Guidelines for Green Belt Development in Industries in the State of Bihar

1. Background

Plants grown in such a way as to function as pollutant sinks are referred to as green belts. Green belts are an effective tool in mitigating air pollution as they form a surface capable of absorbing air pollutants and forming sinks for pollutants. Leaves with their vast area in a tree crown, absorb pollutants on their surface, thus effectively reduce their concentrations in the ambient air.

Apart from functioning as pollutant sinks, green belts 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.

An important aspect of a green belt that is to be consideredis 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 termsof pollution load, would lead to injuryto plants causing death of tissues and reducing their absorption potential. Thus green belt is effective as pollution sink only within the tolerance limits of constituent plants.

2. Air Pollution Scenario in Bihar

The major sources of air pollution in the State are road dust, vehicular emission, domestic fuel burning, open waste burning, construction activities, industrial emissions *etc.* Particulate matter has been identified as major pollutant. Bihar is not a heavily industrialized State. Some of the major air polluting industries are Thermal Power Plants, Cement Units, Sugar and Distillery Units, Brick Kilns, Stone Crushing Units, *etc.* for which green belt may act as sink. Apart from gaseous emission, industrial processes like transportation of raw material/ finished product and fugitive emissions are major contributors of air pollution. Loose alluvial soil north of Ganga Basin also adds to dust pollution.

3. Agro-climatic Zones

Bihar is divided by river Ganges into two parts, the north Bihar and the south Bihar. Based on soil characterization, rainfall, temperature and terrain, four main agro-climatic zones in Bihar have been identified. These are: Zone-I, North Alluvial Plain, Zone-II, north East Alluvial Plain, Zone-III A South East Alluvial Plain and Zone-III B, South West Alluvial Plain, each with its own unique prospects. Agro climatic zone I and II is located north of the river Ganges whereas the Zone III is located south of the river Ganges. Zone I is situated in the north western part of the state whereas zone II is located in the north eastern part. Zone I and II are flood prone whereas zone III is

drought prone. This zonation is an important factor in selection of species to be planted.

Table :Name of the districts under each Agro-Climatic Zone

S.No.	Agro-climatic zone	Districts
1.	Agro- climatic zone I (Northern West)	West Champaran, East Champaran, Siwan, Saran, Sitamarhi, Sheohar, Muzaffarpur, Vaishali, Madhubani, Darbhanga, Samastipur, Gopalganj, Begusarai
2.	Agro-climatic Zone II (Northern East)	Purnea, Katihar, Saharsa, Supaul, Madhepura, Khagaria, Araria, Kishanganj.
3.	Agro-climatic zone IIIA (Southern East)	Sheikhpura, Munger, Jamui, Lakhisarai, Bhagalpur & Banka.
4.	Agro-climatic zone IIIB (Southern West)	Rohtas, Bhojpur, Buxar, Bhabhua, Arwal, Patna, Nalanda, Nawada, Jehanabad, Aurangabad, Gaya.

Table : Important Physiographic features of the Agro-climatic Zone

Sl. No.	Agro-climatic zone	Soil	pH	Organic Matter (%)	Available Nitrogen (Kg./Ha.)	Available Phosphorus (Kg./Ha.)	Available Potash (Kg./Ha.)
1.	Agro-climatic zone I (Northern West)	Sandy loam, loam	6.5–8.4	0.2-1.0	150-350	5-50	100-300
2.	Agro-climatic Zone II (Northern East)	Sandy loam, Clay loam	6.5–7.8	0.2-1.0	150-300	10-35	150-250
3.	Agro-climatic zone III (Southern East & West)	Sandy loam, Clay loam, loam, Clay	6.8–8.0	0.5-1.0	200-400	10-100	150-350

4. Importance of green cover around polluting industries

Trees, shrubs and other vegetation can absorb certain air pollutants if they are within tolerable limits. This concept is utilized in developing strips of vegetation or commonly known as green belt development. Green belts should be developed especially around sources of pollution to be more effective. The design and nature of green belts will vary according to the place and the type of industry. Some of the factors which influence the design of green belts are-

- Climatic factors such as wind velocity, temperature, rainfall, sunlight, humidity etc.
- Assimilation capacity of the ecosystem.
- Height and canopy of trees.
- Size of land available.
- Distance from source.
- Soil and Water quality.
- Nature and extent of pollutants.

