Journal of Ecology and the Natural Environment Vol. 1(5), pp184-190 November, 2009
Available online at http://www.academicjournals.org/jene
ISSN 2006- 9847 © 2009 Academic Journals

Full Length Research Paper

Phytosociology of roadside communities to identify ecological potentials of tolerant species

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Accepted 2 October, 2009

Roadside vegetations are open to contaminations of diverse heavy metals and other gaseous pollutants, and to physical disturbances of being trampled by pedestrians and crushed by vehicles continuously. Being a biodiversity-rich region of the world, roadsides of Southwest India, are expected to be rich in unique pollution-tolerant species. Tolerant plants in heavy metal polluted roadsides may be excluders or accumulators or hyper-accumulators of the metals. Phytosociology of communities on roadsides is significant in the identification of the degree of tolerance of species, because the method in general, is considered efficient and appropriate to assess the ecological potentials of plants in natural communities. Floristic survey and phytosociological analysis of 110 km of busy roadsides of a biodiversity-rich tropical zone, Kottayam District of Kerala, South India, showed 85 species belonging to 27 families differently tolerant to the stressful environment, which included exotics as well as medicinal plants. Botanical details and ecological potentials of the tolerant species found on these roadsides are discussed. Phytosociological investigations on roadsides enable identification of the hyper-tolerant; also provide information regarding patterns of introduction of exotics into natural vegetations. Hyper-tolerance is useful clue to the preliminary screening of the hyper-accumulation potentials of plants.

Key words: Phytosociology, frequency, density, relative abundance, hyper-tolerance phytosociology of roadside communities to identify ecological potentials of tolerant species.

INTRODUCTION

All over the world, especially in developing countries, roads are continuously increasing at a fast rate; and roadsides occupy a very broad area of most countries. Ecologically unique roadside communities (National Research Council, 1997) provide enormous opportunities for investigations (Forman and Alexander, 1998) and roadsides are great frontiers awaiting science and society (Forman and Deblinger, 2000). Usual focus of roadside studies include variations in communities in relation to environmental gradients (Arevalo et al., 2005), survey of certain vegetation characteristics (Ahmad et al., 2004), conservation of wild species occupying the area (Allem, 1997) and of invasive exotics (Rentch et al., 2005).

Physico-chemical disturbance is widely recognized as a primary influence on plant community composition and the spread of invasive exotics (Larson, 2003). Vegetations on diversely polluted and physically disturbed roadsides include highly resilient species. Pollutants on roadsides include high amount of different heavy metals (Li et al., 2004; Juknevicius et al., 2007; Al-Khashman, 2007; Yetimoglu et al., 2007) and other gaseous hydrocarbons (Latimer et al. 1990). Trampling and crushing by people and vehicles are the common physical disturbances. Resilient species of contaminated environments are believed to be reliable indicators of pollution and disturbance. In general tolerant plants in metal contaminated environments are excluders, accumulators or hyper accumulators. Many investigators expect hyper accumulator species to be present among resilient roadside plants (Okunola et al., 2007; Bakirdere and Yaman, 2008). Phytosociological analysis of natural vegetation is recognized as an efficient and appropriate method to select out useful plant species from natural communities

