - Indian jujube; Beng & Hin - Ber; Guj - Bordi;
Kon - Elonji; Mol & Tom - Elentha;
Mar - Bero, bor; Oriyo - Bodori;
Son - Korokandhy; Tel - Reegu.
S/T - T
HA - Tree
HT - 10 m
GR - Quick growing (Early)
R - By seeds.
E/D - Evergreen.
Flo.S. - April - Oct.
CSA - 2638.17 m²
CS - Round
LA - 24.08 cm²
SI - 12.4

No. Z2

Zizyphus oenoplia Mill

- Fam - Rhamnaceae.
 C.N. - Jackal jujube; Beng - Siakul; Hin - Makai;
 Kan - Barige; Mal - Kottavalli;
 Oriya - Kantokalli; Tam - Ambulam;
 Tel - Banka paragi.
- S/T - T
 HA - Straggler shrub.
 HT - 5 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - April - June.
 CS - Round

No. Z3

Zizyphus rugosa Lamk.

- Fam - Rhamnaceae.
 C.N. - Hin - Suran; Mar - Turan - Torni,
 Kan - Mahigotte; Mal - Malantutali;
 Tam - Kattilandai; Tel - Pinduparigham.
- S/T - T
 HA - Straggler shrub.
 HT - 5 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - Dec. - Feb.
 CS - Round

No. Z4

Zizyphus xylopyra Willd.

- Fam - Rhamnaceae.
 C.N. - Hin - Kat - ber; Kan - Mullukare;
 Mar - Koddntegoti; Oriya - Goteoboro,

- S/T - T
- HA - Straggler shrub.
- HT - 4 m
- GR - Quick growing
- R - By seeds.
- E/D - Evergreen.
- Flo.S. - April - June.
- CS - Round

Zonewise recommendation of plant species for constitution of Green Belt :

Note for the use of Appendix C :

For listing plant species for cultivation in on oreo of concern, please follow the following steps.

1. Place the oreo (os per District) of your concern in subzone and zone, after referring to Appendix A.
2. Refer to Appendix C of corresponding zone (Cz) and subzone (I.1, II.3, V.2 etc.).
3. List the alphabets and numbers under zone and subzone (e.g. Cz V.2 - A 1, 2, 3, 4, 5 etc.; B - 1, 2, 3, 4 etc.; C - 2, 3, 4, 12 etc.)separotely on sheets.
4. Decipher the above numbers from Appendix B. (e.g. A - 1 - Abutilon indicum, A - 2 - Acacia ouriculiformis etc.; B - 1 - Balanites roxburghii, B - 2 - Bambusa arundinocia, etc.; C - 2 - Callistemon citrinus, C - 3 - Calophyllum inophyllum, C - 4 - Calotropis gigantea etc. and so on.

Completion of the exercise will mean that your list of plants for cultivation in the area of concern is ready. Detailed information, useful for agronomic and other aspects, is available in Appendix B.

Cz I. Western Himalayan Region

Cz I.1 - **A** - 3,4,7,9-11,13,16,17,19,22-26,28-35,41,44;
B - 6-12,16; **C** - 14,21,22; **D** - 1; **E** - 4-6; **F**
 - 1-4; 7-9; **G** - 6-8; **H** - 4; **I** - 1,2; **J** - 2; **L**
 - 3,4; **M** - 1,8; **N** - 1,2; **O** - 1; **P** - 4-6, 10
 - 14; **Q** - 1-3; **S** - 1-5,8,15; **T** - 1-3, 6, 7,9,
 12,13; **U** - 1; **Z** - 1

- Cz I.2 - A** - 3,4,7,9-11,13,16,17,19,22-26,28-35,39,41, 44; **B** - 4,6-17; **C** - 2-5,14,18,21,22; **D** - 1,4; **E** - 1,4-6,8; **F** - 1-4,8; **G** - 4,6-8; **H** - 3,4; **I** - 1-3,5; **J** - 2; **L** - 3,4; **M** - 1,3,8,12,14; **N** - 1,2; **O** - 1; **P** - 4-6, 10-14,16,21; **Q** - 1-3; **S** - 1-5,7-10,14,15; **T** - 1-3,6,7,9,12,13; **U** - 1; **Z** - 1
- Cz I.3 - A** - 3,4,7,9-11,13,16,17,19,22-26,28-35,39,41, 44; **B** - 4,6-17; **C** - 2-5,9,11,14,18,21,22; **D** - 1,4,5; **E** - 1,2,4-6; **F** - 1-4,8; **G** - 3,4,6-8; **H** - 3,4; **I** - 1-3,5; **J** - 2; **L** - 1,4; **M** - 1, 3,8,12-14; **N** - 1,2; **O** - 1; **P** - 4-16; **Q** - 1 - 3; **S** - 2-5,7-10,14,15; **T** - 1-3,6,7,9,12,13; **U** - 1; **Z** - 1,3,4.
- Cz I.4 - A** - 1-4,7,10,11,13,16,17,19,22-26,28-32,34 - 36,39,41,44; **B** - 4,6-17; **C** - 2-8,9,14, 18,21, 22; **D** - 1,4,5; **E** - 1,2,4-6; **F** - 1-4,8; **G** - 3-4,6-8; **H** - 3,4; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 1,3,5,8,12-14; **N** - 1,2; **O** - 1; **P** - 4-16; **Q** - 1 - 3; **S** - 1-5,7-10,14,15; **T** - 1- 3,6,7,9,12-14; **U** - 1; **Z** - 1

Cz II. Eastern Himamlayan Region

- Cz II.1** - **A** - 1,3,4,7,10,11,13,14,16,17,19,22-26,28-36, 39-41; **B** - 1,4,6-17; **C** - 2-5,7-11,13-16,18, 20-22; **D** - 1,2,4,5,6; **E** - 1,2, 4-6; **F** - 1-4; 8; **G** - 6-8; **H** - 3, 4; **I** - 1-3, 5; **J** - 2; **L** - 1-3; **M** - 1,3,8,9,12-14; **N** - 1-2; **O** - 1; **P** - 4-6, 10 - 14; **Q** - 1-3; **R** - 1; **S** - 1-5,1-10,15; **T** - 1-3, 5-7,9,11,13,14; **U** - 1; **Z** - 1
- Cz II.2** - **A** - 1,3,4,7,8,10,11,13,14,16-26,28-36, 39-44; **B** - 1-4,6-17; **C** - 2-9,11,13-16,18-22; **D** - 1-6,8; **E** - 1-6; **F** - 1-8; **G** - 3,4,6-8; **H** - 3,4; **I** - 2,3,5; **J** - 1,2; **L** - 1-4; **M** - 1-3, 5, 8, 9,12-14; **N** - 1,2; **O** - 1; **P** - 4-6, 10-14,16, 21; **Q** - 1-2; **S** - 2-5,7-10,15,20; **T** - 1-3, 5-7,11,13,14; **U** - 1; **Z** - 1
- Cz II.3** - **A** - 1,3,4,7,8,10,11,13,14,16-26,28,29,32-36, 39-44; **B** - 1-4,6-17; **C** - 2-9,11,13-16,18-22; **D** - 1-8; **E** - 1-6; **F** - 1-8; **G** - 3,4,6-8; **H** - 3,4; **I** - 2,3,5; **J** - 1,2; **L** - 1-4; **M** - 1-3,5, 8,9,12-14; **N** - 1,2; **O** - 1; **P** - 4-10,12-16,21; **Q** - 1-3; **R** - 1; **S** - 2-5,7-10,15,20; **T** - 1-3, 5-7,11,13,14; **U** - 1; **Z** - 1

Cz II.4 - **A** - 1,3-5,7,9,10,11,13,14,16-26,28-44; **B** - 1-4, 6-17; **C** - 2-9,11,13-16, 18-20; **D** - 1-5,8; **E** - 1-6; **F** - 1-8; **G** - 3-4,6-8; **H** - 2-4; **I** - 1-3,5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 1-3,5,8,9, 12-14; **N** - 1,2; **O** - 1; **P** - 2,4-16,20,21; **Q** - 1 - 3; **R** - 1; **S** - 1-5,7-10,15,20; **T** - 1-3,5-7,9,13,14; **U** - 1; **Z** - 1

Cz II.5 - **A** - 1,3,5,7,8,10-14,16-26,28,29,31-44; **B** - 1-4, 6-17; **C** - 1-9,11,13-16, 18-20; **D** - 1-8; **E** - 1-6; **F** - 1-8; **G** - 3,4,6-8; **H** - 2-4; **I** - 1-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 1-3,5,8,9, 12-14; **N** - 1,2; **O** - 1; **P** - 2,4-16,20,21; **Q** - 1 - 3; **R** - 1; **S** - 1-5,7-10,15,20; **T** - 1-9,12, 14; **U** - 1; **Z** - 1

(West Bengal)

- Cz III.1** - **A** - 1,3-5,7,8,10-14,18-20,22,24-26,28-33,36-44; **B** - 1-10,12-16; **C** - 1-9,11-13,15-20, **D** - 1-4,7; **E** - 1-6; **F** - 1-8; **G** - 1,2-4,6-8; **H** - 3,4; **I** - 2-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,4-16,20,21; **Q** - 1-3; **R** - 1; **S** - 1-13,15-20; **T** - 1-3,6,7,9,11-14; **Z** - 1,3,4.
- Cz III.2** - **A** - 1,3-5,7,8,10-14,18-20,22,24-26,28-33,36-44; **B** - 1-10,12-16; **C** - 1-9,11-13,15-20, **D** - 1-5,7; **E** - 1-6; **F** - 1-8; **G** - 1,2-4,6-8; **H** - 1,3,4; **I** - 2-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,4-16,20,21; **Q** - 1-3; **R** - 1; **S** - 1-13,15-20; **T** - 1-3,5-7,9-14; **Z** - 1,3,4.
- Cz III.3** - **A** - 1,3-5,7,8,10-14,18-20,22,24-26,28-33,36-44; **B** - 1-10,12-17; **C** - 1-9,11-20, **D** - 1-5,7; **E** - 1-6; **F** - 1-8; **G** - 1-4,6-8; **H** - 1,3,4; **I** - 2-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,4-16,20,21; **Q** - 1-3; **R** - 1; **S** - 1-13,15-20; **T** - 1-14; **U** - 1; **Z** - 1,3,4.