5. Advantages of green belts

- Air Pollution control- Trees help in removing carbon dioxide and other pollutants from air and by release of oxygen into the air thereby improving air quality. A green belt development can also help in removing particulate matter from the air by trapping such particulate matter.
- Water Pollution control- Some species can remove some pollutants from water. Example- copper absorbed by *Chlorella vulgaris* and Scandium by *Astragalas*, zinc by *Typhalatifolia*, chromium by *Salvinianudans*.
- Noise control- A green belt reduces the intensity of sound. It functions as a barrier. Trees can either deflect, refract or may absorb sound to reduce its intensity. The intensity reduction depends on the distance sound has to travel from source. Trees can also modify suitably the humidity and climate which affects sound intensity.
- Help in soil erosion control. Plant species help in improving soil quality and bind soil particles thereby preventing erosion.Green belts also help in containing water run offs.

6. Greenbelt development guidelines

Ministry of Environment, Forest and Climate Change (MoEFCC) has taken several policy initiatives and promoted integration of environmental concerns in developmental projects. One such initiative is the notification on Environmental Impact Assessment (EIA) of developmental projects issued in 1994 and further revised notification in year 2006 under the provisions of Environment (Protection) Act, 1986. EIA Guidance Manual for building, construction, townships, and area development projects proactively talks about the importance of greenbelts in such projects.

Greenbelt in India refers to a buffer zone created beyond which industrial activity may not be carried on. This concept has developed through a long line of cases and today, greenbelts are present not only for the purpose of protecting sensitive areas to maintain ecological balance but are also be found in urban areas so as to act as a sink for the harmful gases released by vehicles and industries operating in the city area. In this regard, comprehensive Guidelines for Developing Greenbelts have been compiled by the Central Pollution Control Board [Refer Probes/75/1999-2000].

As per the stipulations of MoEFCC, greenbelt is to be provided all along the boundary by planting tall, evergreen trees and the total green area including landscaping area will be 1/3rd (about 33%) of the plant area. This will include Lay down area which

will be later on converted into Green area. Depending on the size, activity and environmental impacts of the industry; extent of land available, agro- climatic conditions, at least 5 m wide greenbelt of two rows of tall and evergreen plants shall be grown at the rate of 600 per Ac (1500 per Ha).

7. Selection of Species :

While making choice of plant species for cultivation in green belts, weightage has to be given to the nutritional supply (soil characteristics), availability of water and pollution load. Preference should be given to the species endemic to the area suitable to local conditions.

Table: Rainfall and temperature conditions in different agro climatic zones of Bihar

Sl. No.	Agro-climatic zone	Soil	Total Rainfall (mm)	Temperature (0C)	
				Max.	Min.
1.	Agro- climatic zone I (Northern West)	Sandy loam, loam	1040 – 1450 (1245.00)	36.6	7.7
2.	Agro-climatic Zone II (Northern East)	Sandy loam, Clay loam	1200 – 1700 (1450.00)	33.8	8.8
3.	Agro-climatic zone III (Southern East & West)	Sandy loam, Clay loam, loam, Clay	990 – 1240 (1115.00)	37.1	7.8

For absorption of gases

1. Longer duration of foliage
2. 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)

Tree as dust collectors		
Sl. No.	**Trees species**	**Dust collected gm/sq m of leaf surface**
1.	*Tectonagrandis* (Teak)	5.35
2.	*Shorearobusta* (Sal)	4.50
3.	*Terminalia arjuna* (Behera)	4.49
4.	*Mangiferaindica* (Mango)	4.05
5.	*Bauhinia purpuria* (Kachnar)	3.90
6.	*Butea monosperma* (Plaw)	3.05
7.	*Azadirachtaindica* (Neem)	2.29
8.	*Cassia fistula* (Amal tas)	2.24
9.	*Tamarindusindica* (Imli)	2.08

Species of plants have been studied for their relative sensitivities towards different air pollutants. Thus, we recognize 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. An industrial or environment normally 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 SO2, 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 tolerant would not indicate.