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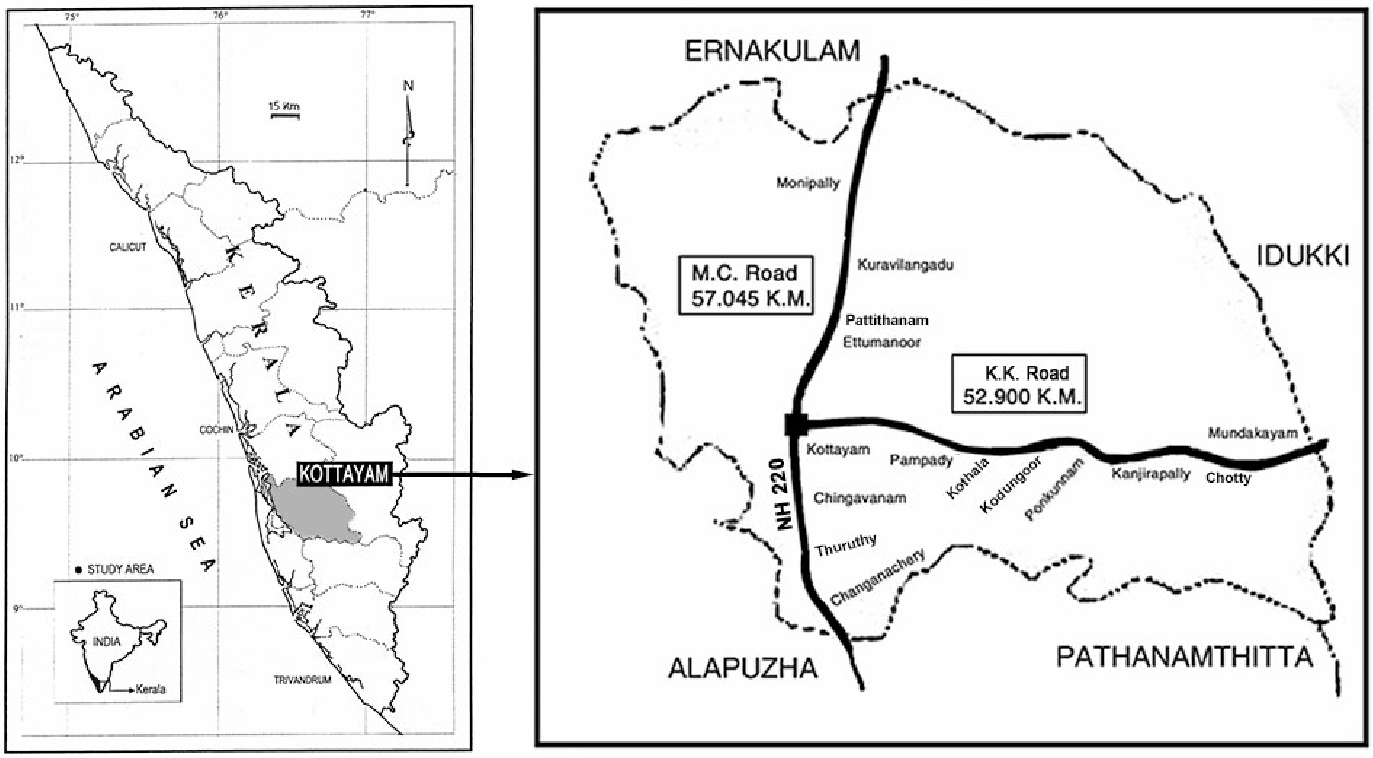

Figure 1. Area map of the place of investigation.

(Katsuno, 1977). According to Yoon et al. (2006) native plants growing on contaminated sites, especially in subtropical and tropical areas are expected to have the potential for phytoremediation. However, practically no literature is found describing roadside vegetation in Kerala, which is one of the biodiversity-rich and fast urbanizing states of tropical India. Therefore, roadsides of this region are expected to be rich in unique pollution-tolerant and resilient species, which may be ecologically relevant as indicators of pollutions or otherwise economically significant. The present investigation was to identify the species richness and the degree of resilience of different roadside species on the basis of certain phytosociological parameters.

