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Quarry dust effect on trees and their tolerance ability at Bethamcharla, Kurnool District, AP, India

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Abstract

Different plant species vary over a considerable range in their susceptibility to air pollution. Since there is a little information available about responses of quarries, we selected the subject to study the influence of quarry dust on selected trees growing around quarries at Bethamcherla, Kurnool district and to measure their Air pollution tolerance indices to suggest the plants that are suitable to raise in such areas to develop a green belt. Dust pollution causes water stress also in habitats. Because growing of species that are having high APTIs are able to increase their number and can also able to increase water table by reducing the temperatures of the area. The study suggests to grow Azadirachta indica, Tamarindus indica, and Terminalia catappa around quarry dust polluted areas. In A.indica and T.indica, the Relative Water Content is very high. Whereas in T.catappa there is no change in RWC in polluted site sample. According to several observations, RWC in plants serves as an important indicator of drought confrontation in plants.

Keywords: Air pollution, susceptibility, tolerance indices, green belt, relative water content, drought confrontation.

Introduction

Pollutants contaminate air everywhere and it is usually a greater problem. A variety of gases, tiny particles or particles that can harm and damage the environment are included under pollutants. The forest and biodiversity have damaging effects by the pollutants emitted from selective industries like cement, quarries, leather paints, aluminium, fertilizers, sugar and paper. It is agreed by several contributors that plant growth is adversely effecting by air pollutants. The dust pollution is localized importance near roads, quarries, cement works and industrial works. Dust on leaves blocks stomata, lowers their conductance, interferes with photo system II and in turn plant species were declined. The pollutants can cause a serious threat to the overall physiology of plants.

Plants are under going to a serious environmental stress by air pollution, as they constantly take up atmospheric gasses. It has an adverse effect on biological processes of plants and cause considerable change in plant communities and ecosystems. Thus there is a need to study, what we are able to do to decrease pollution levels and should increase our awards of pollution.

Pollution is frequently seen as a sign of “progress”. Emissions of gaseous pollutants have increased in India over the past two decades. Environmental problems in India are growing rapidly. Thus, the problem of air pollution has attracted special attention in India. Thus, the state administration needs to assess the impact of air pollution on vegetation which in turn reflects its influence on the entire diversity of biota. Different plant species vary over a considerable range in their susceptibility. Since there is a little information available about the responses of quarry dust, we selected the subject to study the influence of quarry dust on selected trees growing around the quarries at Bethamcherla, Kurnool district and to measure their Air pollution tolerance indices to suggest the plants that are suitable to raise in such areas to develop a green belt.

Thus the study is aimed to determine Air Pollution Tolerance Indices (APTI) values of twenty plant species growing around the quarry at Bethamcherla of Kurnool district, A.P., India. This study is helpful to recognize the plant species which are forbearing to the prevailing environment. Dust pollution causes water stress in habitats. Thus knowing of APTI values of plants growing in such areas is beneficial to list out the plants that are suitable to propose to grown up in dust polluted areas. Because growing of species that are having high APTIs are able to increase their number and can also able to increase water table by reducing the temperatures of the area.

Materials and methods

Study area: The present study is conducted at quarries of Bethamcherla in Kurnool district of Andhra Pradesh, India which is situated between longitudes of 78.15996117 and latitudes of 15.4657456. Autumn, winter, spring, and summer, the four distinct seasons’ can be seen here. The average rain fall of an area is about 150mm which is chiefly confined to monsoon months and the climate of the area is relatively temperate. Temperature ranges of 28^0C-44^0C. Two sites are selected for the study. Site – 1 i.e. control area where there are no quarries (Rayalaseema University campus area), Site - 2 is a dust polluted area, very closer to quarries.

Plant sampling and analysis for physiological studies: Leaf samples from various plant species are collected. Five replicates of samples are collected from selected sites and instantly taken to the laboratory for testing. Immediately upon getting to the laboratory, fresh weight of the leaf for both the samples are taken. Samples are preserved in refrigerator for other chemical analysis.

