OnLine Journal of Biological Sciences 3 (7): 627-634, 2003
ISSN 1608-4127

An Ecological Study of Roadside Vegetation and Soils in Sahiwal District

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Abstract: The present study was carried out to investigate the floristic composition of roadside vegetation and levels of some heavy metals in roadside soils in Sahiwal district, Pakistan. Among sixty recorded species, the main grass species include ***Cynodon dactylon, Desmostachya bipinnata, Panicum turgidum, Cyperus rotundus*** and ***Cenchrus biflorus***. The dominant species exhibited little variation between different zones of verges. Other species however, showed preferences for certain zones of the verges indicating differences in microhabitat conditions in the verges. The roadside soils were analysed for lead, copper, manganese and zinc levels. The amount of total lead, zinc, copper and manganese varied from 0.5 to 48.4, 37.7 to 109.9, 3.8 to 44.3 and 170 to 258.5 μg g^{-1}, respectively with a mean values of 9.4, 63.0, 31.4 and 218 μg g^{-1}. The levels of heavy metals in the roadside soils indicated that these soils were non-contaminated.

Key words: Roadside verges, vegetation, soil, heavy metals

Introduction

The vegetation present on verges of roads is presumably the oldest form of anthropogenic vegetation (Ullmann and Heindle, 1989). Roadside vegetation represents not only a distinct type of synanthropic vegetation, but in areas with high population density and an intense industrial or agricultural landscape, roadside verges are often the only habitats where natural vegetation can develop. The use of roadside verges as habitats by animals and plants has been reported in other countries (Adams and Geis, 1983; Bennett, 1991; Akbar, 1997; Forman, 2001).

With increase in population and economic activities, the road network in Pakistan has increased many times. In Pakistan however, the literature describing the characteristics of roadside vegetation and soils is scanty (Iqbal ***et al.***, 1994; Akbar, 2000). Modern multi-lane roads and motorways have very wide verges with restricted access and it has led to an enormous increase in the area of roadside verges. If properly managed, these verges can be used as a source for the conservation of natural flora and fauna. For proper management of roadside verges, it is necessary to provide meaningful scientific data on various aspects of the ecology of roadside verges.

Sahiwal is a city of Southern Punjab situated on the main Peshawar-Karachi railway line. The district falls in flat plain formed by rivers, Ravi and Sutlej, lying between 30°.0 and 31°.08 latitudes and 72°.25 and 74°.07 east longitudes. The climate of the area is dry and hot, with total annual rainfall average about 261 mm. The district Sahiwal covers an area of 3201 km^2 with a population of 1843194 (Anonymous, 1999). Before the introduction of canal irrigation, Sahiwal had arid vegetation but now it has fertile croplands irrigated by distributaries of Lower Bari Duab canal.

This research work was undertaken to study some aspects of the ecology of the roadside vegetation in Sahiwal district. The central focus of this study was to survey the roadside vegetation and to investigate the levels and patterns of spatial variation of some heavy metals in roadside soils.

Materials and Methods

Plant data collection

Seventeen sites were selected for sampling of vegetation along N-5 (G.T.Road), two inter-city highways (Sahiwal-Pakpattan road and Sahiwal-Faisalabad road) and two rural roads. During initial survey, it was observed that roadside vegetation could arbitrarily be divided into different zones. A typical roadside verge can be divided into three zones (border, verge and hedge) on the basis of physical conditions and homogeneity of vegetation (Dowdeswell, 1987).

To record floristic composition of the roadside verges, a 25-meter long tape was laid parallel to road at each site in each zone. A rectangular (2x0.5 m) quadrat was placed three times along the tape at equal distance in each zone. In each quadrat, all vascular plants were recorded and percentage cover of each species was estimated by visual assessment. In total, 306 quadrats were sampled.

The roadside verges were surveyed during summer 2001. Plant nomenclature follows Chaudhary (1969).

Soil sampling

From each quadrat, a soil sample was taken with a stainless steel trowel. Three soil samples from one roadside verge zone were mixed to make a composite sample representative of that zone. The soil samples were air dried, disaggregated in a pestal and mortar and passed through 2 mm sieve for analysis.

Analysis of soils for heavy metals

The soil samples were analysed for total lead, copper, zinc and manganese. One g of soil was taken in an acid washed beaker with 10 ml of ***Aqua regia*** (1 HNO_3: 3 HCl). It was left for 24 h for complete digestion. After it, soil was refluxed for 30 min. It was then cooled at room temperature and filtered by Whatman 42 filter paper. The volume of filtrate was made up to 25 ml with deionized water.