MATERIALS AND METHODS

Investigations were made along 55 km each of two roads; the Main Central road (MC road) and *Kottayam-Kumily* road (KK road), of average traffic densities of 15,300 vehicles per day (Government of India, 2007), *Kottayam* District (9° 15' - 10° 21' North and 76° 22' - 77° 25' East; total 2208 km^2; population density 884 per km^2) of Kerala, South India (Figure 1), over a period of two years (2005 - 2007); the climate of the region is mostly wet, receiving southwest monsoon (June to September) and northeast monsoon (October - December) separated by a short break of summer (January to April), seasons quite overlapping; average rainfall of Kerala is 3130.33 mm (Government of Kerala, 2008). Along the entire roadside, many specific urban and rural sites of 0 - 1 m distance from tar-edge and 1 km length including both the sides were identified on the basis of degree of traffic densities and other anthropogenial disturbances: four urban and two rural sites on MC road and four urban and three rural sites on KK road. These sites were repeatedly sampled at different months during the two-year period. Monthly samples were grouped into that of monsoon and summer seasons.

Samples were collected using standard quadrat methods (Trivedy and Goel, 1986); quadrats of 40 x 40 cm size, of approximately 0.1 m^2 (Uzbeck, 1981) were used; at each site, 100 - 110 quadrats from both sides of the roads at random were observed. An average of 4 - 5 quadrats from each site, continuously for 24 months was taken; altogether 1350 quadrats from both the roads representing two seasons and two areas (rural and urban) were studied. Quadrats were taken at random in all sites; each month from different spots. Species were identified using the taxonomic key of Sasidharan (2004). Species richness and other vegetation characteristics such as Abundance, Frequency, Density and Relative Abundance of all species were observed as per Trivedy and Goel (1986). These phytosociological parameters of different species were calculated for each quadrat, and the average of a parameter of a species of all quadrats from a site in a particular season (monsoon and summer) was taken as its specific seasonal value at that site. Thus, for each species, depending on their availability, two seasonal values from most of the different sites of two roadsides were obtained. Statistical measures of mean, standard deviation, ANOVA and Chi-square were carried out using Microsoft Excel and the SPSS package.

RESULTS

Species richness and the mean of abundance, frequency, density and relative abundance of individual species are given in Table 1. Comparisons were made seasonwise (summer and monsoon), roadwise (KK Road and MC

Table 1. Species richness and the phytosociology of roadside vegetation.