Cz III.4 - **A** - 1,3-5,7,8,10-14,18-20,24-33,36-41; **B** - 1-10,12-16; **C** - 1-8,11-13,15-20; **D** - 1-5,7; **E** - 1-6; **F** - 1-6; **G** - 1,2-4,6-8; **H** - 1,3,4; **I** - 2-5; **J** - 1; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,4-16,20,21; **Q** - 1-3; **R** - 1; **S** - 1-13,15-20; **T** - 1-7,9-14; **Z** - 4.

- Cz IV.1** - **A** - 1, 3, 4,7,10-15,18,20,22,24-26,28-33,36-42,44; **B** - 1-4,6-10,12-16; **C** - 2-13,15,16,18-20; **D** - 1-5,7; **E** - 1-5; **F** - 1-3,5-7,9; **G** - 3,4,6-9; **H** - 1-4; **I** - 2,3,5; **J** - 1; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,7-9, 12-16,20,21; **R** - 1; **S** - 1-15,20; **T** - 1-4,6,7,9-12,14 **Z** - 1,3,4.
- Cz IV.2** - **A** - 1,3,4,7,10-15,18-20,21,24-26,28-30,32,33,36-44; **B** - 1-4,6-10,12-17; **C** - 2-13,15-20; **D** - 1-8; **E** - 1-3,5; **F** - 1-7,9; **G** - 3,4,6-9; **H** - 1-4; **I** - 2-5; **J** - 1; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,5-9,12-16,20, 21; **R** - 1; **S** - 1-15,20; **T** - 1-4,6,7,9-12,14; **Z** - 1,3,4.

Cz V. Upper Gangetic Plains**(Uttar Pradesh)**

Cz V.1 - A - 1-5,7,10-15,18,20-22,24-33,36-41,44; B - 1-4, 6-10,12-15,17; C - 2-16,18-20; D - 1-4,6-7; E - 2-5; F - 1-3,5-7,9; G - 3,4,6-9; H - 2-4; I - 1-5; J - 1,2; K - 1; L - 1-4; M - 2,3,5,8-14; N - 1,2; O - 1; P - 1-3, 5,7-9, 12-16, 19-21; R - 1; S - 1-17, 20; T - 1-3,6, 7,9-12,14; Z - 1,3,4.

Cz V.2 - A - 1-5,7,10-15,18,20-22,24-33,36-44; B - 1-4, 6-10,12-15,17; C - 2-12,15,16,18-20; D - 1-5,7,8; E - 2-5; F - 1-3,5,7,9; G - 3,4,6-9; H - 1-4; I - 1-5; J - 1,2; K - 1; L - 1-4; M - 2,3,5,8-14; N - 1,2; O - 1; P - 1-3,5,7-9,12-16,19-21; R - 1; S - 1-17,20; T - 1-3,6,7,9-12,14; Z - 1,3,4.

Cz V.3 - A - 1-5,7,10-15,18,20-22,24-26,28-33,36-44; B - 1,3,4,6-10,12-15,17; C - 2-12,15,16,18-20; D - 1-5,7,8; E - 2-5; F - 1-3, 5-7,9; G - 3,4,6-9; H - 1-4; I - 1-5; J - 1,2; L - 1-4; M - 2,3,5,8-14; N - 1,2; O - 1; P - 1-3,5,7,9,12-16,19-21; R - 1; S - 1-15,20; T - 1-4,6,9-12,14; Z - 1,3,4.

Cz VI.1 - A - 1-5,7,8,10-15,18,20,22,24-27,29-32,36-42, 44; **B** - 1-4,6-10,12-15,17; **C** - 2-13,15,16,18, 20; **D** - 1-8; **E** - 1-5; **F** - 1-3, 5-7,9; **G** - 3-4,6-9; **H** - 1-4; **I** - 1,3,4; **J** - 2; **K** - 1; **L** - 1-4, **M** - 2,5,8-14; **N** - 1,2; **O** - 1; **P** - 1-16,18-21; **R** - 1; **S** - 1-13,15,20; **T** - 1-3,6,7,9,11,14; **U** - 1; **Z** - 1,3,4.

Cz VI.2 - A - 1-5,7,8,10-15,18,20,22,24-26,29-32,36-42, 44; **B** - 1-4,6-10,12-15,17; **C** - 2-13,15,16,18, 20; **D** - 1-6,8; **E** - 1-5; **F** - 1-3,5-9; **G** - 3-4,6-9; **H** - 1-4; **I** - 1-3,5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,8-14; **N** - 1,2; **O** - 1; **P** - 1-3,7,9,12,15-17,19; **R** - 1; **S** - 1-13, 15,20; **T** - 1-3,6,7,9-12, 14; **U** - 1; **Z** - 1-4.

Cz VI.3 - A - 1-5,7,8,10-15,18,20,22,24,26,29-32,36-42, 44; **B** - 1,3,4,6-10,13-14,17; **C** - 2-13,15,16,18,20; **D** - 2-8; **E** - 3,5; **F** - 1-3,5-7,9; **G** - 3,4,6-9; **H** - 1-4; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,5,8-14; **N** - 1,2; **O** - 1; **P** - 1-3,7-9,12,15-17, 19-21; **R** - 1; **S** - 1-13,20; **T** - 1-4,6,9-11,14; **U** - 1; **Z** - 1-4.

- Cz VII.1 - A - 1,3,4,6,7,10-15,18-22,25,27,29-32,36-44; B - 1,3,4,6-10, 12-16; C - 2-11,13,15,16,18-20; D - 2-8; E - 2-5; F - 1-7,9; G - 3,4,6,8,9; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2-5,9-14; N - 1,2; O - 1; P - 1-3,5,7-9;12,13,15,16,19-21; R - 1; S - 5-18,20; T - 1-7,9-12; 14; Z - 1-4.**
- Cz VII.2 - A - 1,3,4,7,10,11,13-15,18-22,25,27,29-32,36-44; B - 1-4,6-10,12-16; C - 2-11,13,15,16,18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3,4,6,8,9; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2,3,5,9-14; N - 1,2; O - 1; P - 1-3,5,7,9;12,13,15,16,20,21; R - 1; S - 5-18,20; T - 1-7,9,11,14; Z - 1-4.**
- Cz VII.3 - A - 1,3,5,7,10-15,18-20,22,25,27, 29-32, 36-44; B - 1-4,6-10,12-16; C - 2-11,13,15,16,18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3,4,6,8,9; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2,3,5,9-14; N - 1,2; O - 1; P - 1,2,5,7-9;12-15,16,20,21; R - 1; S - 5,6,9,13-16, 18, 20; T - 1-7,9-12,14; Z - 1-4.**

Cz VII.4 - A - 1,3-5,7,10-15,18-20,22,25,27, 29-32, 36-44; B - 1-4,6-10,12-16; C - 2-11,13,15,16,18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3,4,6,8,9; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2,3,5,9,11-14; N - 1,2; O - 1; P - 1-3,5,7-9; 12,15,16,20,21; R - 1; S - 5,6,9-16,18-20; T - 1-7,9-12,14; Z - 1-4.

Cz VII.5 - A - 1,3-5,7,10-15,18-20,22,25-27, 29-32, 36-44; B - 1-4,6-10,12-16; C - 2-11,13,15,16,18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3,4,6,8,9; H - 2-5; I - 1-3,5; J - 2; K - 1; L - 1-4; M - 2,3,5,9,10-14; N - 1,2; O - 1; P - 1,3,7,9;12,15,16,20,21; R - 1; S - 5,6,13-15,18-20; T - 1-7,9-12,14; Z - 1-4.

- Cz VIII.1** - **A** - 1-4,7,10-15,18,20,22,24-27, 29-32, 36-44;
B - 1-4,6-10,13-17; **C** - 2-9,11,13,15,16,18-20; **D** - 2-8; **E** - 2-5; **F** - 1-7,9; **G** - 3,5,9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-16,19-21; **R** - 1; **S** - 5,6,8-13,20; **T** - 1-3,6,9,10,12,14; **Z** - 1-4.
- Cz VIII.2** - **A** - 1-4,7,10,11,13,14,18,20,22,24,25,27,29-44;
B - 1-4,6-10,12-17; **C** - 2-9,11,13,15,16,18-20; **D** - 2-8; **E** - 2-5; **F** - 1-7,9; **G** - 3-9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-16,19-21; **R** - 1; **S** - 5,6,8-13,20; **T** - 1-3,6,9,10,12,14; **Z** - 1,3,4.
- Cz VIII.3** - **A** - 1,3,4,8,10,11,13,14,18,20,22,25,27,29-32,36-44; **B** - 2-4,6-10,12-16; **C** - 2-11,13,15,16,18-20; **D** - 2-8; **E** - 1,3-5; **F** - 1,7,9; **G** - 3-6,8,9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,9-11; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,14-16,19-21; **R** - 1; **S** - 5-15,20; **T** - 1-4,6,7,9,11,14; **Z** - 1,3,4.