Sl. No.	**Tree species**	**Air pollutant**	**Symptoms/effects**
1.	*Adina cordifolia* (Haldu) *Bauhinia racemosa*(Kachanal) *Diospyroscordifolia* (Bans) *Juniperus*species (Junipers) *Thujaoccidentalis* (Morpankhi) *Populusdelteoides* (Poplar) *Quercus*species (Oak) *Tamarindusindica* (Imli) *Pinusroxburghli* (Chir) *Mangiferaindica* (Mango)	Sulphur dioxide	Intervenial regions of leaf turn yellow (chlorosis) or brown (necrosis)
2.	*Cassia fistula* (Amal tas) *Dalbergiasissoo* (Shisham) *Piceaglauca* (White sprouce) *Juniperuspersica* (Aru) *Salix* species (Willow) *Ulums* species (Elm)	Hydrogen fluoride	Leaf tip and margine turn brown (necrosis)
3.	*Pinusroxburghii* (Chir) *Juglansnigra* (Black walnut) *Quercus* species (Oak) *Picea*species (Sprouces) *Juniperus* species (Junipers)	Ozone	Red and brown spots on leaf surface, folding of leaves if concentration increase, necrosis, chir needle tip burns

4.	*Azadirachtaindica* (Neem) *Mangiferaindica* (Mango)	Dust and smoke	Leaves turn yellow, photosynthesis rate decreases

8. Plantation technique:

A standard horticultural practice involves planting of saplings inpits of 1ft. x1ft.x 1ft.The pits are then filled with earth, sand silt and manure in pre-determined proportionsand are watered liberally. For areas where the soil conditions are poor and the substratum is hard and rocky, as in the districts of Gaya, Nawada, *etc*., pits of 2ft. x 2ft. x 2ft. with 4cft. of external soil and 2 cft. of compost is recommended. The growing plants are then cared for the first three years, or for at least two years (for tall plants) with tending operations like howing, weeding, watering and most importantly through protection from stray animals and pests. Nutrients in pits are occasionally supplemented.

Bihar is a highly populous state with a maximum population density in the country. Space is a big constraint for plantation activities. So, whatever space is available especially in an industrial premises it should be utilized properly. In an industrial unit space for plantation is usually available at the periphery or through the carriage way. If less space is available at the periphery of the unit, one row of long trees and one row of shrub should be planted. Accordingly, if more space is available a row of tall trees followed by shorter trees and shrubs is recommended. If sufficient space is available a row of tall trees followed by a row each of medium trees, small trees and shrub should be planted. The space on the sides of carriage way or internal roads should also be utilized for plantation. For these areas also a row of shrubs followed by a row each of small trees and/ or large trees depending upon the space available should be planted.

The choice of plants for roadside (and traffic island) plantations may be for containment of pollution and for formation of a screen between traffic and roads side residences. This choice of plants should include shrubs of height 1 to 1.5 meter and tree of 3 to 5 meter height. The intermixing of trees and shrubs should be such that the foliage area density in vertical is almost uniform. Option of Vertical Gardening, wherever possible may also be explored.

Shrubs and trees should be planted in encircling rows around the project site. The short trees (<10 m height) will be planted in the first rows (towards plant side) of the green belt. The tall trees (>10 m height) will be planted in the outer row (away from plant side).