Total Chlorophyll Content (TCh.): This is estimated according to the method described by Arnon[1]. 3g. of fresh leaves were taken and grinded with the help of mortar and pestle and then extracted with 10ml. of 80% acetone. Then the content was left for 15 minutes for thorough extraction. The liquid portion was taken into another test tube and centrifuged at 2,500rpm for 3 minutes. The supernatant was then collected and the absorbance taken by using a spectrophotometer at 645nm and 663nm. The concentration of chlorophyll a and chlorophyll b (mg/g-fresh leaf) are obtained by using Maclachlan and Yentsch[2] formula –
Chlorophyll a = 12.7 x $O.D_{663}$ - 2.69 x $O.D_{645}$.
Chlorophyll b = 22.9 x $O.D_{645}$ – 4.68 x $O.D_{663}$.
Chlorophyll a/b = Total amount of chl. a/ Total amount of chl. b
Total chlorophyll content a+b = 8.02 x $O.D_{663}$ + 20.2 x $O.D_{645}$.

Relative Water Content (RWC): The leaf RWC is determined by the method described by Singh[3] and calculated with the formula–
RWC = FW – DW / TW – DW x 100.

FW = Fresh Weight, DW = Dry Weight, TW = Turgid Weight

Fresh leaves are weighed to record the fresh weight. The leaves are dried in a hot air oven at 70^0C for overnight and then the dry weight is taken. The leaves are immersed in water overnight, blotted dry and then weighed for obtaining the turgid weight.

Leaf extracts pH: 5gms. of fresh leaves are taken in 10ml. of de-ionized water and homogenized. This is filtered and pH of the leaf extract determined after calibrating pH meter with buffer solution of pH – 4 as described in Agbaire and Esief[4].

Analysis of Ascorbic Acid (AA) by using titration method: It is determined by using the method described by Anne Marie Helmenstine[5]. Pippetted a 20ml. of the sample solution into a 250ml conical flask and added 150ml of distilled water and 1ml of starch indicator solution. The sample is titrated with 0.005mol/L Iodine solution. The first permanent trace of a dark blue-black colour due to the starch - iodine complex is identified as the end point of titration. Titration is repeated until obtained concordant result with further aliquots of sample solution.

Estimation of ascorbic acid: Average volume of iodine solution is calculated from concordant titters. The number of moles of ascorbic acid reacting is determined by using following equation of the titration –
Ascorbic Acid + $I_2 \rightarrow$ 2I- + De hydro ascorbic acid.

The concentration of ascorbic acid is calculated in the sample of leaf in mg/100ml.

Air pollution tolerance index (APTI) determination: APTI is determined by using the method described by Singh and Rao[6]. The formula is – APTI = A (T + P) + R/ 10.

Where: A = Ascorbic Acid content (mg/g), T=Total Chlorophyll (mg/g), P = pH of leaf extract; R = Relative Water Content of leaves %.

Results and discussion

Results of the study for all parameters are provided in a table along with percentage increase/decrease of APTI in samples collected from both the sites.

Effect on pH: Eight of the following plants had high pH value in unpolluted area and it is decreased in polluted area. i. *Albizia lebbeck* - 6.74 and 6.3; ii. *Albizia odoratissimma* - 6.41 and 5.77; iii. *Alastonia schalaris* (6.58 and 6.49); iv. *Annona squamosa* - 6.34 and 5.93; v. *Derris indica*-6.85 and 6.46; vi. *Ficus benghalensis* 7.37 and 6.61; vii. *Ficus mollicima-7.81* and 7.10; viii. *Ficus recemosa*-7.07 and 6.61.

Five of the following plants had less pH value in unpolluted area and it is increased in polluted area. i. *Holoptelea integrifolia* - 7.10 and 7.73; ii. *Morinda pubescence* - 5.17 and 5.90. iii. *Sapindus emarginatus* - 6.22 and 7.09; iv. *Tamarindus indica* - 3.40 and 6.22; v. *Terminalia catappa* - 5.32 and 6.84.

Eight of the following plants had almost equal pH value in unpolluted and polluted areas. i. *Acacia auriculiforims*-6.89 and 6.80; ii. *Alstonia schalaris* - 6.58 and 6.49; iii. *Azadirachta indica* - 6.22 and 6.30; iv. *Cordia dichotoma* - 7.30 and 7.1; v. *Dalbergia sissoo* - 6.84 and 6.95; vi. *Ficus* religiosa - 7.55 and 7.60; vii. *Polyalthia longifolia* - 6.33 and 6.11; viii. *Syzygium cumini* - 6.20 and 6.3.