32,36-44; B - 1-4,6-10,12,14-17; C - 2-11,13,15,16,18-20; D - 2-8; E - 1,3-5; F - 1,7,9; G - 3-6,8,9; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2,3,5,9-14; N - 1,2; O - 1; P - 1-3,5,7,9,14, 16,19-21; R - 1; S - 5-13,20; T - 1-4,6,7,9,11, 14; Z - 1,3,4.

Cz VIII. 5 - A - 1,3,4,8,10,11,13,14,18,20,22,25,27,29-32,36- 44; B - 1-4,6-10,12,14-17; C - 2-11,13,15,16,18-20; D -2-8; E -1-5; F -1-7,9; G - 3-6,8,9; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2-5,9-14; N - 1,2; O - 1; P - 1-3,5,7,9,16,19-21;R -1; S - 5,6,8-13,20; T - 1-3,6,9,10,12,14; Z - 1,3,4.

Cz VIII.6 - A - 1,3,4,8,10,11,13,14,18,20,22,25,27,29-32,36-44; B - 1,3,4,6-10,12-17; C - 2-11,13,15,16,18 -20; D -2-8; E -1-5; F -1-7,9; G - 3-6,8,9; H - 1-3,5; I - 1-3,5; J - 2; K - 1; L - 1-4; M - 2, 3,5,9-14; N - 1,2; O - 1; P - 1-3,7,9,14-16,19-21; R - 1; S - 5,6,8-13,20; T - 1 - 3,6,9, 10,12,14; Z - 1,3,4.

Cz VIII.7 - A - 1,3,4,8,10,11,13,14,18,20,22,25,27,29,32,36-44; B - 1,3,4,6-10,12-17; C - 2-11,13,15,

16,18-20; **D** - 1,8; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8; **H** - 1-5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1,4; **M** - 2,3,5, 9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-16,19,20; **R** - 1; **S** - 5,6,8-13,20; **T** - 1-3,6,9, 10,12,14; **Z** - 1,3,4.

Cz VIII.8 - **A** - 1-4,7,8,10,11,13-15,18,20,22,25,29,32,36-44; **B** - 1,3,4,6-10,12-17; **C** - 2-11,13,15,16,18-20; **D** - 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1,4; **M** - 2,5, 9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-16,19-21; **R** - 1; **S** - 5,6,8-13,18,20; **T** - 1-4,6,7,9,12,14; **Z** - 1-4.

Cz VIII.9 - **A** - 1-5,8,10,11,13-15,20,22,25,29,30,32, 36-44; **B** - 1,3,6-10,12-14,16,17; **C** - 1-11,13,15, 16,18-20; **D** - 2-7; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,5, 9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,15, 16,19-21; **R** - 1; **S** - 5,6,8-13,18,20; **T** - 1-4,6,7,9,10-12,14; **Z** - 2,3,4.

Cz VIII.10 - **A** - 1-5,8,10,11,13-15,20,22,25,29,30,32,36-44; **B** - 2,3,6-10,12-14,16,17; **C** - 2-10,13,15,16,18-20; **D** - 2-7; **E** - 1-5; **F** - 1-7,9; **G** - 3-

4; M - 2,5, 9-14; N - 1,2; O - 1; P - 1-
3,5,7,9,15, 16,19-21; R - 1; S - 5,6,8-13,20;
T - 1-4,6,7,9 -12,14; Z - 1,3,4.

Cz VIII.11 - A - 1-5,7,8,10,11,13-15,18,20,22,25,29,30,32,
36 -38,40-44; **B - 1,3,6-10,12-14,16,17; C -**
2,4, 6-10,15,18-20; **D - 2-7; E - 1-5; F - 1-**
7,9; **G - 3-6,8; H - 1-3,5; I - 1-5; J - 2; K**
- 1; L - 1-4; M - 2,5,9,11-14; N - 1,2; O -
1; P - 1,2,5,7,9, 14-16,19-21; R - 1; S -
5,6,8-13,20; T - 1-4,6, 9-12,14; Z - 2,3,4.

Cz VIII.12 - A - 1-5,8,10,11,13-15,18,20,22,25,27,29,30,
32, 36-44; **B - 1-3,6-10,13,14,16,17; C -**
2,4,6-8, 13-15,18,20; **D - 2,3,5-7; E - 1-5; F**
- 1-7,9; G - 3-6,8; H - 1-3,5; I - 3,5; J -
2; K - 1; L - 1-4; M - 2,3,5,9-12,14; N -
1,2; O - 1; P - 1-3, 5,7,9,14-16,19-20; R -
1; S - 5-13,20; T - 1-4, 6,9,11,14; Z - 1-4.

Cz VIII.13 - A - 1-5,7,10,11,13-15,18,20,22,25,29,30,
32,36-44; **B - 1-3,6-10,13,14,16,17; C -**
2,4,6-8,13, 18,20; **D - 2,3,5-7; E - 1-5; F -**
1-7; G - 3-6, 8; H - 1-3,5; I - 3,5; J - 2; K
- 1; L - 1-4; M - 2,9,11,12,14; N - 1,2; O -

1; P - 1,3,7,9,14, 15,19-21; R - 1; S - 5,6,8- 197
1747
13,20; T - 1-4,6,9, 11,14; Z - 1-4.

Cz VIII.14 - A - 1-5,7,10,11,13-15,20,22,25,29,30,32,36-
38, 41,44; B - 1,3,6-10,13,14,16; C - 2,4,6-
8,13, 18,20; D - 2,3,5,7; E - 1-5; F - 1-7; G
- 3-6, 8; H - 1-3,5; I - 3,5; J - 2; K - 1; L
- 1-4; M - 2,5,8,10-12,14; N - 1,2; O - 1; P
- 1-3,7,9, 14-16,19-21; R - 1; S - 5,6,8-
13,20; T - 1-4,6, 9, 11,14; Z - 1-4.

Cz IX. 1 - A - 1-3,7,10,11,13-15,18-20,22,25,27,29-32, 36-44, **B** - 1-4,6-10,12-17; **C** - 1-13,15,16,18-20; **D** - 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 1,3-9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9, 14-16,19-21; **R** - 1; **S** - 5-15,18,20; **T** - 1-4,6,7,9,11,12,14; **Z** - 1-4.

Cz IX. 2 - A - 1-3,7,10-15,18-22,25,27,29-44, **B** - 1-4,6-10, 12-17; **C** - 1-13,15,16,18-20; **D** - 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-8; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,14-16,19-21; **R** - 1; **S** - 5-20; **T** - 1-4,6,7,9-12,14; **Z** - 1-4.

Cz IX. 3 - A - 1-5,7,10-15, 18-20,22,25,27, 29-32,36-44, **B** - 1-4,6-10,12-17; **C** - 1-13,15,16,18-20; **D** - 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-16,19-21; **R** - 1; **S** - 5-17, 20; **T** - 1-4,6,7,9,11,12,14; **Z** - 1-4.

2-4,6-10,12-17; C - 1-13,15,16,18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3-9; H - 2-5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2,5,9-14; N - 1,2; O - 1; P - 1-3,5,7,9,14,16,19-21; R - 1; S - 5,6,8-17, 20; T - 1-4,6,7,9-11,12,14; Z - 1-4.

Cz X. 1 - A - 1-3,6-8,10-15,19-22,25,27-33,36-44, B - 1-4,6-10,12-17; C - 1-11,13,15-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3-9; H - 1-3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2-5,9-14; N - 1,2; O - 1; P - 1-3,5,7-9,14-16,19-21; R - 1; S - 5,6,9-20; T - 1-7,9,11,12,14; Z - 1-4.

Cz X. 2 - A - 1-3,6-8,10-15,19-22,25-44, B - 1-4,6-10,12-17; C - 1-11,13,15,16,18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3-9; H - 1-3,5; I - 3-5; J - 2; K - 1; L - 1-4; M - 2-5,9-14; N - 1,2; O - 1; P - 1-3,5,7-9,14-16,19-21; R - 1; S - 5,6,9-20; T - 1-7,9,11,12,14; Z - 1-4.

Cz X. 3 - A - 1-3,6,8,10-15,18-22,25-32,36-44, B - 1-4,6-10,12-17; C - 1-11,13,15,16,18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3-6,8,9; H - 1-3,5; I - 3-5; J - 2; K - 1; L - 1-4; M - 2-5,9-14; N - 1,2; O - 1; P - 1-3,5,7-9,14-16,19-21; R - 1; S - 5, 6,9-20; T - 1-6,9,11,12,14; Z - 1-4.

Cz X. 4 - A - 1-3,6-15,18-22,25,27-33,36-44, B - 1-4,6-10,12-17; C - 1-11,13,15,16,18-20; D - 2-8; E -

1-5; **F** - 1-7,9; **G** - 3-6,8,9; **H** - 2,3,5; **I** -
 1,3-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-5,9-14; **N**
 - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-16,19-21; **R** -
 1; **S** - 5, 6,9-20; **T** - 1-6,9,11,14; **Z** - 1-4.

Cz X. 5 - A - 1-3,6-15,18-22,25,27,28,30-32,36-40, **B** -
 1-4,6-10,12-16; **C** - 1-11,13,15,16,18-20; **D** -
 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8,9; **H** -
 2,3,5; **I** - 3-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-
 5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,14-
 16,19-21; **R** - 1; **S** - 5-20; **T** - 1-6,9,11,14; **Z**
 - 1-4.

Cz X. 6 - A - 1-3,6-8,10-15,19-22,25,27-33,36-44, **B** -
 1-4,6-10,12-17; **C** - 1-11,13,15,16,18-20; **D** -
 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8,9; **H** - 1-
 3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-
 5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,14-
 16,19-21; **R** - 1; **S** - 5-20; **T** - 1-7,9,11,14; **Z**
 - 1-4.