The amount of each heavy metal was determined by A-1800 Hitachi atomic absorption spectrophotometer. The standard solutions of each metal were prepared and the atomic absorption spectrophotometer was calibrated before and during the analyses. Three replicates of each sample were used.

Data analysis

The floristic data were analysed to determine the frequency and mean percentage cover of different species in the study area. In addition, patterns of variation of plant species in different zones of roadside verges were also determined. To measure the significance of differences in four heavy metals between the different zones, an analysis of variance (ANOVA) was carried out.

Results and Discussion

Floristic composition

A total of 60 species were recorded from the roadside verges of Sahiwal district. Sahiwal includes an extensively cropped and modern farmed landscape in which, modern farming methods have excluded wildlife from the farms and many wild plants and animals have taken refuge in verges and roadsides. The presence of such a large number of plant species on roadside verges supports the view that roadside verges can serve as an important habitat for local flora. Similar observations have been made in previous studies of roadside vegetation in different countries (Way, 1977; Batanouny, 1979; Akbar, 1997). Table 1 enumerates the frequent and abundant species (> 5% frequency) on roadside verges in the study area. From Table 1, it appears that ***Cynodon dactylon***, ***Desmostachya bipinnata***, ***Conyza ambigua***, ***Salsola foetida***, ***Chenopodium album*** and ***Chenopodium murale*** are the most frequent species, but their abundance values are low indicating a low plant cover on roadside verges. This low cover is because of frequently found bare patches at the surveyed sites. This condition illustrates the unfavourable habitat conditions and human disturbance (rubbish tipping, digging, grazing, parking etc.) making it difficult for plants to grow luxuriantly. Other frequent species are ***Cyperus rotundus***, ***Suaeda fruticosa***, ***Calotropis procera***, ***Saccharum munja***, and ***Senebiera didyma***. Some other notable species are ***Kochia indica***, ***Euphorbia prostrata***, ***Cenchrus biflorus***, ***Atriplex crassifolia***, ***Alhagi maurorum*** etc.

It was found that most plants have low presence value and few species exhibited repeated presence. Only six species were present in more than 60 quadrats (>20%) whereas 13 species exhibited presence in more than 30 quadrats (>10%). The extreme aggregation of the low presence categories was an indication of a heterogeneous situation. It also indicated the wide ecological amplitude of dominant species of roadside vegetation.

Dominance of native regional species

In the study area, most of the surveyed roadside verges exhibited strong dominance by native perennial species. The proportion of alien species is very small. Along some roads, highway authorities have planted exotic trees. This finding supported the view that roadside verges can make an important contribution to the conservation of the remnants of native vegetation. It highlighted the role of ecological corridors such as roadsides, railway lines and canal banks in preservation of biodiversity. These verges could also act as seed source in re-vegetation and reclamation of degraded areas by native vegetation. The study also indicated that natural plant communities might have a greater chance of survival on roadside verges than in the surrounding agricultural landscape. Grass species in particular, are more threatened in agricultural habitat where demands for crop productivity are steadily increasing. These demands for crop productivity result in increased use of fertilizers, herbicides and pesticides which have adverse effects on native plants.

Table 1: The most frequent species on the roadside verges in Sahiwal district (in order of decreasing frequency in 306 quadrats)

Species	Frequency %	Mean % cover
Cynodon dactylon	46.4	6.0
Desmostachya bipinnata	44.4	9.5
Conyza ambigua	34.3	2.3
Salsola foetida	31.4	3.0
Chenopodium album	20.5	0.6
Chenopodium murale	20.3	0.5
Cyperus rotundus	14.0	0.9
Suaeda fruticosa	14.0	1.6
Calotropis procera	13.4	0.7
Saccharum munja	12.0	0.6
Senebiera didyma	10.5	0.4
Kochia indica	9.4	0.1
Euphorbia prostrata	8.5	0.2
Cenchrus biflorus	7.8	0.1
Atriplex crassifolia	7.5	0.2
Alhagi maurorum	7.2	0.3
Trianthema monogyna	6.9	0.1
Launea nudicaulis	6.6	0.1
Panicum turgidum	6.2	0.1
Achyranthes aspera	5.2	0.2
Sonchus asper	5.1	0.1

Zonal arrangement of roadside species

Previous studies have shown that roadsides species exhibit a pattern of zonation along roadside verges due to variation in habitat conditions (Hansen and Jansen, 1972). In this study the high-presence species did not show any significant variation in frequency and abundance value between different zones (Table 2). The absence of zonal variation in high presence species in this study may be due to relatively narrow roadside verges in the study area. There was a prominent increase in the number of low presence species from border zone to ditch zone In the border zone, 41 species were recorded whereas in verge, 47 and in hedge zone, 55 species were recorded.