Effect on Relative Water Content (RWC): Twelve of the following plants had high relative water content in unpolluted area and it is decreased in polluted area. i. *Acacia auriculiforims* - 82.5 and 72.51; ii. *Albizia lebbeck* - 65.7 and 26.3; iii. *Albizia odoratissimma* - 85.3 and 47; iv. *Annona squamosa* - 91.6 and 50.0; v. *Ficus benghalensis* - 92.4 and 83.8; vi. *Ficus mollicima* - 96.51 and 79.6; vii. *Ficus recemosa* - 91.3 and 86; viii. *Holoptelea integrifolia* - 98.1 and 72.2; ix. *Morinda pubescence* - 62.1 and 45.10; x. *Polyalthia longifolia* - 95.7 and 91.3; xi. *Sapindus emarginatus* -70.32 and 39.3; xii. *Syzygium cumini* - 92.0 and 89.9.

Seven of the following plants had less relative water content in unpolluted area and it is increased in polluted area. i. *Alstonia* *schalaris* - 90.8 and 96.86; ii. *Azadiracta indica* - 79.8 and 92.2; iii. *Cordia dichotoma* - 91.0 and 95.0; iv. *Dalbargia sissoo* - 76.6 and 88.7; v. *Derris indica* - 84.1 and 96.0; vi. *Ficus religiosa* - 95.1 and 98.9; vii. *Tamarindus indica* -77.9 and 88.4.

In one of the following plant relative water content is almost equal in unpolluted and polluted areas. i. *Terminalia catappa* - 87.2 and 87.2.

Effect on Chlorophyll Content (Ch.): In three of the following plants, chlorophyll content value is high in unpolluted area and it is decreased in polluted area. i. *Albizia odoratissimma* - 0.7 and 0.59; ii. *Annona* squamosa - 0.48 and 0.26; iii. *Syzygium cumini* - 1.86 and 0.77.

In twelve of the following plants chlorophyll content value is less in unpolluted area and it is increased in polluted area. i. Acacia *auriculiforims* - 0.34 and 0.78; ii. *Albizia lebbeck* - 0.29 and 0.8; iii. *Alstonea schiaris* – 029 and 0.35; iv. *Cordia dichotoma* - 0.58 and 0.80; v. *Derris indica* - 0.39 and 0.54; vi. *Ficus mollicima* - 0.73 and 1.4; vii. *Ficus recemosa* - 0.24 and 0.38; viii. *Holoptelea integrifolia* - 0.7 and 1.19; ix. *Morinda pubescence* - 0.8 and 0.93; x. *Polyalthia longifolia* - 0.19 and 0.85; xi. *Sapindus emarginatus* - 0.52 and 0.8; xii. *Tamarindus indica* - 0.20 and 0.34.

In five of the following plants chlorophyll content value is almost equal in both unpolluted and polluted areas. i. *Azadirachta indica* - 0.72 and 0.77; ii. *Dalbergia sissoo* - 0.59 and 0.51; iii. *Ficus* benghalensis - 0.86 and 0.85; iv. *Ficus religiosa* - 0.8 and 0.8; v. *Terminalia catappa* - 0.63 and 0.65.

Effect on ascorbic acid: In ten of the following plants ascorbic acid content is high in unpolluted area and it is decreased in polluted area. i. *Albizia odoratissimma* - 8.4 and 5.1; ii. *Alstonia schalaris* - 7.7 and 6.35; iii. *Annona squamosa* - 10.1 and 6.94; iv. *Cordia dichotoma* - 20.1 and 7.24; v. *Derris indica* - 14.3 and 7.24; vi. *Ficus recemosa* - 16.7 and 12.6; vii. *Ficus religiosa* - 7.24 and 5.1; viii. *Morinda pubescence* - 16.7 and 11.21; ix. *Polyalthia longifolia* -10.1 and 7.24; x. *Tamarindus indica* - 62.6 and 16.7.

The following seven plants are showing less ascorbic acid content in unpolluted area and it is increased in polluted area. i. *Albizia lebbeck* -7.2 and 9.19; ii. *Azadirachta indica* - 3.4 and 5.6; iii. *Ficus benghalensis* - 5.1 and 7.4; iv. *Ficus mollicima* - 6.35 and 7.24; v. *Holoptelea integrifolia* - 5.1 and 8.4; vi. *Syzygium cumini* - 6.35 and 10.1; vii. *Terminalia catappa* - 5.9 and 8.43.

