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SOME PRELIMINARY STUDIES ON PLANTS AND POLLUTANT LEVELS ALONG PINDI BHATTIAN-FAISALABAD MOTORWAY (M-3) (PAKISTAN)

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Abstract

The roadside verges of M-3 were surveyed to investigate their floristic composition and the levels of heavy metals in their soils. For this purpose, the floristic data from 102 quadrats, each 1x2 m in size were collected and their associated soils were analyzed for total lead, cadmium, copper, manganese, iron and zinc. These quadrats were distributed on three zones (border, verge, and fence) within the M-3 verges. Fifty eight plant species were recorded. By considering their frequency and abundance values, *Cynodon dactylon*, *Anagallis arvensis*, *Imperata cylindrica*, *Trifolium alexandrianum* and *Sonchus oleracea* were the most frequent and abundant species of M-3. The mean concentrations of total Cu, Cd, Zn, Mn, Pb and Fe in the roadside soils of M-3 were 14.0 μgg^{-1}, 1.8 μgg^{-1}, 43.4 μgg^{-1}, 336.1 μgg^{-1}, 43.2 μgg^{-1} and 683.1 μgg^{-1} respectively. By comparing these values with their standard toxic levels, these soils can be considered as non-contaminated.

Introduction

Communication is an important prerequisite for economic development and roads are one of the major means of an efficient and widespread communication system as these constitute the largest transport system on earth reaching every part of the globe. Road building, improvement and management programs have significant ecological implications. These programs are generally criticized for their negative environmental effects such as habitat loss, habitat fragmentation, pollution, spread of invasive plants, animal mortality and loss of biodiversity (Tromans, 1991; Spellerberg, 1993). However, in intensively cropped and urbanized areas, the roadside verges can provide some positive ecological services such as refugia for species, conservation of biodiversity, education and recreation (Bennett, 1991; Brocks, 1993). Roadside plants are helpful in controlling soil erosion, reducing chemical and noise pollution and can enhance the landscape quality of roadside environment. Roadside verges have been described as important ecological habitats and their biological and edaphic characteristics have been studied extensively in all parts of the world (Ullmann & Heindel, 1989; Ahmad & Jabeen, 2009; Ahmad *et al.*, 2009; Akbar *et al.,* 2009; Ahmad *et al.*, 2010).

In recent past, Pakistan has witnessed an increase in the number of automobiles, public travelling and transportation of goods. To provide an efficient, safe and widespread road network for ever-growing transport sector of the country, National Highway Authority (NHA) started a Motorways building project which includes construction of 10 motorways with a total length of 2222 kilometers. Out of these, 3 motorways, Peshawar-Islamabad motorway (M-1), Islamabad-Lahore motorway (M-2) and PindiBhattian-Faisalabad motorway (M-3) have been completed. Pindi Bhattian-Faisalabad motorway was completed in 2004 and its length is 53 km. The climate of the area is generally dry and hot with summer temperature ranging from 27-50^{o}C and winter temperature varies from 6-21^{o}C. The annual rainfall is 40 mm. The predominant land use is agriculture. This study was aimed at a floristic survey of roadside verges along M-3 and the determination of concentration levels and patterns of distribution of some heavy metals in roadside soils. This information is expected to provide useful information for better management of roadside verges to tap their ecological potential. In addition, this study will also provide baseline information for future possible studies.

Materials and Methods

Only those sites for floristic survey were selected which had a well developed plant cover and were not recently disturbed by any visible anthropogenic activity. For vegetation sampling, roadside verge was divided into three arbitrary zones (border, verge and fence) on the basis of physical conditions and homogeneity of vegetation. This zonation of roadside vegetation has been reported by many authors (Dowdeswell, 1987). The Border zone lies adjacent to paved road and its width ranges from 1-3 meters. It is the most heavily affected zone of roadside verges. The next zone, verge is 3-5 meters wide and it is comparatively less disturbed. The fence zone is the last zone and it usually consists of hedge of shrubs or small trees and a ditch and is bordered by a road, crop fields or orchards etc. Because of the linear nature of the habitat, a 1x2 m rectangular quadrat was used. At each site, three quadrats were laid away from the paved roads at regular intervals of distance. At each site, both sides of the motorway were sampled. In each quadrat, all vascular plant species were recorded. The cover of each species (in percentage) was estimated by visual assessment (Kent & Coker, 1995). The nomenclature of the plants follows Chaudhary (1969).