S/No.	Name of Species	Abundance mean(±)SD	Frequency mean(±)SD	Density mean(±)SD	Relative abundance Mean(±)SD
1	*Axonopus compressus* (Sw.) P.Beauv[§].	18.45± 09.58	28.41+24.77	07.22+08.18	21.19+19.93
2	*Eleusine indica* (L.) Gaertn[§].	08.31± 02.10	45.48+10.35	03.76+01.21	13.59+04.63
3	*Cynodon dactylon* (L.) Pers[§].	15.06± 08.97	14.06±11.16	02.31±02.14	08.38±08.48
4	*Pilea microphylla* (L.) Liebm[†].	07.18±05.64	08.89±07.43	00.91±00.83	03.77±03.43
5	*Hedyotis corymbosa* (L) Lam [§].	05.12± 03.23	15.12±09.82	00.93±00.81	03.41±02.74
6	*Portulaca oleracea* L[†].	04.88±03.88	09.98±09.66	00.75±00.74	03.11±03.10
7	*Chloris barbata* Sw[†].	02.67±02.91	03.01±03.44	00.17±00.21	02.62±08.83
8	*Cleome rutidosperma* DC[§].	04.51±02.33	12.00±06.76	00.64±00.46	02.37±01.63
9	*Synedrella nodiflora* (L.) Gaertn[§].	05.72±01.31	10.80±09.94	00.63±00.57	02.16±01.74
10	*Kyllinga nemoralis*(J.R&G.Forst.)DandyexHutch.&Dalz[§].	06.49±05.37	06.32±05.27	00.52±00.48	02.08±01.84
11	*Scoparia dulcis* L[§].	03.82±01.25	14.09±04.21	00.55±00.25	02.06±01.08
12	*Vernonia cinerea* (L.) [§]	05.02±01.57	10.61±05.13	00.56±00.36	02.05±01.29
13	*Amaranthus viridis* L[§].	03.87±02.91	09.18±08.51	00.53±00.56	01.99±02.07
14	*Brachiaria ramose* (L.)Staf[§].	06.96±07.07	04.99±06.94	00.56±00.75	01.82±02.27
15	*Commelina benghalensis* L[§].	06.81±05.46	04.95±03.83	00.47±00.42	01.82±02.27
16	*Desmodium triflorum* (L.) DC[§].	10.24±08.59	04.76±06.21	00.51±00.67	01.65±01.79
17	*Sporobolus diander* (Retz.) Jovet&Guedes[§].	06.63±04.94	06.43±03.75	00.44±00.28	01.65±01.08
18	*Digitaria ciliaris* (Retz.) Koeler[§].	05.45± 04.78	05.50±05.63	00.48±00.52	01.64±01.86
19	*Cyperus compressus* L[§].	04.42±03.62	06.59±06.09	00.43±00.47	01.57±01.53
20	*Mimosa pudica* L[§].	02.62±03.26	09.85±14.72	00.57±00.85	01.55±02.12
21	*Phyllanthus amarus* Schum. & Thonn[§].	02.71±01.42	09.10±06.75	00.31±00.25	01.26±01.16
22	*Ischaemum indicum* Hook f[§].	06.99±12.17	03.44±05.91	00.39±00.61	01.17±01.74
23	*Alternanthera tenella.Moq.in* DC[§].	04.18±05.22	03.04±04.25	00.31±00.48	01.15±02.07
24	*Dactyloctenium aegyptium* (L.) P. Beauv [§].	04.23±03.48	05.08±05.56	00.30±00.35	01.09±01.22
25	*Eleutheranthera ruderalis* (Sw.) sch.Bip[§].	04.50±04.02	04.48±04.11	00.31±00.35	01.04±01.25
26	*Euphorbia hirta* L[§].	03.72±02.19	06.21±05.42	00.24±00.18	00.95±00.85
27	*Amaranthus spinosus* L[§]	04.17±03.28	04.82±04.88	00.26±00.26	00.90±00.89
28	*Boerhavia diffusa* L[§].	04.33±03.37	04.08±04.25	00.22±00.25	00.79±00.80
29	*Paspalidium flavidum* (Retz.)A.Camus in lecomte. †	01.84±07.13	00.78±02.79	00.20±00.86	00.64±02.70
30	*Eclipta prostrata* (L.) L[§].	03.42±02.94	03.52±03.53	00.16±00.16	00.64±00.64
31	*Eragrostis uniloides* (Retz.) Nees ex Steud [§].	03.05±03.74	02.58±05.58	00.21±00.54	00.62±01.23
32	*Aerva lanata* (L.) Juss. ex Schult[§].	03.80±03.58	02.41±02.49	00.14±00.14	00.56±00.57
33	*Emilia sonchifolia* (L.) DC. in Wight[§].	02.64±01.93	03.21±03.06	00.13±00.13	00.53±00.61
34	*Gomphrena serrata* L[†].	02.52±04.14	02.33±04.65	00.15±00.27	00.52±00.91
35	*Ageratum conyzoides* L[§].	03.54±02.37	03.65±02.87	00.18±00.16	00.51±00.42
36	*Sida acuta* Burm.f[§].	01.60±02.74	03.76±07.55	00.16±00.32	00.45±00.84
37	*Ludwigia perennis* L[§].	02.14±01.55	04.08±03.75	00.11±00.10	00.43±00.41
38	*Lindernia crustacea* (L.) F.v.Muell[‡].	02.60±05.06	01.32±02.45	00.13±00.24	00.41±00.78
39	*Sida rhombifolia* L [‡].	01.10±01.98	03.25±06.49	00.15±00.31	00.39±00.82
40	*Spermacoce ocymoides* Burm.f[§].	04.21±04.17	01.87±02.03	00.12±00.14	00.39±00.41
41	*Pouzolzia zeylanica* (L.) Bennett[‡].	02.01±03.11	01.65±03.08	00.09±00.18	00.35±00.70
42	*Heteropogon contortus* (L.) P.Beauv. ex Roem. &Schult [‡].	03.84±11.62	00.75±02.62	00.12±00.35	00.34±00.99
43	*Cyanotis cristata* (L.) D.Don[†]	00.80±02.57	01.19±03.79	00.09±00.27	00.31±00.94
44	*Tridax procumbens* L[§].	02.29±02.62	01.72±01.99	00.08±00.11	00.31±00.46
45	*Alternanthera sessilis* (L.) R. Br. ex DC[†].	04.03±13.41	00.51±01.14	00.09±00.30	00.30±00.93
46	*Centrosema pubescens* Benth[‡].	00.97±02.09	02.25±04.90	00.10±00.22	00.29±00.65
47	*Chromolaena odorata* (L.) King & Robin[§].s	02.19±02.21	02.45±03.35	00.11±00.16	00.29±00.41
48	*Cyperus iria* L[§].	02.06±03.44	01.45±02.73	00.09±00.19	00.28±00.50