Cz XI. 1 - A - 1-3,6-8,10,11,13,14,18,19-22,25-32,36-44,
B - 1-10,12-16; **C** - 1-20; **D** - 1-8; **E** - 1-5; **F** - 1-7,9;
G - 1-6,8,9; **H** - 1-3,5; **I** - 3-5; **J** - 2;
K - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1; **O** - 1;
P - 1-3,5,7-9,14,16,19-21; **R** - 1; **S** - 5,6,8-20;
T - 1-3,5-12,14; **Z** - 1-4.

Cz XI. 2 - A - 1,3,6-8,10-15,18-22,25-32,36-44, **B** - 1-10,
 12-17; **C** - 2-20; **D** - 1-8; **E** - 1-5; **F** - 1-7,9;
G - 1-6,8,9; **H** - 1-3,5; **I** - 1,3-5; **J** - 2;
K - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1; **O** - 1;
P - 1-3,5,7-9,14,16,19-21; **R** - 1; **S** - 5,6,8-20;
T - 1-3,5-12,14; **Z** - 1-4.

Cz XI. 3 - A - 1-3,6-8,10-15,18-22,25-32,36-44, **B** - 1-10,
 12-17; **C** - 1-20; **D** - 1-8; **E** - 1-5; **F** - 1-7,9;
G - 1-6,8,9; **H** - 1-3,5; **I** - 1,3-5; **J** - 2;
K - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1,2; **O** - 1;
P - 1-3,7-9,14-16,19-21; **R** - 1; **S** - 5,6,8-20;
T - 1-3, 5-12,14; **Z** - 1-4.

Cz XI. 4 - A - 1-3,6-15,18-22,25,27-32,36-44, **B** - 1-10,
 12-17; **C** - 1-20; **D** - 1-8; **E** - 1,3-5; **F** - 1-7,9;
G - 1-6,8,9; **H** - 1-3,5; **I** - 3-5; **J** - 2;

K - 1; L - 1,2,3,4; M - 2-6,9-14; N - 1,2; O - 1; 203

P - 1-3,7-9,14-16,19-21; R - 1; S - 5,6,8-20;

T - 1-3,5-12,14; Z - 1-4.

Cz XI. 5 - A - 1-3,6-15,18-22,25,27,32,36-44, B - 1-10, 12, 14-17; C - 1-20; D - 1-8; E - 1-5; F - 1-7,9; G - 1-6,8,9; H - 1-3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2-6,9-14; N - 1,2; O - 1; P - 1-3,7-9, 14-16,19-21; R - 1; S - 5-20; T - 1-3,5-9,11,14; Z - 1-4.

Cz XI. 6 - A - 1-3,6-15,18-22,25,27-32,36-44, B - 1-10, 12-14,16,17; C - 1-20; D - 1-8; E - 1-5; F - 1-7,9; G - 1-6,8,9; H - 1-3,5; I - 3-5; J - 2; K - 1; L - 1-4; M - 2-6,9-14; N - 1,2; O - 1; P - 1-3,7-9,14-16,19-21; R - 1; S - 5-20; T - 1-3,5-12,14; Z - 1-4.

Cz XII. 1 - A - 1,3,4,6-8,10-15,18-22,25,27-33,36-44, B - 1-10,12-17; C - 1-20; D - 1-8; E - 1-5; F - 1-7,9; G - 1-6,8; H - 2,3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2-6,9-14; N - 1,2; O - 1; P - 1-3,5, 7-9,14-21; R - 1; S - 5-15,17-20; T - 1-4,11,12, 14; Z - 1-4.

Cz XII. 2 - A - 1,3,4,6-15,18-22,25,27-33,36-44, B - 1-10, 12-17; C - 1-20; D - 1-8; E - 1-3,5; F - 1-7,9; G - 1-6,8; H - 2,3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2-6,9-14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1; S - 5,6,8-13,15-20; T - 1-11,14; Z - 1-4.

Cz XII. 3 - A - 1,3,4,6-8,10-15,18-22,25,27-33,36-44, B - 1-10,12-17; C - 1-20; D - 1-8; E - 1-5; F - 1-7,9; G - 1-6,8; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2-6,9-14; N - 1,2; O - 1; P - 1-3,5, 7-9,14-21; R - 1; S - 5,8-20; T - 1-11,14; Z - 1-4.

Cz XII. 4 - A - 1,3,4,6-15,18-22,25,27-33,36-44, B - 1-10, 12-17; C - 1-20; D - 1-8; E - 1-5; F - 1-7,9; G - 1-6,8; H - 2,3,5; I - 1-5; J - 2; K

- 1; L - 1-4; M - 2-6,9-14; N - 1,2; O - 1; P
1755 205
- 1-3,5,7-9,14-21; R - 1; S - 5-20; T - 1-9,
11,12,14; Z - 1-4.

Cz XIII. Gujarat Plains and Hill Region.

- Cz XIII.1 - A - 1-6,10,11,13-15,18,20,22,25,27,29-32,36-44, B - 1-4,6-10,12-14,17; C - 2-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3-9; H - 1-3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1; S - 5,6,8-14,17-20; T - 1-4,6-12,14; Z - 1-4.**
- Cz XIII.2 - A - 1-6,10,11,13-15,18,20,22,25,27,29-32,36-44, B - 1-4,6-10,12-14,17; C - 2-18; D - 2-8; E - 1-5; F - 1-7,9; G - 3-5,9; H - 1-3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1; S - 5,6,8-14,16,17,20; T - 1-4,6-12,14; Z - 1-4.**
- Cz XIII.3 - A - 1-6,10,11,13-15,18,20,22,25,27,29-32,36-44, B - 2-4,6-10,12-14,17; C - 2-20; D - 2-8; E - 1, 3-6,8,9; F - 1-7,9; G - 3-9; H - 2,3,5; I - 3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1; S - 5,6,8-14,16,17,20; T - 1-4,6-12,14; Z - 1-4.**

Cz XIII.4 - A - 1-6,10,11,13-15,20,22,25,27,29-32,36-44,
B - 1,6-10,12-14,17; C - 2-20; D - 2-8; E -
1-5; F - 1-7,9; G - 3-9; H - 1-3,5; I - 1,3-
5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-14; N
- 1,2; O - 1; P - 1-3,5,7-9,14-21; R - 1; S -
5,6,9-13,15-17,20; T - 1-4,6,8,12,14; Z -
1-4.

Cz XIII.5 - A - 1-6,10,11,13-15,18,20,22,25,27,29-32,36-
44, B - 1,6-10,12-14,17; C - 2-20; D - 2-8; E
- 1-5, F - 1-7,9; G - 3-9; H - 1,3,5; I -
1,3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-
14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1;
S - 5,6,9-13,15-17, 20; T - 1-4,6,8-12,14; Z
- 1-4.

Cz XIII.6 - A - 1-6,10,11,13-15,18,20,22,25,27-32,36-44,
B - 1-3,6-10,12-14,17; C - 2-20; D - 2-8; E -
1-5; F - 1-7,9; G - 3-5,9; H - 1-3,5; I -
1,3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-
14; N - 1,2; O - 1; P - 1-3,5,7-9,14-21; R -
1; S - 5,6,9-13,15-20; T - 1-4,6-12,14; Z -
1-4.

Cz XIII.7 - A - 1,3-7,10,11,13-15,18,20,22,25,27-32,36-
44, B - 1,2,6-10,12-14,16,17; C - 2-20; D -

2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-9; **H** - 1-3; **I**
- 3-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,9-
14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-21; **R** -
1; **S** - 5,6,9-13, 15-17,20; **T** - 1-4,6-12,14; **Z**
- 1-4.

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Cz XIV. - **A** - 1-7,10,11,13-15,20,22,27,29-32,37,38,
41,44; **B** - 1-3,6-10,12-14,17; **C** - 2-5,13,18;
D - 2,5,8; **E** - 2-5; **F** - 1-7,9; **G** - 3,4,9; **H** -
2-5; **I** - 3,5; **L** - 3,4; **M** - 2,5,14; **N** - 1; **O** -
1; **P** - 2,7,9,15-21; **R** - 1; **S** - 6,8,10-
12,15,20; **T** - 1-4,6,9,14; **Z** - 1-4.

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(Andaman, Nicobar And Lakshadweep)

Cz XV. - **A** - 1-3,5-7,9-13,18-20,22,24,25,27,30-32,37-44, **B** - 1-10,12-17; **C** - 1-20; **D** - 1-8; **E** - 1-6; **F** - 1-7,9; **G** - 1-9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1,4; **M** - 1-3,5,6,8-14; **N** - 1,2; **O** - 1; **P** - 1-3,5-9,12,15-21; **R** - 1; **S** - 1,5,6,8,15-18,20; **T** - 1-14 **Z** - 1-4.

APPENDIX D

REFERENCES

Agarwal, M. and D.N. Rao (1983). Effect of ozone and sulphur dioxide pollutants on seed characters of rice plants. *Sci. and Cult.* 49 (c) : 177-178.

Agarwal M. and N. Khanam (1989). Man and His Ecosystem. L.J. Brassler & W.C. Mulder (Eds). Proceedings of the 8th World Clean Air Congress 1989, The Hague, The Netherlands, 11-15 September 1989.

Agarwal M. and S.B. Agarwal (1989). Phytomonitoring of air pollution around a thermal power plant. *Atmosph. Environ.* 23 : 763-769.