Statistical analysis of floristic data: The frequency percentage and cover percentage of each species was calculated for whole area and for each zone. The statistical significance of differences in frequency percentage between different zones was expressed in terms of confidence limits. The 95% confidence limits for the frequency percentages of recorded species were calculated by the following formula (Hansen & Jansen, 1972):

$$2\sqrt{\ }\ \underline{P(100\text{-}P)}$$

where p = the frequency of the species; N= the number of quadrats in sample area.

Any species is regarded as significantly present if the frequency percentage minus confidence limit is greater than zero. A difference in the frequency of a species within two zones of the motorway was considered in this work as significant if a higher frequency value minus confidence limit is greater than the lower frequency value plus confidence limit.

Soil sampling and analysis: From each quadrat, a soil sample was taken at the depth of 10-15 cm of the topsoil with the help of stainless steel trowel. Fresh soil samples were dried and then passed through 2mm sieve. One gram of soil was taken in acid washed beaker with 10ml Aqua regia, (1HNO3:3HCl). It was left for 24 hours for complete soil digestion After 24 hours soil sample was refluxed at reflux condenser for about 30 minutes and cooled at room temperature. Then it was filtered by Whattman (42) filter paper and volume made up to 25 ml with de-ionized water. The amount of each heavy metal was determined by an atomic absorption spectrophotometer (A-1800, Hitachi Japan) using standard stock solution of each element. The atomic absorption spectrometer was calibrated after every 10 samples with de-ionized water and the standards were also run after every 10 samples so as to check for drift (Akbar *et al.*, 2003). Analysis of each sample was made in duplicate.

Results

Floristic composition: In all 58 vascular plant species belonging to 21 families were recorded. Out of these, only 20 species occurred with frequency of more than 10% (Table 1). The roadside vegetation along M-3 is dominated by *Cynodon dactylon, Anagallis arvensis, Imperata cylindrica, Sonchus oleracea, Trifolium alexandrianum and Chenopodium album.* Out of these *C. dactylon, A. arvensis, I. cylindrica and S. oleracea* make a cover of about 40.7% of the total plant cover.

Table 1. Cover percentage in whole area and frequency percentage and confidence limit for species (in order of decreasing frequencies) with frequencies of ≥10 within whole study area and in different road verge zones.

Species	M-3	M-3		Border		Verge		Fence	
	Cover %	Freq	Conf limit	Freq.	Conf. limit	Freq.	Conf. limit	Freq.	Conf. limit
Cynodon dactylon	11	63	9.5	55	17.0	63	16.4	71	15.5
Anagallis arvensis	10.5	53	9.8	48	17.1	54	17.0	57	16.9
Imperata cylindrica	10	50	9.9	33	16.0	57	16.9	60	16.8
Sonchus oleracea	9.2	49	9.9	42	16.9	48	17.1	57	16.9
Trifolium alexandrianum	1.3	47	9.9	33	16.0	51	17.1	57	16.9
Chenopodium album	2.9	41	9.6	30	15.7	36	16.4	57	16.9
Sonchus asper	2.1	39	9.5	36	16.4	36	16.4	45	17.0
Chenopodium murale	2.1	33	9.3	21	13.8	30	15.7	48	17.1
Conyza boriensis	1.5	31	9.3	21	13.8	33	16.0	39	16.7
Sueda fruticosa	4.7	25	8.5	21	13.8	24	14.6	30	15.7
Avena sativa	1.1	23	9.4	--		33	16.0	36	16.4
Heteropogon contortous	2.6	17	7.4	12	11.0	15	12.2	24	14.6
Dicanthium annulatum	1.1	17	7.4	12	11.0	14	11.9	25	14.8
Asphodelus tenuifolius	1.7	16	7.2	17	12.8	16	12.5	15	12.2
Xanthium strumarium	1.8	14	6.8	--		18	13.1	24	14.6
Cymbopogon martini	1.1	14	6.8	--		15	12.2	27	15.2
Calatropis procera	5.2	12	6.4	9	9.8	13	11.5	14	11.9
Cenchrus ciliaris	1.8	11	5.8	3	5.8	11	10.7	18	13.1
Convolvulus arvensis	1.1	10	5.8	3	5.8	12	11.0j	15	12.2
Euphorbia helioscopia	1.2	10	5.8	2	4.8	13	11.5	15	12.2