Life form spectrum of roadside flora

According to Raunkaier (1937) system of describing life form, therophytes (annuals) are prominent at the roadside verges (Fig.1) but their abundance was low. In the border zone where the effects of off-road vehicles such as treading were important, certain hemicryptophytes were relatively more abundant.

Heavy metals in roadside soils

Transport is a major resource of pollution by heavy metals such as lead, zinc, manganese and copper. The roadside soils are supposed to receive these contaminants from vehicles. A heavy metal analysis of roadside soils was carried out to determine the levels of heavy metals and their contamination potential.

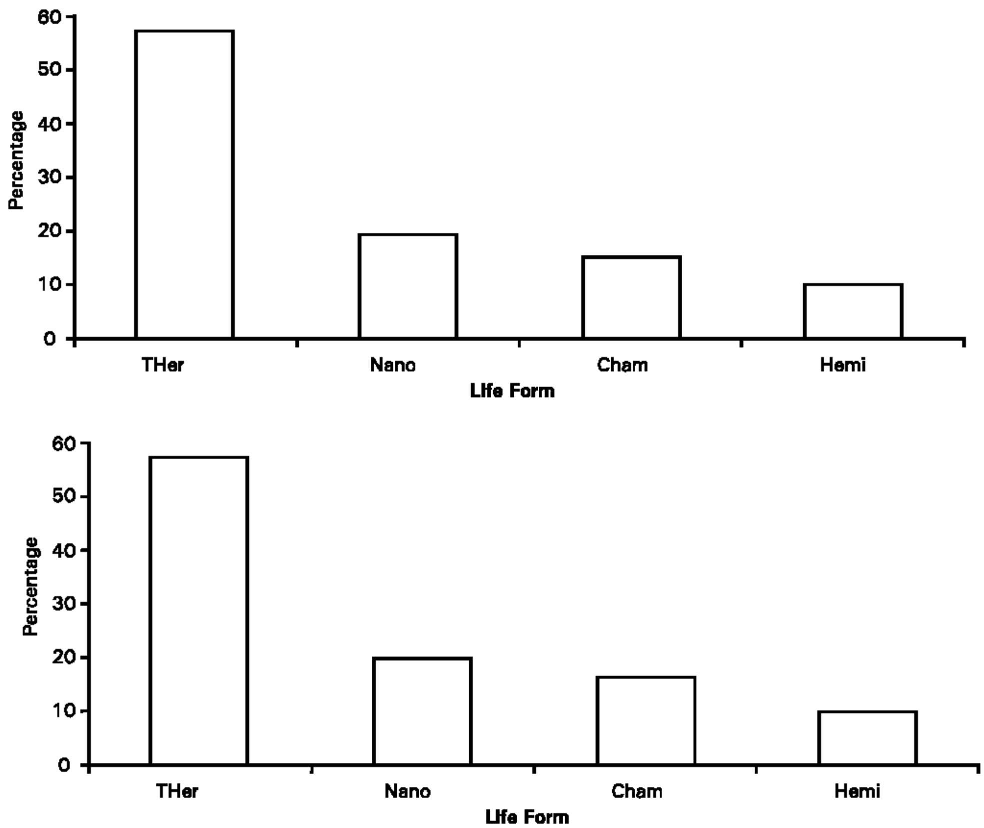

Fig. 1: Percentage distribution of different life forms (therophytes, nanopahanerophytes, chamaephytes, hemicryptophytes) in roadside vegetation in Sahiwal district

Total lead

Lead is one of the major pollutants of the roadside environment. Combustion of gasoline containing lead is a major source of lead pollution. Much attention has been directed towards lead in roadside environment as a result of its wide spread use as anti-knocking agent in the past. (Smith, 1976)

The lead content of the roadside soils ranged from 0.5-48.4 $\mu g\ g^{-1}$ with a mean value of 9.4±12.7 $\mu g\ g^{-1}$ (Table 3). Alloway (1995) reported that total lead content of normal soils ranges from 2-300 $\mu g\ g^{-1}$. The roadside soils however, have been reported to have usually higher lead content (Culbard ***et al.***,1988).