Ahmad K.J.; M. Yunus; S.N. Singh; K. Srivastava; N. Singh; V. Pandey and J. Misra (1991). Air Pollution and Plants. *CSIR News*. Vol. 41 No. 15 Aug. 91.

Alagh, Y.K. (Summary by Wadia F.K.) (1990). Agro-climatic regional planning : Overview of a new approach. *Jour. Ind. School of Political Economy.* 2 (1) : 81-111.

Ambasht, R.S. (1970). Conservation of soil through plant cover of certain slopes in India. *Proc. IX Tech. Meeting IUCN.* pp. 44-48.

Arya, K.P.S. (1971). Ecophysiological and Cytogenetical Response of Certain Crop Plants to Sodium fluoride and Sulphur dioxide Toxicity. Ph.D. thesis, B.H.U., Varanasi.

Banerjee, A.K. and S.B. Chaphekar (1978). A significant observation on the effect of sulphur dioxide on root nodulation in *Dolichos lablab*. I. *Proc. Internatl. Symp. Environmental Agents and their biol. effect, Hyderabad.*

Banerjee, A.K. and S.B. Chaphekar (1978). Effects of SO₂ on germination and early growth of seedlings. *Geobios*, 7:8-11.

Bedi, S.J.; M.D. Patel, and S.J. Shah (1982). Ecomorphological and phytochemical studies to determine the pollutant and its source, causing damage to vegetation. A case study of damage to banana plantation. *Ind. J. Ecol.* 2 : 335-338.

Bell, D.C. and S.J. Bedi (1981). Effect of industrial air pollution on the biomass and yield of *Lycopersicon lycopersicum* L. Karsten (Tomato) Winter Crop. *Proc. Silver Jub. Symp. of VIISTE, Bhopal.*

Bennett, J.H. and A.C. Hill (1973). Absorption of gaseous air pollutants by a standardized plant canopy. *J. Air. Pollut. Contr. Ass.* 23 : 203-206.

Bennett, J.H. and A.C. Hill (1975). Interaction of air pollutants with canopies of vegetation. In : J.B. Mudd and T.T. Kozlowski (eds) *Response of Plants to Air Pollution*. Academic press, New York, 273-306.

Bhairavmurthy, P. V. and P.V. Kumar (1983). Air pollution and epidermal traits of *Calotropis gigantea* (L) R. Ind.J.Air.Pollut. Contr.I : (1&2), 23-26.

Bhatia, Roop Rekha (1978). Effect of Fly-ash on Plant growth. M.Phil. Thesis, J.N.U, New Delhi.

Boralkar, D.B. and S.B. Chaphekar (1978). Sulphur dioxide effects on Jawar - *Sorghum vulgare* Var. CSH-1. Proc. Symp. Environ. Biol. Muzaffarnagar, 361-366.

Boralkar, D.B. and S.B. Chaphekar (1980). Effects of atmospheric pollution due to a glass industry on plants in Kera, Maharashtra.

Boralkar, D.B. and S.B. Chaphekar (1980). Nature of sensitivity of plant species to sulphur dioxide. Current Ecol.Res.in India.

Boralkar, D.B. and S.B. Chaphekar (1981). Effects of sulphur dioxide on sunhemp *Crotalaria juncea* L. Geobios, 8 : 236-237.

Boralkar, D.B. and S.B. Chaphekar (1983). Foliar injury to *Trigonella foenum graecum* due to sulphur dioxide exposure. Ind. J. Air. Pollut.Contr.4 :

Boralkar, D.B. and D.B. Shinde (1983). Effects of sulphur dioxide and ozone singly and in combination, on germination and chlorophylls of *Abelmoschus esculantus* Var. *pusa savani*. j. Environ. Biol. 4 : 99-102.

Bradshaw, A.D. and M.J. Chadwick (1980). The Restoration of Land. Blackwell Scientific. pp. 317.

Brennan, E.; I.A. Leone, and R.H. Daines (1965). Chlorine as Phytotoxic air pollutant. Int. J. Air Water Pollut, 9 : 791-797.

Carter, D.B. (1954). Climates of Africa and India according to Thornthwaite's (1948) Classification John Hopkins University Publication (in) Climeology, 7 (4).

Chadwick, R.C. and A.C. Chamberlain (1970). Field loss of radionuclides from grass. Atmospheric Environment 4, 51-56.

Chamberlain, A. C. (1970). Interception and retention of radioactive aerosols by vegetation, Atmospheric Environment, 4, 57-78.

Chamberlain, A.C. (1953). Aspects of travel and deposition of Aerosol and Clouds, A.E.R.E. Report H.P. 1261, Atomic Energy Research Establishment, Harward, Berks, U.K.

Chaphekar, S. B. (1972). Effect of atmospheric pollutants on plants in Bombay. J. Biol. Science. 15 : 1-6.

Chaphekar, S.B. and M.R. Karbhari (1974). Sulphur dioxide injury to plants : some experiments. *Geobios*, 1 : 141-142.

Chaphekar, S.B. (1979). An evidence of high pollution level in Chembur. *Scavenger* 9 : 22-25.

Chaphekar, S.B. and D.B. Boralkar (1979). Effects of gaseous ammonia on plant growth and protection. *Ind. J. Air. Pollut. Contr.* 2 : 19-23.

Chaphekar, S.B.; D.B. Boralkar, and R.P. Shetye (1980). Effects of Industrial Pollutants on Plants. Final Report of UGC sponsored project.

Chaphekar, S.B.; V. Bhavani Shankar, and F.A. Poonawala (1986). Plantation in disturbed habitats. In : *Plantation Crops*. Vol.II : 171-174. Oxford & IBH.

Chaphekar, S.B.; V. Bhavanishankar and F.A. Poonawala. *Plantation Crops* (Ed.) 171-174.

Chaphekar, S.B. (1989). Revegetation of Zn-Pb Mine Tailings. Final Report to Sponsors.

Cholak, J. (1952). The nature of the atmosphere in a number of industrial communities. *Proc. 2nd Nat. Air Pollut. Symp.* Stanford. Res. Inst. Los Angeles, Calif.

Chowdhury, A.; H.P. Das and S.S. Singh (1993). Agro-climatic Classification of India *Mausam*, 44 (1) : 53-60.

Das, T.M. and P. Pattanayak (1978). Dust filtering property of green plants and the effect of air borne particles on growth and yield. pp. 224-234. In: *Proceedings of the Internat. Symp. Environmental Agents and their biol. effects.* Hyderabad.

Das, T.M. (1981). Plants and Pollution. Presidential address in Section of Agricultural Sciences. Indian Sc. Cong. Ass. Meeting, B.H.U. Varanasi.

Das, T.M.; A. Bhaumik; A. Ghosh, and A. Chakraborty (1981). Trees as dust filters. *Science Today*, 19 : 19-21.

Davis, D.D. (1975). Variable tree response due to environmental factors climate. In : W.H. Smith and L.S. Dochinger (Eds.), *Air Pollution and Metropolitan Woody Vegetation*. U.S.D.A. Forest Service. PIEFR - PA-1, Upper Darby, Pennsylvania, 14-16.

Dubey, P.S.; K. Pawar; S.K. Shringi, and L. Trivedi (1982). Effects of fly ash deposition on photosynthetic pigment and dry weight production of Wheat and Gram. *Agro. Ecosystem* 8 : 137-140.

Dubey, P. S.; L. Trivedi, and S.K. Shringi (1982) - Pollution studies of Betul forest area due to Satpura Thermal Power Station aerial discharge. Final report. DOE project no.19/27/78. *Env.* 53.

Environmental Health Science Centre (1975). The role of plants in environmental purification, Oregon State University, Corvallis, Oregon, 53.

Evans, D.W. and J.P. Giesy (Jr) (1979). Trace metal concentrations in stream swamp system. In : Ecology and Coal Resource Development (ed) Mohan K. Wali, Vol.2. 782-790.

Flemming, G. (1967). When can forest belts reduce the emissions concentration? Luft and Kaeltechnik. 6, 255-258.

Fulekar, M.H. and J.M. Dave (1990). Environmental Impact Assessment of Fly-Ash from Coal-Fired Power Plants. Encology, Vol. 4, No. 8, pp. 25-34.

Ganguli A.K. (1976). A proposal for a national Programme of development of perennial green envelope and large scale afforestation. Scavenger 6 : 8-17, Bombay.

Garg, K.K. and C.K. Varshney (1980). Effect of air pollution on the leaf epidermis at submicroscopic level. Experintia, 36 : 1364-1366.

Ghouse, A.K.M. and F.A. Khan (1983). Growth responses of Melilotus alba L. to air pollutants emerging out of coal burning. Geobios, 10 : 227-228.

Gupta, V.K. and R.K. Kapoor (1985). Reducing the consequences of reactor accidents, with a green belt. Nuclear Technology, 70.2, : 204-214.

Gupta V.K. and R.K. Kapoor (1992). Attenuation of air pollution by green belt - Optimisation of density of tree plantation. Conference on Precipitation Scavenging and Atmosphere Surface Exchange, Washington D.C., U.S.A.

Halbwachs, G. (1983). Effects of air pollution on vegetation. In : W. Holzner, M.J.A. Werger and I. Ikusimaa (eds.) Man's Impact on Vegetation, Dr.W.Junk Publishers, London, 55-67.

Hanson, G.P. and L. Thorne (1970). A partial pollution solution - plant trees. Lasca Leaves 20 : 35-36.

Hill, A.C. (1971). Vegetation : A sink for atmospheric pollutants. J. Air pollution control Assoc. 21 : 341-346.