Some of guidelines to be considered are:

a. Planting of trees in each row will be in staggered orientation.
b. In the front row, shrubs will be grown.
c. Since the trunks of the tall trees are generally devoid of foliage, it will be useful to have shrubs in front of the trees so as to give coverage to this portion.
d. The spacing between the trees will be maintained slightly less than the normal spaces, so that the trees may grow vertically and slightly increase the effective

height of the green belt.

e. Providing the Greenbelt in at least 33% area of the total project area with various species.

9. Recommendation of plant species for constitution of Green Belt

Sl. No.	Plant Name	Common Name	Sensitive/ Tolerant	Height (Meter)
1.	*Acacia catechu*	Khair	T	3
2.	*Acacia dealbata*	Silver wattle	T	15
3.	*Acacia leucophloea*	Safed Babul	T	3
4.	*Acacia nilotica*	Babul	T	8
5.	*Acacia pennata*	Biswal	T	8
6.	*Acacia polyacantha*	-	T	10
7.	*Acacia senegal*	SwetaKhadira	T	5
8.	*Acacia sinuata*	Kochi	T	10
9.	*Acacia tortilis*	Umbrella thorn tree	T	8
10.	*Achrassapota*	Sopata	T	10
11.	*Adina cordifolia*	Haldu	T	20
12.	*Ailanthus Altissimo*	Ailanto	T	12
13.	*Ailanthus excelsa*	Maharakha	T	20
14.	*Albizialebbeck*	Siris	T	30
15.	*Albiziaprocera*	White siris	T	20
16.	*Alstoniascholaris*	Chattiyan	T	15
17.	*Anonasquamosa*	Sharifa	T	10
18.	*Anonareticulata*	Luvuni	T	10
19.	*Anogeissuslatifolia*	Dhaura	T	-
20.	*Anthocephaluschinenis*	Kadamba	T	20
21.	*Aphanamixispolystachya*	Harin	T	13
22.	*Artocarpusheterophyllus*	Kathal	T	10
23.	*Artocarpuslacucha*	Beng	T	18
24.	*Azadirachtaindica*	Neem	T	20
25.	*Bambusaarundinocia*	Kantabans	T	20
26.	*Bambusa vulgaris*	The Golden Bamboo	T	15
27.	*Barringtoniaacutangula*	Indian Oak/Hijol	T	12
28.	*Bauhinia acuminata*	Kanchan	T	3
29.	*Bauhinia purprea*	Khairwal	T	7
30.	*Bauhinia racemosa*	Astha	T	5
31.	*Bauhinia semla*	Semla	T	10
32.	*Bauhinia varigata*	Kachnar	T	5
33.	*Bischofiajavanica*	Paniala	T	15
34.	*Bougainvillea spectabilis*	Bougainvillea	T	8
35.	*Brideliasquamosa*	Khaja	T	10
36.	*Braussanetiapapyrifera*	Jangli Toot	T	12
37.	*Buchananialanzon*	Achar	T	13
38.	*Buteomonosperma*	Kashmir	T	10
39.	*Callistemon citrinus*	Bottle Brush	T	5