The border zone is dominated by *Cynodon dactylon, Anagallis arvensis, Sonchus oleracea, Sonchus asper, Chenopodium album and Trifolium alexandrianum* regarding high frequency and cover values. The border zones had the least number of species and patchy plant assemblages as compared to other zones. This might be due to various disturbing factors such as trampling by off-road vehicles and rubbish dumping etc. *Cynodon dactylon, Imperata cylindrica, Anagallis arvensis, Trifolium alexandrianum, Suaeda frutiocsa* and *Chenopodium murale* are the leading species of the verge zone. Other frequent species in this zone are *Conyza boneriensis, Sonchus asper, Salsola foetida, Xanthium strumarium and Heteropogon contortus.* Some species exclusive to this zone were *Cencrus ciliaris and Tribulus terresteris*.

The fence zone exhibited the highest floristic diversity as compared to other zones. The dominant species of this zone are *Cynodon dactylon, Imperata cylindrica, Chenopodium album, Sonchus oleracea, Anagallis arvensis and Trifolium alexandrianum.* At some sites the trees of *Eucalyptus spp, Dalbergia sisso, Acacia modesta and Acacia nilotica* were also recorded. Other frequently occurring species of this zone are *Sonchus asper, Suaeda fruticosa, Combopogon maritini, Dicanthium annulatum, Dactyloctenium aegyptium, Asphodelus tenuifolius, Atriplex crassifolia and Conyza bonariensis.* This zone had comparatively moist habitat conditions at different sites due to seepage of water from different water channels as it is neighboured by different habitats such as croplands, water channels, small woodland, houses etc.

According to Raunkier life form system (Raunkier, 1937). The life form analysis of the recorded species showed that 64% were therophytes, 15% chamaephytes, 11 hemicryptophytes, 5% phanerophytes and 4% geophytes.

Heavy metals in roadside soils

Zinc: The main source of contamination of zinc in roadside environment is motor tyres. The total zinc concentration of the roadside soils ranged from 18.8-72.8 μgg^{-1} with a mean value of 43.47 ± 10.45 μgg^{-1} (Table 2). The border, verge and fence zones had 45.09 μgg^{-1}, 44.3 μgg^{-1} and 45.3 μgg^{-1} of zinc respectively.

Table 2. Mean total concentrations (μgg^{-1}) and standard error for six heavy metals for roadside soils of M-3 and for different road verge zones.

Metal	M-3	Border	Verge	Fence	Toxic limit
Copper	14.0 ± 4.78	16.2 ± 4.2	13.5 ± 2.8	12.7 ±	60-125
Manganese	336.2 ± 56.88	353.9 ± 51.8	322.7 ± 22.1	337.1 ±	100-400
Zinc	43.5 ± 10.45	45.0 ± 9.58	44.3 ± 10.2	45.3 ± 11.1	70-400
Iron	683.6 ± 7.15	736.3 ± 58.3	725.0 ± 52.1	703.4 ± 4.9	
Cadmium	1.8 ± 0.884	1.5 ± 0.89	1.9 ± 0.78	1.4 ± 91.7	3-8
Lead	43.3 ± 22.05	61.1 ± 21.0	45.1 ± 10.5	21.5 ± 9.8	100-400

Copper: The possible sources of copper contamination are copper piping, overhanging electric cables, smelting and mining. The total copper content in the M-3 soils was found to between 6.0-27.4 μgg^{-1} with a mean of 14.02 ± 4.78 μgg^{-1} (Table 2). It exhibited a gradual decrease from border zone (16.2 μgg^{-1}) to verge (13.5 μgg^{-1}) and to fence zone (12.7 μgg^{-1}).

