3. MATERIALS AND METHODS

Investigations were carried out to study the impact of urbanization on the urban and rural forest soils of National Capital Region of Delhi. For achieving the objective physical and physico-chemical analysis of soil, chemical analysis of dustfall and air samples were carried out. Brief account of the study area and the methodology is presented as follows:

3.1. Delhi and its environment

Delhi state is a narrow strip forming a part of the Indo-Gangetic plain. It is situated between the Himalayas and Aravali ranges in the heart of the Indian subcontinent and lies between north latitude 28°24'17" and 28°53'00" and east longitudes 76°50'24" and 77°20'37". The state having an area of 1483 sq km of which 798 sq km forms the rural area and the rest as urban area. The maximum length and width of the state is 51.90 km and 48.48 km, respectively. Ghaziabad district of Uttar Pradesh forms the eastern boundary of the state, while it is surrounded by the state of Haryana on three sides. Rohtak and Sonipat districts are situated on western and northern sides, respectively while southern boundary of state joins Gurgaon and Faridabad districts. Delhi state has six administrative blocks namely Najafgarh, Mehrauli, Alipur, Nangloi, Shahdara and main City Block. Block Kanjhawala was renamed as Nangloi, and recently some of its villages have been transferred to Alipur block. City block is totally urbanized while other blocks are partially
urbanized. The urban development has increased nearly 12 times during the last 53 years resulting into progressively reduced agricultural land and rural areas to about 79800 ha. Number of villages falling under urban rural category were 209 during 1998.

Delhi state falls under 4th agro-ecological region comprising hot semi-arid climate of northern plain and central highlands including Aravallis, alluvium derived soils (NBSS and LUP, 1992). Its climate is mainly influenced by its inland position and the prevalence of continental type air during the major part of the year. Main characteristics of the climate are extreme dryness with an intense hot summer and cold winter as compared to other part of the country.

In Delhi state, there are six major meteorological observations located at Chandrawal, Safdarjang, Delhi University, Palam, Okhla and Indian Agricultural Research Institute. According to data available for the study period, May and June are hottest months with mean temperature of 30.9° C and 32.4° C respectively (Table 1). January is the coldest month in this region with mean temperature as 12.5° C in 2008 and 12.8° C in 2007. With the advance of the monsoon into the area towards the mid of June or the beginning of July, day temperature drops appreciably while the night temperatures remain high.

In the months of February and August, 2007 relative humidity recorded as 79.1 and 80.1 per cent, respectively. In Jan. 2007 relative humidity
was 63.6% whereas in Jan. 2008 it was 46.8% showing a decrease of 16.8% (Table 1).

In the month of July 2007, average wind speed recorded as 6.4 km h\(^{-1}\) whereas in Nov. 2007 it was 1.5 km h\(^{-1}\). Between the months of March and June 2007, variation in average wind speed was from 5.2 to 5.6 km h\(^{-1}\) (Table 1). The prominent wind direction in Delhi is northwesterly, except during the monsoon season (July to mid September). It is observed that in the morning the prominent wind direction is Westerly and in evening it is Northwesterly.

3.2. Sampling sites

The sampling sites are located on approximately 15 km wide x 70 km long transect that extended from forested area of Bawana, New Delhi to forested area in Tilpat, Faridabad, Haryana (Fig 1). The gradient study was undertaken considering down-wind direction from north-west to south-east. Five different forest sites were selected for soil sampling. These are:
Fig. 1
Map of National Capital Region of Delhi showing experimental locations along the study transect
Fig. 1
Map of National Capital Region of Delhi showing experimental locations along the study transect
i) Bawana City Forest, ii) Central Ridge Reserved Forest, iii) South Central Ridge near Deer Park, iv) Southern Ridge (Asola Wildlife Sanctuary, and v) Forest area between villages Tilpat and Dadsia (Faridabad, Haryana). Soil samples were collected from more or less undisturbed forest areas. The forest regions mostly covered by Dhak, Kikar (desi and kabuli), Kher, Pipal and Neem etc.