Hill, A.C. and E.M. Chamberlain, Jr. (1974). The removal of water soluble gases from the atmosphere by vegetation. Atmospheric surface. Exchange of Particulate and Gaseous pollutants symp. Richland, Washington, Sept. 4-6, 1974, 12 pp.

Hukkoo et all (1988). Manual of dose evaluation from atmospheric releases, Bhabha Atomic Research Centre, BARC - 1412, Bombay.

IAEA (International Atomic Energy Agency) Safety Guide. Safety Series No. 50-SG-S3 (1980), Atmospheric Dispersion in Nuclear Power Plant Siting.

IAEA - TEA DOC - 379 (1986) Atmospheric Dispersion Models for Application in Relation to Radionuclide Releases.

Jafri, S.; K. Srivastava, and K.J. Ahmed (1979). Environmental pollution and epidermal structure in *Syzygium cumini* L. Skeel. *Indian J. Air Pollut. Contr.* 2 : 74-77.

Jha, A.K. and J.S. Singh (1944). Rehabilitation of mine spoils with particular reference to multipurpose trees in agroforestry systems for sustainable land use Ed. Punjab Singh, P.S. Pathak, and M.M. Roy. Oxford and IBH publishers. : 237-250.

Juwarkar, A.S.; V.P. Thergaonkar; A.S. Malhotra, and Animesh Kumar (1989). Reclamation of mined land and mine spoil using sewage sludge and soil. *Natl. Sem. Protection of Environ. and Ecol by Mining Ind., Panjim, Vol. I* : 396-408.

Kalyushnyi, Y. et al, (1952). Effectiveness of sanitary clearance zones between industrial enterprises and residential quarters. *Gicienai sanit* 4 : 179.

Kapoor R. K. and V.K. Gupta (1984). A pollution attenuation coefficient concept for optimisation of green belt. *Atmospheric Environment* 18 : 1107-1113.

Keller, T. and H. Schwager (1977). Air pollution and ascorbic acid. *Eur. J. Forest Pathol.* 7 (6) : 338-350.

Keller T. (1978). How effective are forests in improving air quality? Eight World Forestry Conference, Jakarta, Indonesia, 1978, pp. 9.

Kellogg, W.W.; R.D. Cadle; E.R. Allen; A.L. Lazarus, and E.A. Martell (1972). The Sulphur Cycle. *Science* 175 : 587-596.

Knabe, W. (1976). Effects of sulphur dioxide on terrestrial vegetation, *Ambio.*, 5 : 213-218.

Krishnan, A. (1988). Delineation of soil climatic zones of India and its practical application in agriculture fertilizer News, 33 (4) : 11-19.

Kumar, S. and C.B. Prakash (1978). Sulphur dioxide : The major gaseous pollutant. *Ind. J. Air. Pollut. Control*, 1 : 102-109.

Kumar, S. and S.N. Upadhyay (1983). Atmospheric emissions from thermal power plants in India. In : *Proceedings of symposium of Air Pollution Control, India*, 119-131.

Linzon, S.N. (1978). Effects of airborne sulfur pollutants on plants. In : J.O. Nriagu (Ed.), *Sulfur in the Environment : Part II, Ecological Impacts*. Wiley, New York, 109-162.

McMohan, T.A. and P.J. Denison (1979). Empirical atmosphere deposition parameters - a survey, *Atmospheric Environment*.

Meenakshy, V.; T.N. Mahadevan, and U.C. Misra (1981). Nature and extent of biomagnification of fluoride in forage around a phosphate fertilizer plant. Proc. Biol. Ind. Env. Pollut. pp 9.

Mishra, L. C. (1980). Effect of sulphur dioxide fumigations on ground nut, *Arachis hypogea* L. Environ and Expt. Bot. 20 : 397-400.

Mudd, J.B. (1973). Biochemical effects of some air pollutants on plants. In J.A. Naegele (Ed.) Air Pollutants damage to vegetation. Adv. Chem. Series. No. 122, Amer. Chem. Soc., Washington D.C., pp. 31-47.

Murthy, M.S.R.; O. Bhagyalakshmi; S.H. Raza, and A. Ahmad (1991). A new Method for Evaluating Sulfur Dioxide Tolerance of Certain Trees. Intern. J. Environmental Studies. Vol. 39, pp. 85-94.

National Academy of Sciences (1977 a). Ozone and other Photochemical Oxidants. National Academy of Sciences. Washington, D.C., pp. 717.

National Academy of Sciences (1977 b). Effects of nitrogen oxides on vegetation. In : Nitrogen Oxides. NAS, Washington D.C., pp. 147-158.

Painter, D.E. (1974). Air pollution technology. Mc Graw Hill publishers.

Pandey, R.N. and S.D. Vaidya (1976). Plants and pollution. Scavenger 6 : 8-14.

Pandey, G.P. (1979). Eco - Physiological Responses of Plants to Gaseous Hydrogen fluoride Pollution. Ph.D. Thesis, B.H.U., Varanasi.

Pandey, G.P. and D.N. Rao (1980). HF induced effects and their amelioration by $\text{Ca}(\text{OH})_2$ solution in *Gladiolus* plants. Beitr. Biol. Pflanzen 55 : 119-128.

Pandey, S.N. and D.N. Rao (1979). Eco-physiological investigation of sulphur dioxide pollution effects on Soybean. Proc. Symp. Environ. Biol. 173-182.

Pandey, V.; J. Misra; S.N. Singh; N. Singh; M. Yunus and J. Ahmad (1994). Growth response of *Helianthus annuus* L Grown on fly-ash Amended soil J. Environ. Biol. 15 (2) : 117-125.

Pawar, K.; L. Trivedi, and P.S. Dubey (1982). Comparative effects of cement, coal, dust and fly - ash on *Abelmoschus exculantus*. Inter. J. Env. studies 19 : 221 - 223.

Pawar, K. and P.S. Dubey (1982). Growth response of wheat cultivar N-14 to fly ash incorporated black cotton soil. All India seminar on Air pollution. 19-21. April. Indore.

Pawar, K. and P.S. Dubey (1983). Effects of atmospheric pollutants on the morphology and pigment content of *Mangifera indica* L. Proc. VI World Congr. Air Quality. Paris, pp. 501-507.

Pawar, K.; L. Trivedi, and P.S. Dubey (1983). fly ash deposition and productivity measurements in beans. *Ind. J. Air. Pollut. contr.* 5 : 18-20.

Pieser, G.D. and S.F. Yang (1978). Chlorophyll destruction in the presence of bisulfite and linoleic acid hydroperoxide. *Phytochem.*, 17 : 79-84.

Prasad, B.J. and D.N. Rao (1979). Influence of Nitrogen dioxide (NO₂) on photosynthetic apparatus and net primary productivity of wheat plant. *Acta. Bot. Indica.* 7 : 16-21.

Prasad, B.J.(1980).Phytotoxicity of petroleum refinery air pollutants. Ph.D. Thesis, B.H.U., Varanasi.

Prasad, B.J. and D.N. Rao (1981). Growth responses of *Phaseolus aureus* plants to petro-coke pollution, *J. Expt. Bot.* 32 : 1343-1350.

Prasad, B.J. and D.N. Rao (1982). Relative sensitivity of a leguminous and a cereal crop to sulphur dioxide pollution. *Environ. Pollut. Ses. A.* 29 : 57-70.

Rao, D.N. and F. Leblanc (1966). Effects of sulphur dioxide on the lichen algae, with special reference to chlorophyll. *Bryologist*, 69 : 60-75.

Rao, D.N. (1971). A study of air pollution problem due to coal unloading in Varanasi, India. pp : 273-276. In *Proceeding of Second International Air Congress* (Eds. M.M. Englund and G.T. Beny), Academic Press, New York.

Rao, D. N. (1972). *Mangifera indica*, a bioindicator of pollution in the tropics. *Proc. 22nd Int. Geog. Cong. Montreal*, p. 272.

Rao, D.N. and O. Pai (1978). Effect of hydrogen fluoride on growth and yield of corn. (*Zea mays*) In : *Glimpses of Ecology*, Ed. J.S. Singh and B. Gopal. International Scientific Publications. Jaipur, India, 461-470.

Rao, D.N. (1979). Plants as a pollution monitoring device. *Fertiliser News*, 24 : 25-28.

Rao, D.N.; R.S. Srivastav; R.S. Rai; P. Jain; B.J. Prasad; S.K. Singh; M. Agarwal; V. Singh, and P.K. Nandi (1983). To Study the Relative Susceptibility of Saplings of Some Common Fruit and Avenue Trees to Sulphur diokide Pollution. Final Tech. Report of UGC sponsored research project No. F-23-115/79 (SR II) 29.

Rao D.N., M. Agrawal, J. Singh (1990). Study of Pollution Sink Efficiency. Growth Response and Productivity Pattern of Plants with Respect to Fly-ash and SO₂. Final Tech. Report of MAB project DOE / 14 /256 / 85-MAB/RE.

Raynor G. S.; J.V. Hayes, and E.C. Ogden (1974). Particulate dispersion into and within a forest. *Boundary - Layer Met.* 7 : 429-456.

Raza, S.H.; M.S.R. Murthy, and A. Ahmed (1988). Foliar sulfate content in certain tropical trees under low levels of SO₂. *Air Pollution and Forest Decline* (J.B. Bucher & I. Bucher

Wallin, eds.) Proc.14th Int. Meeting for specialists in Air Pollution Effects on Forest Ecosystems, IUFRO P₂ 05, Interlaken, Switzerland, Oct, 2-8, 1988. Birmensdorf, 1989, pp. 105-109.

Raza, S.H.; M.S.R. Murthy; O. Bhagylakshmi and G. Shylaja (1990-91). Effect of vegetation on urban climate and healthy urban colonies. *Energy and Buildings*. 15-16 (1990-91) : 487-491.