40.	*Calophylluminophyllum*	Sultanachampa	T	18
41.	*Calotropisgigantea*	Gigantic swallow wart	T	5
42.	*Calotropisprocera*	Akoda	T	6
43.	*Carissa spinarum*	Karaunda	T	3
44.	*Cassia fistula*	Amaltas	T	12
45.	*Cassia javanica*	-	T	12
46.	*Cassia pumila*	Yellow Cassia	T	12
47.	*Cassia renigera*	Pink Cassia	T	10
48.	*Cassia siamea*	Iron wood tree	T	12
49.	*Casuarina equisetifolia*	Janglisaru	T	10
50.	*Ceibapentandra*	Kapok	T	15
51.	*Citrus aurantium*	Nibu	T	5
52.	*Citrus limon*	Bara Nimbu	T	3
53.	*Clerodendruminerme*	Vanjai	T	5
54.	*Clerodendruminforunatum*	Bhant	T	4
55.	*Cordia dichotoma*	Chata	T	10
56.	*Dalbergialatifolia*	Shisham	T	20
57.	*Dalbergiasisoo*	Shisham	T	10
58.	*Dendrocalamusstrictus*	Solid Bamboo /Banskaban	T	12
59.	*Derris indica*	Karanja	T	10
60.	*Diospyrosmelanoxylon*	Tendu	T	10
61.	*Dryptesroxburghii*	Putronjiva	T	15
62.	*Durantarepens*	-	T	3
63.	*Emblica officinalis*	Amla	T	5
64.	*Embryopterisperegrina*	-	T	10
65.	*Erythrina variegate*	Indian Coral Tree	T	10
66.	*Eucalyptus hybrid*	Mysore gum	T	20
67.	*Ficusbenghalensis*	Banyan Tree/Bargad	T	20
68.	*Ficusbenjamina*	-	T	12
69.	*Ficus elastic*	Indian Rubber Tree	T	12
70.	*Ficusgibbosa Blume*	-	T	10
71.	*Ficusglomerata*	Gular	T	15
72.	*Ficushispida*	Kanea dumber	T	10
73.	*Ficusreligiosa*	Pipal	T	20
74.	*Ficusvirens*	Pilkhan	T	10
75.	*Gardenia jasminoides*	Anant, Gandhraj	T	5
76.	*Gardenia resinifero*	Dikamali	T	5
77.	*Grevillea robusta*	Silky Oak	T	20
78.	*Grewia elastic*	Dhaman	T	10
79.	*Grewiasubinequalis*	Phalsa	T	7
80.	*Guazmaulmifolio*	Rudraki	T	10
81.	*Hamelia patens*	Scarlet Bush	T	3
82.	*Hibiscus rosa-sinensis*	Jasum	T	3
83.	*Ixorachinensis*	-	T	6
84.	*Ixoracoccinea*	Rangan	T	6

85.	*Lagerstroemia porviflora*	Phurush	T	20
86.	*Lagerstroemia speciosa*	Joroal	T	10
87.	*Lantana comora*	Lantana	T	3
88.	*Lawsoniainermis*	Mehndi	T	5
89.	*Madhucalongifolia*	Mahwa	T	15
90.	*Mollotusphillippensis*	Kamala	T	12
91.	*Mangiferaindica*	Aam	S	15
92.	*Millingtoniahortensis*	Indian Cork Tree	S	10
93.	*Mimusopshexandra*	Khirni	T	10
94.	*Moringaoleifero*	Sajino	S	10
95.	*Morus alba*	Tut	S	8
96.	*Murrayapaniculata*	Marchula	T	5
97.	*Neriumindicum*	Kaner	T	5
98.	*Peltophorumpterocarpum*	Copper Pod Tree	T	-
99.	*Phoenix sylvestris*	Khajur	T	10
100.	*Pithecellobiumducle*	Vilaytimli	T	8
101.	*Paincianapulcherrina*	Guletura	T	3
102.	*Polyalthialongifolia*	Devdaru	S	15
103.	*Prosopischilensis*	VilaytiKikkar	T	10
104.	*Prosopis cineraria*	Khejri	T	12
105.	*Psidiumguayava*	Amrud	T	5
106.	*Pterygotaalata*	Tula	T	15
107.	*Sapindus emarginatus*	Soapnut	T	10
108.	*Spathodea campanulata*	India tulip tree	T	12
109.	*Syzgium cumini*	Jamun	T	20
110.	*Tectono grandis*	Sagwan	T	20
111.	*Terminalia arjuna*	Arjun	T	15
112.	*Terminalia bellarica*	Bahera	T	15
113.	*Terminalia chebulo*	Harra	T	15
114.	*Thespesia populneoides*	Paraspipal	T	10
115.	*Thuja accidentalis*	White cedar	T	15
116.	*Zizyphus mauritiana*	Ber	T	10
117.	*Zizyphus rugosa*	Suran	T	5