The selection of forest sites was carried out on the basis of the Greening Delhi Action Plan (2006-07) published by the Department of Forests and Wildlife, Govt. of NCT of Delhi and personal communication with the forest department. Samples were collected from soil profiles up to 70 cm depth with screw auger as given below.

**Site 1. Bawana City Forest (BCF):** It is a protected forest of 32 ha, being maintained by Department of Forests and Wildlife, Govt. of NCT of Delhi as city forest. BCF comes under north-west district in Delhi and is a suburban area.

The comparison of landuse pattern of this area (NTPC, 2002) by GIS of two decades showed that the percentage of urban and industrial area is increased from 6% to 20%, while there is a decline in percentage of agricultural and fallow land. The proportion of barren land also increased in year 2003. Water bodies are remained same in both the decades and there is no change in forest cover also. Overall analysis showed that the anthropogenic activities are increased in this decade.
Site 2. Central Ridge Reserved Forest (CRRF): The managing agencies of this forest (864 ha) are forest department, DDA, army, CPWD, NDMC and MCD. This forest lies among highly urbanized zones in its vicinity. In this area traffic emissions are highest as compared to all the five sites.

Site 3. South Central Ridge Forest (SCRF): The managing agency of this forest (626 ha) is DDA. The surroundings of this forest are urbanized having lower traffic emissions as compared to CRRF.

The Ridge area of Delhi has degraded tremendously due to by roads, buildings, traffic, garbage dumping, lopping of trees and grazing by livestock. Mining and quarrying activities in the past have degraded the South-Central Ridge causing enormous loss to biodiversity. Although as reported by the Deptt. of Forests there has been an overall increase in the forest cover in the last 10 years, degradation of the forests in some pockets of the city has increased.

Site 4. Asola Wildlife Sanctuary (AWS): AWS is a part of southern ridge (6200 ha) managed by forest department, DDA and sports authority of India (SAI). The department of forests is implementing the project on rehabilitation of 2100 acres of Bhatti mines area since October 2000, which is a part of Asola Bhatti Wildlife Sanctuary. In comparison to above four sites, AWS is least urbanized having very low traffic emissions.
44% of the geographical area of Delhi is built-up area. This includes the Delhi urban limits, built-up area in rural-use zones and farmhouse. Even though the Delhi ridge and Asola wildlife sanctuary area has been designated as protected area, built up areas are found in certain pockets. 41% of the area is under agriculture. An ecologically important location, the Asola Wildlife sanctuary, was established to protect and conserve the city's flora and fauna. However, this sanctuary is again under threat with the proposed scientific land fill at the Bhatti Mines. (DEUIP and State of Environment, Report for Delhi, 2001).

Site 5. Tilpat Forest Faridabad (TFF): TFF area is least urbanized with least traffic emissions among all the five study sites. This area lies in District Faridabad of Haryana State. This sampling site is relatively undisturbed.

3.3. Methods for collection of soil samples

3.3.1. Soil sampling

Soil samples were collected from five different forest sites along the study transect. Soil samples were placed into labeled, sealed plastic bags. Samples were preserved for further analysis.

Two soil profile samples were collected from each site in all the three seasons (summer, monsoon of 2007 and winter of 2007-08) with the help of screw auger, made of steel and marked with 10 cm interval. Profile samples were collected from different depths i.e. 0-10 cm, 10-20 cm,
20-30 cm, 30-40 cm, 40-50 cm, 50-60 cm and 60-70 cm for determination of soil physical, physico-chemical and chemical properties. Two surface soil core samples were taken from each site in all the three seasons for the measurement of bulk density and soil moisture content.