Raza, S.H.; G. Shylaja (1992). Studies of tolerance of certain succulent plants to ambient air sulfurdioxide levels in urban environments of a city in India. *A New Approach. Intern. J. Environmental Studies*. Vol. 42 : 301-318.

Roberts, B.R. (1974). Foliar sorption of atmospheric sulphur dioxide by woody plants.. *Eviron. Pollut.* 7 : 133-140.

Seiler, W. (1974). The cycle of atmospheric CO. *Tellus* 26 : 116-135.

Sharma, H.C. (1981). Plant Responses to Sulphur-dioxide and Hydrogen fluoride Air Pollutants. Ph.D. Thesis, B.H.U., Varanasi.

Shetye, R.P. (1979). Investigations of Responses of Some Common Plants to Air Pollution. M.Sc thesis. University of Bombay.

Shetye, R.P. and S.B. Chaphekar (1980). On measurement of dustfall with plants. pp. 205-213. in Proc. Sem. Management of Environment, BARC, Bombay. (Ed.) Patel. B.

Singh, S.N and D.N. Rao (1978). Possibilities of using chlorophyll and potassium contents in plants to detect cement dust pollution. *J. IPHE, India*, 1 : 10-13.

Singh, N and D.N. Rao (1979). Studies of the effect of sulphus dioxide on alfafa plants especially under conditions of natural precipitation. I. Changes pertaining to growth pattern , phytomass accumulation and productivity in plants. *Indian J. Air Pollut. Contr.* 2 : 55-69.

Singh, N. and D.N. Rao (1980). Growth responses of wheat plant to cement dust polluted environment. *Proc. Indian Natl. Sci. Acad.* 3 : 325-320.

Smith, W.H. (1981). *Air Pollution and Forests Interactions between Air Contaminants and Forest Ecosystems*. Springer-Verlag New York.

Smith, W.H. and L.S. Dochinger (1976). Capabilites of metropolitan trees to reduce atmospheric contaminats. In : H. Gerhold, F. Santamor and S. Little (Eds.) *Proc. Better Trees for Metropoliton Landscapes*, U.S.D.A., Forest Service, Gen. Tech. Report No. NE-22, Upper Darby, Penvsylvania, pp. 49-59.

Sreeranga swamy, S.R.; O. Padmanabhan; R. Jambulingam, and M. Gurunathan (1973). Effect of cement dust on plant ecotypes. *Madras agric I.* 60 : 1776.

Srivastava, K.; S. Jafri, and K.J. Ahmed (1980). Effect of Air pollution on epidermal features of *Tabernaemontanacoronaria*. Willd. New Botanist, 167- 170.

Sutton, O.G. (1953). *Micrometeorology*, McGraw Hill Book Co. Inc.

Tandon, G.L. (1989). Planning for sustained mineral development by 2001 A.D. Proc. Sem. Protection of Environment and Ecology by Mining Industry. Panjim. Vol. 1, 15-45.

Taylor, O.C.; C.R. Thompson; D.T. Tingey, and R.A. Reinert (1975). Oxides of nitrogen. In : J.G. Mudd and T.T. Kozlowski (Eds.), *Responses of Plants to Air Pollution*. Academic Press, New York, pp. 121-139.

Treshow, M. (1970). *Environment and Plant Response*, Mc Graw Hill, New York.

Vaishnavi, M. L. (1975). Pollutants and plants. *Scavenger*, 5 : 8-9.

Varshney, C.K. and S.R.K. Varshney (1979). Effects of sulphur dioxide on pea seedlings. *Indian J. Air pollut. Contr.* 2 : 47-49.

Varshney, C.K. Use of sulphur content in *Nerium indicum* for monitoring sulphur dioxide pollution in Delhi.

Varshney, S.R.K. and C.K. Varshney (1981). Effect of sulphur dioxide on pollution generation and pollen tube growth. *Environ. Pollut. Ser. A.* 24 : 87-92.

U.S. Environmental Protection Agency (1976). *Diagnosing Vegetation Injury Caused by Air Pollution*. U.S.E.P.A., Washington, D.C.

U.S. EPA (1978). *Guideline on air quality models*. OAQPS guideline series no. 1.2-080, EPA-450/2-78-027.

Warren, J.L. (1973). *Green space for air pollution control*. N.C. State University Sch. for Resour. Tech. Rep. 50. Raleigh N.C.

Wash - 1400 (1975). *Reactor safety study : An assesment of accident risks in U.S. commercial nuclear power plants*, Appendix - VI, U.S. Nuclear Regulatory Commission, Report NUREG - 75/014, National Technical Information Service.

Weinstein, L.N. (1977). Fluoride and plant life. *J. Occupa. Med.* 19 : 49-78.

Winner, W.E. and H.A. Mooney (1980). Ecology of SO₂ resistance II. photosynthetic changes of shrubs in relation to SO₂ absorption and stomata behaviour. *Oecologia* (Berlin), 44 : 296-302.

Yunus M. and K.J. Ahmad (1979). Use of epidermal traits of plants in pollution monitoring. Proc. of Nat. Sem. on Environ. Pollut. and Its Control. A Status Review. National Productivity Council, Bombay.

Yunus, M and K.J. Ahmed (1980). Effect of air pollution on leaf epidermis of *Psidium guava* L. *Indian J. Air. Pollut. Contr.* 3 : 62-67.

Yunus, M. and K.J. Ahmad (1981). Changes in cuticular and epidermal features of *Calotropis procera* (Ascl. epiadaceae) due to air pollution. *J. Biol.* 10 (2 and 3) 275-282.

Yusuf, M. and L.N. Vyas (1982). Effect of cement dust pollution on some selected plant species growing around udaipur cement works, Bajaj Nagar, Udaipur. Presented at the All India Seminar on Air pollution, April, 1982, Indore.

Zeevart, A.J. (1976). Some effects of fumigating plants for short periods with NO₂. *Environ. Pollut.* 11 : 97- 108.

Some of the Important Literature in the subject referred

In addition to the Reference List, the following were offered extensively as sources of information.

Air Pollution and Plants; A State-of-The-Art-Report. Ed. Subramanyam G.V.; D.N. Rao; C.K. Varshney and D.K. Biswas; Ministry of Environ. and Forests, Govt. of India. 1985 pp. 193.

Effects of Air Pollutants on Plants Ed. T.A. Mansfield. Society for Experimental Series 1, Cambridge Univ. Press, 1976.

Flora of Eastern Karnataka. Vol. I, II by N.P. Singh, Mittal Publ. Delhi, 1988 pp. 794.

Flora of Coibatore. M. Chandrabose and N.C. Nair, Publ. Bishan Singh Mahaendral Pal Singh Dehradun, 1988 pp. 398.

Flora of the Presidency of Bombay by Theordore Cooke. Vol. I, II, III. pp. 1-649. Publ. by BSI, Calcutta 1901, 1902, 1903.

Glossary of Indian Medicinal Plants. R.N. Chopra, S.L. Nayar; I.O. Chopra. CSIR New Delhi, 1956 pp. 329.

Indian Medicinal Plants. Vol. I, II by K.R. Kirtikar, B.D. Basu, Published by Sudhindra Nath Basu, 1918 pp. 1419.

Name changes in Flowering Plants of India and adjacent regions. SSR Bennet; Triseas Publishers, Dehradun, 1987 pp. 772.

Presepectives in Botanical Museums with Reference to India. V.S. Agarwal; Today and Tommorrow's Publ. New Delhi, 1983.

Trees for Drylands Ed. By Drake Hocking Publ. by Mohan Primalani Oxford IBH New Delhi.

Annexure¹⁷⁷C (Colly)

Plumeria (Champa)

161 trees



Phyllanthus Emblica (Amla)

32 trees



Azadirachta (Neem)

10 trees



Tabebuia Rosea (Basant Rani)

8 trees



Cassia Fistula (Amaltas)

32 trees



Morus Alba (Shahtut)

5 trees



Delonix Regia (Gulmohar)

106 trees



Pongamia Tree (Karanj)

30 trees



Syzygium Cumini (Jamun)
6 trees



Saraca Ashoka (Ashoka)
203 trees



Moringa Oleifera (Sahajan)
1 tree



Ficus Benjamina (Benjamin tree)
241 trees



Bauhinia Variegate (Kachnar)
19 trees



Psidium Guajava (Guava)
10 trees



Mango Tree
6 trees



Lagerstroemia thorelli (Sawani)

13 trees



Chukrasia Tabularis (Chikrasi)
32 trees



Plumeria Rubra
7 trees



Mimusops Elengi (Maulsari)

2 trees



Jackfruit

2 trees



Blackboard tree/ *Alstonia scholaris* (Saptaparni)

1 tree



**UTTAR PRADESH POLLUTION CONTROL BOARD**

TC-12V, Vibhuti Khand, Gomti Nagar, Lucknow-226010

Phone:0522-2720828, 2720831 Fax:0522-2720764

Email: info@uppcb.com Website: www.uppcb.com

**FORM III
(See Rule 10)
AUTHORISATION**

(AUTHORISATION FOR OPERATING A FACILITY FOR COLLECTION, RECEPTION, TREATMENT, STORAGE, TRANSPORT AND DISPOSAL OF BIOMEDICAL WASTES)

Category : RED**Application Id : 28657246**

1. File no. of authorisation and date of issue: No:- 28657246 and Date:-03/12/2024
2. M/s Medanta Lucknow Unit of Medanta Holdings Pvt Ltd, MANOJ SHUKLA an occupier or operator of the facility located at Plot-SSH, Sector-A, Pocket-1, Sushant Golf City, Lucknow ,LUCKNOW,226030 is hereby granted an authorisation for:

Generation, segregation**Collection****Storage****Transportation****Reception****Use****Recycling****Offering for sale****Packaging****Transfer****Treatment or Processing or Conversion****Disposal or destruction****Any other form of handling**

3. M/s Medanta Lucknow Unit of Medanta Holdings Pvt Ltd is hereby authorized for handling of biomedical waste as per the capacity given below:
 - (i) Number of beds of HCF: 750
 - (ii) Number of health care facilities covered by CBMWTF: NA
 - (iii) Installed treatment and disposal capacity: NA
 - (iv) Area or distance covered by CBMWTF: NA
 - (v) Quantity of Biomedical waste handled, treated or disposed: 150 Kg/day
4. This authorisation shall be in force for a period of 03 Years from the date of issue.
 - 4.1 The authorization shall be valid for till 31/12/2027
5. This authorisation is subject to the conditions stated below and to such other conditions as may be specified in the rules for the time being in force under the Environment (Protection) Act, 1986

Rajendra Singh
Chief Environmental Officer, Circle-5

Terms and Conditions of Authorisation

1. The authorisation shall comply with the provisions of the Environment (Protection) Act, 1986 and the rules made there under.
2. The authorisation or its renewal shall be produced for inspection at the request of an officer authorised by the prescribed authority.
3. The person authorized shall not rent, lend, sell, transfer or otherwise transport the biomedical wastes without obtaining prior permission of the prescribed authority.
4. Any unauthorised change in personnel, equipment or working conditions as mentioned in the application by the person authorised shall constitute a breach of his authorisation.
5. It is the duty of the authorised person to take prior permission of the prescribed authority to close down the facility and such other terms and conditions may be stipulated by the prescribed authority.
6. The Unit will file the renewal application at least 2 months prior to the expiry of this Order

Specific Conditions:

- 1-The Authorization shall comply with provisions of the Environment (Protection) Act 1986 and the rules made there under.
- 2-The Authorization or its renewal shall be produced for inspection at the request of an officer, Authorized by Board.
- 3-The Authorized person shall not rent, lend, transfer or otherwise transport the bio-medical waste without obtaining prior permission of the prescribed authority.
- 4-It is duty of the Authorized person to take prior permission of the Board to close down the facility and such other terms and conditions may be stipulated by the prescribed authority.
- 5-Any unauthorized change in personnel, equipment or working condition as mentioned in the application by the person authorized shall constitute a breach of his authorization.
- 6-Bio Medical Waste shall not be mixed with other waste.
- 7-Needle cutter /shredders should be installed, maintained & operated to stop it's reuse.
- 8-Segregated Bio-Medical Waste in defined colour coded bags shall be handed over to valid agency as engaged for disposal.
- 9-You shall also ensure that untreated Bio-Medical Waste shall be transported on regular basis by engaged agency only in such vehicle as may be authorized for the purpose by the Board.
- 10-Bio-Medical Waste shall be segregated into containers/bags at the point of generation in accordance with schedule I. prior to its storage, transportation, treatment and disposal. The container shall be labeled as per provision. Record of Bio-Medical Waste for Incineration and other waste must be maintained in the Hospital.
- 11-It shall be your sole responsibility to engage a valid authorized agency engage for C.B.T.F. (By U.P. Pollution Control Board) for the disposal of Bio-Medical Waste.
- 12-No untreated biomedical waste shall be kept stored beyond a period of 48 hours in compliance of Rule 8 of Bio-Medical Waste (Management and Handling) Rules-2016.
- 13-You shall submit an annual report to the U.P. Pollution Control Board in form IV by 30th June every year for a period from January to December. And include information about the categories and quantities of Bio-Medical Waste during the preceding year.
- 14-This authorization is issued on the basis of agreement made in between the unit and M/s SMS Watergrace Medi-waste Management Pvt. Ltd., Lucknow. In case the agreement is breached/cancelled, the authorization issued to you, will automatically be deemed as cancelled.
- 15-You shall maintain records related to the generation, collection, reception, storage, transportation, treatment and disposal and/or any form of handling of Bio-Medical Waste in accordance with rules and guidelines. All records shall be subject to inspection and verification by the board at any time.

16-It is within the power and functions of U.P. Pollution Control Board to modify/revoke the terms and conditions of the Authorization issued under the Rule 10 of the Bio-Medical Waste Management Rules-2016.

17-You are hereby directed to comply the stipulated above, mentioned conditions and submit the compliance report and steps taken in this regard within a month so that capacity of the facility may be verified failing which the authorization may be revoked and necessary legal proceeding shall be initiated.

18-The Bio-Medical Waste shall not be disposed in open place in the premises.

19-Strict Compliance of Rule 18 and all other provisions of BMW Rule 2016 must be ensured.

20-The mercury contaminated Bio Medical Waste shall be properly segregated in the healthcare facility & the same shall be treated and disposed by CBMWTF in compliance of the said rule and Hazardous Waste (Management Handling & Trans Boundary Movement) Rules, 2008 and thereof.

21-The Registration Certificate issued by Chief Medical Officer shall be submitted within one-month time.

22-Remaining Authorization fees shall be submitted within fifteen days.

23- Necessary Consent under section 25/26 of Water (Prevention & Control of Pollution) Act 1974 and under section 21 of Air (Prevention & Control of Pollution) Act 1981 shall be obtained within 02 months.

24- You are directed to focus your attention on above mentioned conditions and submit

Memo No.: 28657246

Dated:03/12/2024

Copy To:

Regional Officer, UPPCB, Lucknow

Rajendra Singh
Chief Environmental Officer, Circle-5



मिशन LIFE - पर्यावरण के लिए जीवन शैली
(Lifestyle For Environment)
जनसहभागिता का सन्देश



- स्वच्छता – देशसेवा में अपने परिवेश की स्वच्छता हेतु अपना सक्रिय योगदान सुनिश्चित करें
- संकल्प लें -एकल उपयोग प्लास्टिक उत्पाद जैसे कप, तश्तरी, चम्मच, स्ट्रॉ, ईयरबड्स आदि का उपयोग न हो एवं पर्यावरण अनुकूल विकल्पों जैसे कागज/पत्तों से बने दोने या कटलरी को प्राथमिकता दी जाय |
- एकल उपयोग प्लास्टिक उत्पाद के प्रयोग को रोकने एवं प्लास्टिक बैग के बजाय कपड़े के थैले का उपयोग करने मात्र से 375 मिलियन टन ठोस (प्लास्टिक) कचरे का उत्सर्जन बचाया जा सकता है
- चक्रीय अर्थव्यवस्था (सर्कुलर इकोनॉमी) का समुचित कार्यान्वयन वर्ष 2030 तक लगभग 14 लाख करोड़ रुपये की अतिरिक्त बचत उत्पन्न कर सकता है | वेस्ट /अपशिष्ट फेकने के पूर्व सोचें, ये किसी का संसाधन तो नहीं ...?
- अनुपयोगी इलेक्ट्रिक / इलेक्ट्रॉनिक उत्पाद को कचरे में फेकने से रुकें | इसके उपयुक्त निस्तारण हेतु इसे प्राधिकृत ई – वेस्ट रीसाइकलर को दें | प्राधिकृत ई-रीसाइकिलिंग इकाई में अनुपयोगी इलेक्ट्रिक / इलेक्ट्रॉनिक उत्पाद को देने मात्र से 0.75 मिलियन टन तक ई-कचरे का पुनर्चक्रण किया जा सकता है एवं ई-कचरे के विषम पर्यावरणीय दुष्प्रभाव से बचा जा सकता है
- बाहर जाते समय - सोचें कि क्या आपको वास्तव में परिवहन की आवश्यकता है - वह भी क्या व्यक्तिगत रूप से ? छोटी दूरी के लिए पैदल चलना पसंद करें, अथवा सम्भव हो तो कार पूल के रूप में संसाधन को साझा करें अथवा सार्वजनिक परिवहन पर विचार करें
- घरेलू स्तर पर कम से कम ठोस अपशिष्ट का उत्सर्जन करें और इनका प्रथाक्रीकरण करें
- उपयोगी शेष खाद्य सामग्री आपके स्वयं प्रयास अथवा निकटस्थ सक्रिय स्वयं सेवी संस्थाओं की सहायता से समाज के वंचित वर्ग तक पहुंचाई जा सकती है | वहीं अनुपयोगी भोजन /खाद्य सामग्री को कंपोस्ट (वर्मी कम्पोस्ट) करने से 15 अरब टन भोजन को नष्ट होने से बचाया जा सकता है
- ध्यान रखें - उपयुक्त नल और शावर के उपयोग से पानी की खपत को 30 - 40% तक कम किया जा सकता है। एवं उपयोग में न होने पर नलों को बंद रखने मात्र से 9 ट्रिलियन लीटर पानी बचाया जा सकता है
- ट्रेफिक लाइट/रेलवे क्रॉसिंग पर कार/स्कूटर के इंजन बंद करने मात्र से 22.5 बिलियन kWh तक ऊर्जा की बचत हो सकती है
- परम्परागत बल्ब के स्थान पर CFL का उपयोग बिजली की खपत में प्रभावी कमी लाते हैं | उपयोग में न होने पर बिजली उपकरणों को बंद करें | स्टार रेटेड विद्युत उपकरणों के उपयोग को प्राथमिकता दें

हमारे द्वारा अपनी जीवन शैली की प्राथमिकताओं का उचित और पर्यावरण अनुकूल पुनर्निर्धारण समाज और पर्यावरण के प्रति हमारा दायित्व है |