Lead: Lead is a major pollutant of the roadside environment. Alloway (1995) reported that total lead content of normal soil ranges from 2-300 $\mu g\ g^{-1}$. The roadside soils however, have been reported to have usually higher lead contents. Lead in roadside soil seems to increase with traffic volume. Another factor affecting the spatial distribution of lead in roadside soils is the distance from road. In the present study, lead concentration ranged from 8.7-100.2 $\mu g\ g^{-1}$ with a mean value of 43.3μgg^{-1}(Table 2). The amount of lead in roadside environment decreases with increase from road. In the M-3 soils, the mean lead values showed a decrease from border zone (61.1μgg^{-1}) to verge (45.1μgg^{-1}) and to fence (21.5μgg^{-1}).

Manganese: Soils generally contain 200-3000 μgg^{-1} of manganese with an average value of 600μgg^{-1}(Alloway, 1990). In this search work the amount of total Mn ranged from 257-513 μgg^{-1} with a mean value of 336.2μgg^{-1} (Table 2). The mean values for border, verge and fence zones were 353.9μgg^{-1}, 337.1μgg^{-1} and 322.7μgg^{-1} respectively.

Iron: The amount of iron in the study area varied between 530.01-851.40 μgg^{-1} with a mean value of 683μgg^{-1}(Table 2). It exhibited a gradual but insignificant decrease from border (736.3 1.5 μgg^{-1}), to verge (725.0 1.5 μgg^{-1}) and to fence zone (703.4 μgg^{-1}).

Cadmium: Cadmium occurs naturally in soils and is regarded as one of the most toxic metals in the ecosystem because it is a cumulative poison to mammals (Alloway, 1990). Cadmium is released in the environment as a waste material, especially from lead, zinc and copper smelters and motors oils, from the burning of plastics, from Ni-Cd batteries, tyres and rubber goods. Other sources of Cd pollution are fertilizers, pigments and municipal waste. In the present study cadmium concentration ranged from 0.2-2.6 μgg^{-1} with a mean value of 1.8μgg^{-1} (Table 2). The border zone had the highest amount of cadmium (1.9μgg^{-1}) with a gradual decrease towards verge (1.5μgg^{-1}) and fence (1.4 μgg^{-1}).

Discussion and Conclusions

The recording of 58 plant species on M-3 roadside verges indicated the potential of roadside verges as a species rich habitat providing refuge to a number of species. Since M-3 is a newly built motorway and its verges were not well settled after different construction activities such as digging, transport of soil from different locations and pressing etc. It was expected that after these media are homogenized with passage of time and as the propagules of plants from neighboring habitats start migrating and settling, the floristic composition of these verges will improve further. Only three species were found to have frequencies greater than 50%, one with maximum of 63%. The calculation of confidence limits for these frequency percentages shows that the statistical significance is high. The confidence limits applicable to the three frequencies greater than 50% are only between 9.5 and 17. The confidence limits of species with frequencies between 50% and 20% are also above 8.5. In case of the frequency of >10%, the confidence limits are between 4.8 and 14.8. Overall, it is observed that the frequencies of all species exhibit a high degree of significance and the qualitative composition of the vegetation can be described with authenticity. Similar results were found along M-2 and around Havelian (Ahamd & Jabeen, 2009; Ahmad, 2009; Ahmad *et al.,* 2009).

Within 3 zones of the roadside profile, various numbers of species were recorded. However, slight and insignificant differences in the frequencies between different zones have been observed. This is probably due to the fact that in a young roadside habitat, the majority of the zones show rather slight differences as to microclimate. However, as compared with the border zone, the verge and fence zone have been found to be mutually more uniform in regard to composition, both quantitatively and qualitatively. The fence however, is the most peculiar zone, as a relatively large number of species have been recorded. The species preferring moist conditions or species found in neighboring croplands are found mostly in this zone.