Table 1. Contd.

49	*Senna tora* (L.) Roxb§.	01.53±02.80	02.15±04.84	00.11±00.26	00.27±00.66
50	*Sebastiana chamaelea* (L.) Muell.Arg†.	02.38±10.62	00.11±00.49	00.05±00.23	00.25±01.11
51	*Hyptis capitata* Jacq§.	01.27±02.26	02.13±04.48	00.09±00.17	00.24±00.47
52	*Mitracarpus villosus* (Sw.) DC§.	01.94±03.04	01.28±02.60	00.08±00.16	00.23±00.45
53	*Spermacoce hispida* L‡.	00.48±02.13	00.92±04.09	00.09±00.39	00.22±00.98
54	*Triumfetta rhomboidea* Jacq§.	00.77±01.73	02.08±05.45	00.08±00.19	00.22±00.52
55	*Eragrostis plumosa* (Retz.) Link†.	01.32±02.86	00.80±01.86	00.05±00.11	00.22±00.51
56	*Euphorbia rosea* Retz†.	02.33±03.91	00.76±01.29	00.06±00.11	00.21±00.37
57	*Cyathula prostrata* (L.) Blume §.	02.53±06.20	00.65±01.55	00.06±00.11	00.20±00.42
58	*Eragrostis tenella* (L.) P. Beauv†	00.83±02.57	00.69±02.45	00.06±00.22	00.19±00.71
59	*Leucas aspera* (Willd.) Spreng§.	01.62±03.08	01.19±02.72	00.06±00.14	00.18±00.38
60	*Pseudanthistris umbellate* (Hack.)Hook.f‡.	01.03±03.51	00.75±02.67	00.06±00.17	00.15±00.47
61	*Rungia parviflora* (Retz.) Nees in Wall§.	01.05±03.54	00.42±01.31	00.04±00.12	00.14±00.48
62	*Mikania micrantha* Kunth in HBK§.	01.37±02.85	00.80±01.70	00.06±00.12	00.14±00.30
63	*Achyranthes aspera* L‡.	00.82±02.12	00.92±02.38	00.05±00.12	00.13±00.32
64	*Dentella repens* (L.) J.R. & G.Forst†.	00.52±02.32	00.42±01.86	00.04±00.19	00.12±00.52
65	*Stachytarpheta jamaicensis* (L.) Vahl‡.	00.77±01.62	01.08±02.77	00.04±00.12	00.12±00.33
66	*Alysicarpus vaginalis* (L.) DC†.	01.18±04.14	00.48±01.80	00.04±00.11	00.11±00.36
67	*Pennisetum polystachyon* (L.) Schult‡ .	00.43±01.41	00.83±02.56	00.04±00.11	00.10±00.33
68	*Hyptis suaveolens* (L.) Poit‡.	00.63±01.56	00.92±03.03	00.04±00.13	00.10±00.31
69	*Cardiospermum halicacabum* L§.	01.70±03.06	00.44±00.69	00.03±00.04	00.09±00.16
70	*Oplismenus burmannii* (Retz.)Jovet&Guedes‡.	00.74±02.31	00.42±01.31	00.03±00.09	00.08±00.26
71	*Peperomia pellucida* (L.) Kunth†.	00.61±01.87	00.33±01.04	00.02±00.06	00.07±00.20
72	*Spermacoce latifolia* Aubl‡.	00.58±01.41	00.75±01.90	00.03±00.07	00.07±00.18
73	*Sida cordifolia* L†.	00.48±01.64	00.33±01.15	00.01±00.03	00.06±00.18
74	*Eriocaulon odoratum* Dalz†.	00.75±03.35	00.11±00.49	00.02±00.07	00.05±00.23
75	*Commelina maculata* Edgew†.	00.36±01.62	00.22±00.99	00.02±00.07	00.05±00.22
76	*Phyllanthus urinaria* L†	01.00±01.86	00.40±00.77	00.01±00.02	00.05±00.09
77	*Colocasia esculenta* (L.) Schott in Schott & Endl†	00.23±01.01	00.27±01.19	00.01±00.05	00.04±00.17
78	*Sporobolus indicus* (L.) R. Br†	00.50±02.23	00.11±00.49	00.01±00.04	00.03±00.15
79	*Dipteracanthus prostratus* (Poir.) Nees in Wall†	01.00±04.47	01.11±00.05	00.01±00.04	00.03±00.15
80	*Acalypha indica* L†.	00.36±00.88	00.37±01.02	00.01±00.02	00.03±00.08
81	*Senna occidentalis* (L.) Link §.	00.55±01.90	00.47±01.06	00.01±00.02	00.03±00.06
82	*Crotalaria pallida* Dryand. In Ait‡.	00.23±01.00	00.17±00.74	00.01±00.03	00.02±00.09
83	*Laportea interrupta* (L.) Chew†	00.23±01.00	00.03±00.59	00.01±00.02	00.02±00.08
84	*Physalis angulata* L†.	00.30±01.34	00.07±00.29	00.01±00.01	00.01±00.05
85	*Ipomoea cairica* (L.) Sweet†.	00.08±00.33	00.11±00.49	00.01±00.01	00.01±00.02