In three of the following plants ascorbic acid content is almost equal in unpolluted and polluted areas. i. *Acacia auriculiforims* - 3.4 and 3.67; ii. *Dalbergia sissoo* - 12.6 and 12.6; iii. *Sapindus emarginatus* - 3.9 and 3.7.

Effect on Air Pollution Tolerance Index: The following 12 plants are showing high Air pollution tolerance index (APTI) in unpolluted area and it is decreased in polluted area. i. *Albizia lebbeck* - 9.16 and 11.6; ii. *Albizia odoratissimma* 8.33 and 14.5; iii. *Annona* squamosa - 9.30 and 16.05; iv. *Cordia dichotoma* -15.23 and 24.9; v. *Derris indica* - 14.67 and 18.8; vi. *Ficus recemosa* - 17.46 and 23.3; vii. *Ficus religiosa* - 14.18 and 15.5; viii. *Ficus mollicima*- 14.19 and 15.0; ix. *Morinda pubescence*- 12.17 and 16.3; x. *Polyalthia longifolia*- 14.17 and 16.16; xi. *Sapindus emarginatus* - 6.8 and 9.69; xii. *Tamarindus indica* -19.8 and 29.0.

The following 5 plants are showing less APTI in unpolluted area and it is increased in polluted area. *i. Azadirachta indica*-13.23 and 10.3; ii. *Dalbergia sissoo*-18.2 and 17.0; iii. *Holoptelea integrifolia*-14.75 and 13.8; iv. *Syzygium cumini*- 16.18 and 14.32; v. *Terminalia catappa*-15.05 and 12.2.

The following two plants are showing almost equal APTI in unpolluted and polluted areas. i. *Acacia auriculiforims*-10.4 and 10.7; ii. *Alstonia schalaris*-14.03 and 14.4; iii. *Ficus* benghalensis -13.64 and 13.4.

Discussion: Plants can serve as primary recipients of all types of pollutants and can act as best filtering systems and sink for air pollutants and accumulate pollutants on their surface. Holt and Miller[7] identified plants as bio-indicators and bio-monitors of air pollution on basis of the studies on pollution induced changes in plants. Green cover development around industries can moderate pollution to a certain level. For plantation, plants must have resistant or tolerant to pollutants of the area. Thus, eco-friendly plant species can choose to lessen the airborne particulate pollution on basis of APTI. According to Sing and Rao[8], plants having higher APTI value are tolerant to air pollution and can be used as huge sinks for pollution easing , while low APTI show their less tolerance and they can be used as indicators of air pollution.

pH: In this study the pH values in leaves ranged from 3.4 to 7.55 in control site and 5.77 to 7.73 in stone dust polluted area during the months of January and February were determined to be maximum in *F. mollisima* (7.81) and minimum in *T. indica* (3.4) in control area and it is maximum in *H. integrifolia* (7.73) and minimum in *A. odoratissimma* (5.77) in polluted area. Among the 20 species studied, in 5 species it is reduced in polluted area and is increased in 8 plant species and is almost equal in 7 species. Scholz and Reck[9] said that the reducing rate of P^H is less in tolerant species. Thus the study revealed that 9 species are tolerant species.

Singh and Varma[10] have described that plants with lower pH are more susceptible to air pollution than those with high pH. pH is increased at polluted site plants in species of *T. indica* (3.4 to 6.22); *T. catappa* (5.32 to 6.84); *S. emarginatus* (6.22 to 7.09); *S. cumini* (6.2 to 6.34); *M. pubescence* (5.17 to 5.9) *H. integrifolia* (7.10 to 7.73), *F.religiosa* (7.55 to 7.6); *D. sissoo* (6.84 to 6.95); and in *A.indica* (6.22 to 6.3). The high increase in pH is observed in *T.indica* (2.82) followed by *T.catappa* (1.52).