3.3.2. Air sampling

Dust samples falling freely due to gravity were collected from two points at each site in all the three seasons in dustfall collectors at recommended height. Collection was done for one month in each season. Simultaneous measurements were performed for \( \text{SO}_2 \) and \( \text{NO}_2 \) gases. Sampling was done by impinger method with Handy Sampler (Model HS-6) made by Kimoto Electric Company Limited, Japan. For \( \text{SO}_2 \), 30 mL of 0.04 M absorbing reagent (potassium tetrachloromercurate; TCM) solution and for \( \text{NO}_2 \), 30 mL of sodium arsenite absorbing reagent solution were taken in impinger bubblers. The impingers were covered with aluminium foil to protect the reagents from sunlight. Flow rates of air were adjusted and started the instrument bubblers for 4 hours. Flow rate were adjusted to 1.5 litre per minute. Time was recorded for initial flow rate and for final flow rate.

3.4. Methods of analysis

3.4.1. Soil physical parameters

i) Mechanical analysis: Mechanical composition of soil (2mm size) was carried out by using Bouyoucus hydrometer. From this analysis, the
percentage composition of sand, silt and clay were determined. Textural
classes were found out with the help of international triangular chart.

ii) **Soil moisture retention:** Soil moisture retention was measured at
tension of 33 k Pa (field capacity). Pressure plate apparatus was used 33
k Pa tension (Richard, 1954).

iii) **Bulk density:** Bulk density was determined using core method
(Black *et al.*, 1965).

### 3.4.2. Soil physico-chemical parameters

i) **pH:** pH was measured by a glass electrode pH meter after
equilibrating soil with water in the ratio of 1:2:5 for 30 minutes (Jackson,
1973).

ii) **Electrical conductivity:** The electrical conductivity was
determined in supernated liquid suspension of 1:2:5 soil water ratio
using conductivity bridge (Jackson, 1973).

### 3.4.3. Soil chemical parameters

i) **Organic carbon:** The organic carbon content was estimated by wet
digestion method using Walkley and Black’s procedure as described by
Jackson (1973).

ii) **Total-N:** Total nitrogen was estimated by micro-kjeldahl method as
described by Jackson (1973). 1 g soil was digested using H₂SO₄ and
digestion accelerator (a mixture of K\textsubscript{2}SO\textsubscript{4}:CuSO\textsubscript{4}:Se in the ratio of 10:1:0.1) followed by distillation of digested material in to 4% boric acid of pH 4.5. The boric acid was titrated against 0.1 N H\textsubscript{2}SO\textsubscript{4}. From the titre value, N was calculated in the following manner:

1 mL of 1 N H\textsubscript{2}SO\textsubscript{4} consumed $\equiv$ 14 mg of N

iii) Total-S: Total sulphur was estimated by digestion of soil in HNO\textsubscript{3} and HClO\textsubscript{4}. After digestion it was cooled and made up the final volume to 100 mL. Sulphur was estimated colorimetrically in a suitable aliquot followed by turbidity method as described by Chesnin and Yien (1950).

3.4.4. Trace elements in soil

Di-acid digestion were performed as described by Hesse (1971) followed by analysis on atomic absorption spectrophotometer (Electronics Corporation). A suitable hollow cathode lamp was used for each element i.e. Fe, Mn, Zn, Cu, Pb, Ni and Cr. Calculations were done on the basis of standard graph plotted and dilution factor.

3.4.5. NO\textsubscript{3} and SO\textsubscript{4} in dustfall

For extraction of nitrate and sulphate ion from dustfall samples, the method followed was Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air (EPA 1999). Ultrasonication was done for 30 minutes in the suspension of 1 g dustfall and 50 mL de-
ionized water. Samples were filtered through 0.22 μ nitrocellulose filter paper and analysed for nitrate and sulphate by ion-chromatograph (Dionex ICS-90).

3.4.6. Determination of nitrogen dioxide in the atmosphere (Naarsenite method)

Ambient nitrogen dioxide (NO₂) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO₂⁻) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl)-ethylenediamine dihydrochloride (NEDA) and measuring the absorbance of the highly colored azo-dye at 540 nm.