‡ Rural, † Urban, § Rural and Urban.

Road) and area-wise (urban and rural). Hyper-tolerance is conceived as tolerance to multitude of extreme physico-chemical disturbances such as trampling by pedestrians, crushing by vehicles, heavy metal accumulations in soils and the aerial pollutants from automobile exhausts, all of which are well documented on busy roadsides. Growth of any species in excess of others in such hyper-disturbed environments is considered high degree of hyper-tolerance. Naturally relative abundance becomes the best measure of the degree of hyper-tolerance among roadside species. Frequency also is a good parameter to assess the dominance of a plant over that of others in a natural community; but it is more reliable in distinguishing species which are more or less equal in relative abundance.

A total of 85 species were observed on these roadsides; 26 species (30.6% of total species) were monocots belonging to the five families, Poaceae, Eriocaulaceae, Cyperaceae, Araceae and Commelinaceae*;* 18 species were grasses (Poaceae) of average density of 164.1 shoots per m^2 and average relative abundance was 55.52%. Among the grasses, the three very hyper-tolerant species were *Axonopus compressus* (Sw.) *P. Beauv, Eleusine indica* (L.) Gaertn and *Cynodon dactylon* (L.) Pers of total density of 132.9 shoots per m^2 and average relative abundance of 43.16%. Of the different grasses, *Axonopus compressus* was the most tolerant species: with the highest relative abundance of 21.19% and density of 72.2 shoots per m^2. In general, when the data were combined irrespective of roads, seasons and regions, the difference in abundance, frequency, density and relative abundance of all species was statistically significant ($p < 0.005$). However, seasonwise, roadwise and regionwise comparisons gave different results. Neither the difference in species richness nor the frequency or relative abundance of different species was significant over different seasons; but the differences in abundance and density of species over the different seasons were significant ($p < 0.05$). Either in the rural or urban sites, there was no significant roadwise variation in species richness and other phytosociological variables of all species. However, species richness of vegetations over the rural and urban sites on both these roadsides was significantly different.