Relative water content: As stated by Innes and Haron[11], the high water content with in a plant body help to maintain its physiological balance under stressful conditions, such as exposure to air pollution. Varma[12] suggested that the increased RWC in a particular species improves its drought tolerance and the maintenance of RWC by the plant may determine its relative tolerance to pollution. Rai et al.[13] stated that in a polluted site sample, the high RWCs of plants may be responsible for the normal function of plant biological processes. Geravandia et al.[14] said that RWC serves as an important indicator of drought resistance in plants. Krishnaveni et al.[15] stated that RWC in plants is mainly associated with their protoplasmic permeability which results in early senescence of leaves due to loss of water and dissolved nutrients.

Table-1: All parameters studied to determine APTI of the plants.

Name of the plant	Family	pH value		RWC		Chl		Ascorbic acid		APTI		% Increase /decrease
		C	P	C	P	C	P	C	P	C	P	in APTI
Acacia auriculiforims A.cunn ex Benth	Fabaceae	6.89	6.8	82.3	72.58	0.34	0.78	3.4	3.67	10.71	10.4	-2.89
Albizia lebaeck (L)wild	Fabaceae	6.74	6.3	65.7	26.39	0.29	0.8	7.2	9.19	11.6	9.16	-21.03
Albizia odorotissima (L.f.) Benth.	Fabaceae	6.41	5.77	85.3	47.8	0.7	0.59	8.4	5.1	14.5	8.33	-43.24
Alostonia schalaris (L.) R.Br	Apocyanaceae	6.58	6.49	90.8	96.86	0.29	0.35	7.7	6.35	14.4	14.03	-2.57
Annona squmosa L.	Annonaceae	6.34	5.93	91.6	50	0.48	0.26	10.1	6.94	16.5	9.3	-43.63
Azadirachta indica Juss.	Fabaceae	6.22	6.3	79.8	92.2	0.72	0.77	3.4	3.4	10.3	13.23	28.44
Cordia dichotoma G.Forst	Boraginaceae	7.3	7.1	91	95	0.58	0.8	20.1	7.24	24.9	15.23	-38.83
Dalbergia sissoo Roxb	Fabaceae	6.84	6.95	76.6	88.7	0.59	0.51	12.6	12.6	17	18.2	7.06
*Derris indica(*Lan) Bennett	Fabaceae	6.85	6.46	84.1	96	0.39	0.54	14.3	7.24	18.8	14.67	-21.96
Ficus benghalensis L.	Moraceae	7.37	6.61	92.9	83.8	0.85	0.86	5.1	7.4	13.4	13.64	1.8
Ficus molisima Ridl	Moraceae	7.81	7.1	96.51	79.6	0.73	1.4	6.35	7.24	15	14.19	-5.4
Ficus recemosa L.	Moraceae	7.5	6.61	91.5	86.5	1.24	0.38	16.7	12.6	23.3	17.46	-25.06
Ficus religiosa L.	Moraceae	7.55	7.6	95.1	98.9	0.8	0.8	7.24	5.1	15.5	14.18	-4.5
Holoptelea integrifolia Roxb	Ulmaceae	7.1	7.73	98.1	72.2	0.7	1.19	5.1	8.4	13.8	14.75	6.88
*Morinda pubescence*Roxb	Rubiaceae	5.17	5.9	62.1	45.1	0.8	0.93	16.7	11.21	16.3	12.17	-25.3
Polyalthia longifolia (sonn)	Annonaceae	6.33	6.11	95.7	91.3	0.19	0.85	10.1	7.24	16.16	14.17	-1.19
*Sapindus emerginatus*Vahl symb	Sapindaceae	6.22	7.09	70.32	39.3	0.52	0.8	3.9	3.7	9.69	6.8	-29.82
Syzygium cumini (L) skeel	Myrtaceae	6.2	6.34	92	89.9	1.86	0.77	6.35	10.1	14.32	16.18	12.98
Tamarindus indica L	Fabaceae	3.4	6.22	77.9	88.4	0.2	0.34	62.6	16.7	29	19.8	-68.27
Terminalia cattapa L.	Combretaceae	5.32	6.84	87.2	87.2	0.63	0.65	5.9	8.43	12.2	15.5	27.04