An analysis of the recorded species according to Raunkier's System of life forms shows that the study area is dominated by perennials. If calculated quantitatively on the basis of the cover percentage, this dominance is still more conspicuous. Only the border zone contains relatively higher percentage of annual species because of its unstable and disturbed habitat conditions. But since the border zone constitutes a small part of the total roadside area, it may be concluded that perennial species play a major role in the composition and development of roadside vegetation.

In general, roadside soils are expected to have higher levels of heavy metals. In the soils along M-3, the concentrations of heavy metals are below their standard toxic limits (Ross, 1994) indicating that the roadside soils of M-3 are not contaminated. This may be due to the young age of motorway and with passage of time, their levels are expected to increase further. The information provided in this study, therefore can be used as baseline for future comparisons.

References

Ahmad, S., A. Wahid and K. F. Akbar. 2010. Multivariate classification and data analysis of vegetation along Motorway (M-2), Pakistan. *Pak. J. Bot*., 42(2): 1173-1185.

Ahmad, S.S. 2009. Ordination & classification of herbaceous vegetation in Margalla Hills National Park Islamabad Pakistan. *Biological Diversity Conservation*. 2(2): 38-44.

Ahmad, S.S. and T. Jabeen. 2009. Multivariate analysis of environmental and vegetation data of Ayub National Park Rawalpindi. *Soil & Environment.* 28(2): 106-112.

Ahmad, S.S., S. Fazal, E.E. Valeem, Z.I. Khan, G. Sarwar and Z. Iqbal. 2009. Evaluation of *Pakistan Journal of Botany*, 41(1): 53-60.

Akbar, K.F., W.H.G. Hale and A.D. Headley. 2009. Floristic composition and environmental determinants of roadside vegetation in north England. *Polish J. Ecol.,* 57(1): 73-88

Akbar, K.F., Z. Ahmad, M.A. Shad and T.M. Ansari. 2003. An ecological study of roadside vegetation and soils in Sahiwal district. *J. Biol. Sciences*. 3(7): 627-634.

Alloway, B.J. 1990. *Heavy Metals in Soils*. 1st. ed. Blackie Academic and professional, UK.

Alloway, B.J. 1995. *Heavy Metals in Soils*. Chapman and Hall, UK.

Alloway, B.J. 1995. Soil processes and the behavior of heavy metals. Heavy Metals in Soils. 2nd. ed. (Eds.): B.J. Alloway, pp. 11-37. Chapman and Hall, London.

Bennett, A.F. 1991. Roads, roadsides and wildlife conservation: a review. *Nature Conservation 2: The Role of Corridoors.* (Eds.): D.A. Saunders and R.A. Hobbs. p. 99-118. Surrey Beatty and Sons. Chipping Norton, Australia.

Brooks, M.A. 1993. Evaluation of Roadside Vegetation in central Arizona. Ph.D. thesis. University of Arizona.

Chaudhary, S.A. 1969. *Flora of Lyallpur and the adjacent colony districts*. West Pakistan. Agriculture University, Lyallpur.

Dowdeswell, W.H. 1987. *Hedgerows and Verges*. Allen and Unwin. UK.

Hansen, K. and J. Jensen. 1972. The vegetation on roadsides in Denmark. *Dansk Botanisk Forening,* 28(2): 1-61.

Kent, M. and P. Cooker. 1992. Vegetation descriptrion and analysis, 1st ed. Belhaven Press, London.

Raunkier, C. 1937. *Plant Life Forms*. Clarendon Press, Oxford.

Ross, M.S. 1994. Sources and form of potentially toxic metals in soil-plant systems. In: *Toxic metals in Soil-Plant Systems* (Eds.): M.S. Ross. pp. 3-25. John Wiley, Chichester.

Spellerberg, I.F. and M.J. Gaywood. 1993. Linear Features: linear Habitats and wildlife corridors. *English Nature. Research Report,* no. 60.

Tromans, S. 1991. Roads to prosperity or roads to ruin? *Journal of Environmental Law,* 3(1): 1-37.

Ullmann, I. and B. Heindle. 1989. Geographical and ecological differentiation of roadside vegetation in temperate Europe. *Botanica Acta*, 102: 261-269.

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