Altogether 58 species were found in the rural regions, whereas 73 species were found in the urban region; 27 species were found in the urban region alone, whereas 12 species were found in the rural region alone. 46 species were common to rural and urban sites. In the frequency and relative abundance of individual species also the two regions (rural and urban) were significantly different ($p < 0.05$). 53% of the total species (45 species) found on roadsides were exotics as per Sasidharan (2004). It may be noted that most species with high relative abundance such as *A. compressus* and *E. indica* were exotics. 16 species (18.82% of the total) noted on roadsides were well known medicinal plants described in many of the books on *Ayurvedic* Medicine in India.

DISCUSSION

Species richness on roadside margins as revealed in the current investigations underlines the observations of Tansely (1949) that roadsides are botanically and ecologically significant places. Moreover, unlike the less diverse and regularly managed roadsides of the west with only few species (Way, 1977; Ross, 1986), the negligibly managed roadsides of South India showed a rich diversity of resistant species. Apart from some studies on vegetation-site relationship of a broader area (Rentch et al., 2005) and comparison according to climatic differences (Ullmann et al., 1995), no specific floristic investigations, especially that of the phytosociological details of resistant species close to tar-edge of roads are mentioned in the literature, even in recent vegetation analyses of roadsides of the Indian subcontinent (Akbar et al., 2003). Ahmad et al. (2004) reported 227 species from a broad distance of roadsides; but total species diversity so far reported from roadsides close to tar-edges is less than 70 (Wester and Juvik, 1983; Akbar et al., 2003; Rentch et al., 2005).

The significant differences in species richness and certain phytosociological characteristics found over urban and rural roadsides occupying same climatic conditions can be attributed to differences in the degree of anthropogenic disturbance over the zones. Non-climatic differences in species richness of roadside vegetations are known earlier (Wilson et al., 1992). However, the explanations of the differences in vegetation types on urban and rural roadsides without quantitative analytical details of individual species (Cilliers and Bredenkamp, 2000) cannot reveal the ecological potentials of different species. Therefore, the inclusion in the present investigation of such details enabled identification of the degree of hyper-tolerance of very many new species. Phytoremediation is an emerging cost effective eco-technology to deal with heavy metal contaminations and phytomining. These types of plant inventory researches are essential to the preliminary identification of hyper accumulators useful in phytoremediation.

Roadsides are not contaminated of just one metal; it is well documented fact that the roadsides contain many heavy metals and the common are Pb, Zn, Cu, Ni and Cd; all of which are traffic related in origin (either from automobile exhausts, tear of vehicle parts or road pavements and paints). It is also a documented fact that plants do not show the same response to all these contaminants and disturbances. Moreover, when many contaminants occur together, there can be interactions of them in the soil which can be positive or negative to plant growth and establishments. In addition to these chemical disturbances, there exist physical disturbances as well. The hyper resilient are tolerant to these complex situations of roadsides.