Replaced any water lost by evaporation during sampling by adding distilled water up to the calibration mark on the absorber and mixed thoroughly. Pipette out 10 ml of the collected sample into a test tube. Pipette in 1 ml of hydrogen peroxide solution, 10 ml of sulfanilamide solution, and 1.4 ml of NEDA solution, with thorough mixing after the addition of each reagent and made up to 50 ml with distilled water. A blank was prepared in the same manner using 10 ml of unexposed absorbing reagent. After a 10 min. colour development interval, absorbance at 540 nm were measured and recorded against the blank. Quantity of NO₂ can be calculated as follows:
3.4.7. Determination of sulphur dioxide in the atmosphere (Modified West and Gaeke method)

Sulphur di-oxide from air is absorbed in a solution of potassium tetrachloro-mercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. Once formed, this complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some times prior to analysis. The complex is made to react with pararosaniline and formaldehyde to form the intensely coloured pararosaniline methylesulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer and calculated as follows:

\[
\text{SO}_2 \ (\mu g \ m^{-3}) = \frac{\text{Absorbance} \times \text{Graph factor} \times 1000 \times \text{final volume (mL)}}{\text{Sampling time} \times \text{Flow rate} \times \text{Aliquot taken for analysis} \times 0.82}
\]

\[
\text{NO}_2 \ (\mu g \ m^{-3}) = \frac{\text{Sampling time} \times \text{Flow rate} \times \text{Aliquot taken for analysis} \times 0.82}{\text{Absorbance} \times \text{Graph factor} \times 1000 \times \text{final volume (mL)}}
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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil $[\text{H}]^+$ ion activity (pH)</td>
<td>Potentiometric method through pH meter in 1:2.5 soil water ratio</td>
<td>Jackson, 1973</td>
</tr>
<tr>
<td>Soil electrical conductivity (EC)</td>
<td>Through conductivity bridge in supernated liquid suspension</td>
<td>Jackson, 1973</td>
</tr>
<tr>
<td>Soil organic carbon (OC)</td>
<td>Chromic acid wet digestion method followed by titration</td>
<td>Walkley and Black, 1934</td>
</tr>
<tr>
<td>Soil total nitrogen (N)</td>
<td>Modified micro-kjeldahl method</td>
<td>Jackson, 1973</td>
</tr>
<tr>
<td>Soil total sulphur (S)</td>
<td>Turbidimetric method</td>
<td>Chesnin and Yien, 1950</td>
</tr>
<tr>
<td>Trace elements Fe, Mn, Zn, Cu, Pb, Ni, Cr in soil and dustfall</td>
<td>Digestion with perchloric-nitric acids followed by analysis by AAS</td>
<td>Hesse, 1971</td>
</tr>
<tr>
<td>$\text{SO}_4^{2-}$ and $\text{NO}_3^{-}$ in dustfall</td>
<td>Extraction by ultrasonication followed by analysis on ion chromatograph</td>
<td>EPA, 1999</td>
</tr>
<tr>
<td>Mechanical composition of soil</td>
<td>Bouyoucos hydrometer method</td>
<td>Bouyoucos, 1962</td>
</tr>
<tr>
<td>Bulk density of soil</td>
<td>Core sample method</td>
<td>Black, 1965</td>
</tr>
<tr>
<td>Moisture retention capacity of soil (33 k Pa)</td>
<td>Pressure plate method</td>
<td>Richard, 1954</td>
</tr>
<tr>
<td>$\text{SO}_2$</td>
<td>Improved West and Geake (TCM) method</td>
<td>West and Geake, 1956; West and Ordoveza, 1962</td>
</tr>
<tr>
<td>$\text{NO}_2$</td>
<td>Jacob and Hochheiser modified (Na-arsenite) method</td>
<td>Jacob and Hochheiser, 1958; Margsen et al., 1977</td>
</tr>
</tbody>
</table>