Table 2: Frequency and cover values of ten most frequent species for different road-verge zones in Sahiwal district

	Border		Verge		HedgeNo.	
Zone Species	Frequency %	Mean cover	Frequency %	Mean Cover	Frequency % Cover	Mean
Cynodon dactylon	43.1	5.3	42.2	6.3	53.9	6.4
Desmostachya bipinnata	41.2	9.9	47.2	6.3	45.1	9.7
Conyza ambigua	33.4	1.2	33.3	2.2	46.1	3.3
Salsola foetida	32.4	3.5	30.4	2.8	39.2	2.7
Chenopodium album	21.6	0.7	22.5	0.7	23.2	0.4
Chenopodium murale	20.6	0.6	16.7	0.6	18.6	0.6
Suaeda fruticosa	13.7	1.8	13.7	1.3	14.7	1.7
Saccharum munja	13.7	0.7	13.7	0.3	14.7	0.8
Cyperus rotundus	12.7	0.6	13.7	0.8	15.7	1.2
Calotropis procera	10.8	0.2	12.7	0.6	16.6	0.5

Table 3: Minimum, maximum and mean value with S.E. for four heavy metals in roadside soils of Sahiwal district

Metal	Minimum $\mu g\ g^{-1}$	Maximum $\mu g\ g^{-1}$	Mean with S.E.
Mn	170.0	258.5	218.0±29.7
Cu	3.8	44.3	31.4±9.7
Zn	37.7	109.9	63.0±7.8
Pb	0.5	48.4	9.4±12.7

S.E.= Standard Error

Table 4: Mean values ($\mu g\ g^{-1}$) of four heavy metals in different road-verge zones

Metal	Border	Verge	Hedge
Copper	20.7±6.4	23.5±7.5	24.0±6.4
Lead	14.4±3.5	9.1±2.6	3.1±1.1
Manganese	214.7±10.9	219.2±11.6	228.5±16.3
Zinc	61.0±9.9	63.7±11.1	62.7±8.2

Differences between means insignificant ($p<0.05$) based on ANOVA calculation

The lead in roadside soil showed a significant increase with increase in traffic volume. The soils along G.T. road showed the highest mean value of lead ($48.4\mu g\ g^{-1}$) where as soils along rural roads contained the lowest mean value ($0.5\mu g\ g^{-1}$) of lead.

Another factor affecting the spatial distribution of lead in roadside soils is the distance from road. It is generally reported that amount of lead in roadside environment decreases with increasing distance from road (Warren and Birch, 1987; Aksoy, 1996). In the present study a sharp decrease was observed from the first zone to the last zone (Table 4). The extent of decrease, however, was different on different roads depending upon the width of the verges and distance between different zones.

Total zinc

The main source of contamination of zinc in the roadsides environment is motor tyres. In the present study total zinc content of roadside soils ranged form 37.7-109.9 $\mu g\ g^{-1}$ with the mean value of 63.0±7.8 $\mu g\ g^{-1}$ (Table 3). Normal concentrations of zinc in soils are in the range of 1-900 $\mu g\ g^{-1}$ (Alloway, 1995). For polluted soils, total zinc level of soils may be up to several hundred and thousand of $\mu g\ g^{-1}$ (Kiekens, 1995). There is no significant variation of zinc levels in three zones (Table 4).

Total copper

Copper is among the elements essential for healthy plant growth. It is required in small amount only and is involved in plants as a facultative activator of enzyme system and as a part of many enzyme systems (Baker and Sneft, 1995). With increased industrialization and urbanization, its input into the environment has increased and now copper is among the main heavy metal pollutants of the environment. The total copper content in roadside soils in this research work ranged from 3.0-44.3 $\mu g\ g^{-1}$ with the mean31.4±9.4$\mu g\ g^{-}$1 (Table 3). There was no significant variation in copper content between different zones of roadside verges (Table 4).

Total manganese

Soils generally contain 200-3000 $\mu g\ g^{-1}$ of manganese with an average value of 600 µg g^{-1} (Lindsay and Novell, 1979). In the present work, amount of Mn ranged from 170-258.5 $\mu g\ g^{-1}$ with the mean value of 218.0±29.7$\mu g\ g^{-1}$ (Table. 3). There was no significant difference between different zones in manganese content (Table. 4). Roadside soils are expected to have higher levels of heavy metal pollutants. The results of present study indicate that these concentrations are generally below the trigger concentration for these metals (Anonymous, 1987). So it can be inferred that roadside soils in Sahiwal district are non-contaminated. At these levels, the toxic effects of Copper and Zinc for roadside plants are also negligible. These heavy metals however, may have some effects on the roadside fauna by entering the food chain.

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