Since roadsides are multiple contaminated and stressful towards diverse environment characteristics, high relative abundance of species growing in such environment is a sure sign of high resilience to meet with the challenges of the environment; such species are designated as hyper-tolerant in the current investigation. Therefore, the measure of relative abundance of a species in hyper-disturbed environments can be used to identify the hyper-tolerant species and their degree of hyper-tolerance. Species with high degree of hyper-tolerance may possess high ecological potentials, and they can be subjected to further experimental procedures as to their hyper-accumulation potential and resistance to physical disturbance in general. Knowledge of herbs with high degree of physical disturbances also has very many ecological and economic uses. Thus, phytosociological investigations have predictive or indicative importance in ecological inquiries towards the search of hyper-tolerant or hyper-accumulator species. This is especially relevant because, some of the hyper-tolerant roadside species noted in the present study are already reported hyper-accumulators as well. Moreover, many species from the already identified hyper-accumulator plant families such as Poaceae, Asteraceae, Cyperaceae, Fabaceae, Lamiaceae and Euphorbiaceae (Prasad, 2005) were found on roadsides in the present studies; the fast growing Poaceae are noted for their tolerance and hyper accumulation capacities (Jankaite and Vasarevicius, 2007). The ecological potentials of the dominant grass species noted on these roadsides may be further explored for their specific ecological indications of tolerance or hyper-metal accumulation. The results of this research thus open up new vistas of ecological opportunities, which the exploration of roadside vegetation provides.

Disturbance frequently is implicated in the spread of invasive exotic species (Larson, 2003). Roads being the ecological corridors of exotic species (Trombulak and Frissel, 2000), highly disturbed roadsides are open places where natural communities contain many exotic species. If the percentage of exotic species on roadsides is equated to the degree of disturbing environmental influence on the integrity of roadside communities, the South Indian roads with 53% exotics, (45 species), irrespective of seasons or regions, could be assessed as highly disturbed; however, none of the exotics observed were of nationally notified species for control and prevention of spread. Among the total exotics 78% (35 species) were dicots and only 22% (10 species) were monocots. The high density and relative abundance of a few monocots over that of many dicots revealed that the former are more invasive on roadsides than the latter.

The observation of a sharp and significant increase in the total number of species and also exotics in the urban environment over that of rural zone indicated that the competitions between native and exotic species for establishment in the urban environment are an ongoing and continuous process. It may also be noted that the increase in species richness in the disturbed urban environment cannot be a sign of stability; instead, it appeared that an increase in anthropogenic influence in wet tropical urban system of developing countries can be associated with an increase in the number of exotics in general, which contributes to a general increase in species diversity in such places.

E. indica, a well known exotic roadside invader species (Anoliefo et al., 2006; Goosem, 2008) and *C. dactylon,* a cosmopolitan dominant roadside tolerant species (Taranath et al., 2005) were observed on these roadsides also, in plenty. Moreover, the current investigations showed large number of resistant species and, among them, well known medicinal plants mentioned in the Indian Ayurvedic system of medicine (Table 1). This observation indicated the chances of contamination of herbal medicines, if collected from roadsides. The danger of collection of plants from roadsides, either as fodder or as medicines is ecologically implicated (Champanerkar et al., 2006; El-Rjoob et al., 2008) of biodiversity rich tropics are significant places of

The overall assessment is that contaminated roadsides botanical expeditions to find out hyper-resilient species against physico-chemical disturbance, which are ecologically significant in many ways. Such inventories of plants in relation to their environmental characteristics can be suggested as the task of botanists and ecologists towards the preliminary identification of hyper-accumulators, which are essential to the fast emerging of eco-technologies such as phytoremediation. Systematic phytosociological analyses of vegetations are inevitable to such investigatory expeditions.

Conclusions

Systematic phytosociological methods, especially the measure of relative abundance enable identification of the degree of hyper-tolerance of species in hyper-disturbed environments such as roadsides; otherwise ignored as wasteland weeds. The ecological potentials of such species, especially those with high degree of hyper-tolerance observed on roadsides shall further be explored for the development of eco-technologies using them. Experimental studies can reveal their capacities of tolerance towards individual disturbances of each kind (metals or other physical disturbances). Therefore, detailed roadside vegetation analysis, especially on unmanaged roadsides in tropics in general is of high ecological relevance as is revealed in the current investigations.

ACKNOWLEDGEMENT

Financial support received by the second author from the University Grants Commission, New Delhi for carrying out the investigations is gratefully acknowledged.

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