In present study, the RWC of leaves ranges from 60.1% to 98.1% in control site and 39.3% to 96.86% in polluted area. In 12 species, RWC is decreased in polluted area where as in 7 species it is increased and in only one species there is no change. Thus totally 8 species are to be advantageous for drought resistance. *F. religiosa* has shown high (98.9) RWC and *S. emarginatus* has less (39.3) RWC in polluted area. There is much decrease of RWC in *S.emarginatus* is recorded. In 7 species such as *F.religiosa* (95.1 to 98.9); *A.indica* (79.8 to 92.2), *D.indica* (84.1 to 96.0); *T.indica* (77.9 to 88.4), *D.sissoo* (76.6 to 88.7), *C.dichotoma* (91 to 95.0), *A.scholaris* (90.8 to 96.86) are showing increased RWC. The high increase is in *A.indica* (12.4) followed by *D.sissoo* (12.1), *D.indica* (11.9), *T.indica* (10.5), *A.scholaris* (6.06), *D.tichotoma* (4) and *F.religiosa* (3.8).

Chlorophyll content: According to Kaur et al.[16] plants having high chlorophyll content are generally found tolerant to air pollution. It was documented by Tripathi and Gautam[17]; Mir et al.[18]; Rahmawati et.al.[19] that there is a decrease in chlorophyll content due to high level of air pollution in plants.

In the present study total chlorophyll content is decreased in 3 plant species and is increased in 12 plant species. Where as in 5 species there is no much change in total chlorophyll content. It is ranged from 0.2 to 1.86 in control site and from 0.26 to 1.4 in polluted site. High chlorophyll content is recorded in *S. cumini* (1.86) and the lower is in *T.indica* (0.20) of the control site, whereas the high chlorophyll content is in *F.mollisima* (1.4) and the low content is in *T.indica* (0.34) at polluted site. There is a slight increase in chlorophyll content is also observed in *T.indica* (0.14).

Ascorbic acid: Ascorbic acid is an antioxidant that increases the resistant of plants against air pollutants[20]. Plant species with high amount of ascorbic acid are considered to be tolerant to air pollutants[21]. It is vital in cell wall synthesis, defence, and cell division and plays an important role in photosynthetic carbon fixation[22]. Sanghi et al.[23] stated that the plants having high ascorbic acid content were found to be more tolerant to air pollution.

The present study revealed the range of Ascorbic acid as 3.9 to 62.6 in control site, where as it is 3.9 to 16.7 in polluted area. The lowest Ascorbic acid is shown by *S. emarginatus* (3.9) both in polluted and control sites. Though it is very high (62.6) in *T. indica* of control site, it is highly reduced in polluted area (16.7). The high Ascorbic acid is recorded in *T. indica* (16.7) among the studied plants of polluted area. In *T.catappa,* there is an increase of 2.53 (from 5.9 to 8.43) in ascorbic acid content.

Air pollution tolerance index: In this study the APTI values for 20 plant species are examined. It revealed that different plants respond differently to air pollution. Hence a different index is observed with *T.indica* (19.8), *D. sissoo* (18.2), *F. recemosa* (17.46), *S.cumini* (16.18) and *T.catappa* (15.5). The least APTI is recorded in *S. emarginatus* (6.8). Though there is an increase in pH, RWC, Chlorophyll content and in ascorbic acid, APTI value in polluted area is reduced in *T.indica*. But the pollution tolerance is high in *T. indica* (19.8) among the studied plants of polluted area which may be attributed to the increase in its pH, RWC, and its high ascorbic acid.

Percentage tolerance increase of APTI: Percentage tolerance increase of APTI is high in *A. Indica* (28.44) followed by *T. catappa* (27.04), *S.cumini* (12.98), *D. Sissoo* (7.06), *H.integrifolia* (6.88) and *F.benghalensis* (1.8).

Conclusion

Though the APTI is high in *T.indica* (19.8), percentage increase of APTI is high in A. *Indica* (28.44). *T. indica* is having high RWC and pH values. Ascorbic acid is highly reduced in polluted samples of *T. indica*. Therefore, the high APTI is because of its high RWC, which is responsible for drought resistant. In *A.indica* where the % increase of APTI is high, the RWC is also high (92.2) in polluted sample than in control sample (79.8). P^H is also slightly increased in polluted sample. There is no change in ascorbic acid. In *T.catappa* there is an increase in P^H and ascorbic acid content. No change in RWC. Thus the study suggests to grow *A. Indica*, *T. indica*, and *T. catappa* around quarry dust polluted areas to develop a green belt in those areas.

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