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Atmospheric Dry Deposition on Leaves at an Urban Location

P. R. Salve, A. Maurya, S. R. Wate

National Environmental Engineering Research Institute, Nehru Marg, Nagpur 440020,India

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Atmospheric deposition is an important mechanism controlling the fate of toxic airborne pollutants and their transfer from the atmosphere to the natural surfaces (Gupta et al., 2004). Atmospheric deposition of particles to ecosystem takes place via both wet and dry processes. Wet deposition is removal by precipitation scavenging and, to a lesser extent; impaction of fog or cloud droplets on vegetation; and dry deposition includes the uptake of gases at the surface and the settling and impaction of particles. For both gases and particles the dry deposition process comprises two stages, atmospheric transport and uptake at the surface. It occurs by several processes, such as Brownian motion of particles, sedimentation and impaction (Morselli et al., 1999 and Hui-Jung Yun et al., 2002).

Few studies on dry deposition have been reported in urban, semi-urban and rural areas of India using surrogate surface (Tripathi et al., 1991; Rao et al., 1992; Saxena et al., 1992; Pandey et al., 1995; Singh et al., 1999; Kumar et al., 2002; Gupta et al., 2004). The main objective of the present investigation is to characterize dry deposition of major ions on leaves of guava (P. guyava) to determine their sources and generate data in this region.

MATERIALS AND METHODS

Nagpur district is located between $21^0$45 N to $20^0$30 N and $78^0$15 E to $79^0$45 E, which essentially indicates that, it is located in the Deccan Plateau. Nagpur district covers an area of 9,931.00 Sq. km, and has a dry tropical weather. This region encompassed by agricultural land and by major to minor industrial activities related to chemical and pharmaceutical based units, metal based units, brick and refractory kilns and lime oxidation and pulverization. Besides these, the mobile sources also contribute a significant amount of atmospheric pollutants.

Dry deposition samples (n = 25) were collected from leaves of guava (P. guyava) located at National Environmental Engineering Research Institute (NEERI) bearing $21^0$07'11.3"N and $79^0$04'02.4"E. The leaves while attached to living tree were marked and washed with deionised water using a sprayer and air dried prior to exposure. The dry deposition samples were collected after 72h exposure. The

Correspondence to: P. R. Salve

surface washing method was employed to collect the dry deposition (Davidson and Wu, 1990; Gupta et al., 2004), the leaf surface was washed off into polyethylene bottle at the site and the volume was made up to 100 ml with deionized water. The collected samples were centrifuged and supernatant samples were stored in the refrigerator till analysis.

The major inorganic anions and cations were quantitatively determined by Dionex ion chromatograph, a Dionex IonPac AS11 for anions and CS12A for cations, a self-regenerating suppressed conductivity detector and gradient pump. The gradient weak base eluent (1.7 mM sodium carbonate or 1.8 mM sodium bicarbonate) was used for anion detection, while weak acid eluent (2 mM Methane Sulphonic Acid) for cation detection at a flow of 1 ml/min. and air pressure 10 kg/cc. This provides a simple, cost-effective, fast accurate and highly sensitive method for determination of micro level ions present in environmental samples. In order to check the instrumental errors and for procedural contamination, quality control (QC) standards prepared from commercially available (EMerck) 1000 ppm stock standards of all the ions were used. Each calibration curve was evaluated by analysis of these standards ranged between 0.02 and 10 ppm in triplicates, i.e. before, during and after the analysis of a set of samples. The standards were run after every 10 samples to check the accuracy. The limits of detection for cations and anions were I ppb in Dionex ion chromatograph.

RESULTS AND DISCUSSION

The minimum, maximum, average and standard deviation of dry deposition flux of major ions on the surfaces of leaf were presented in Table 1. The deposition flux was highest for Ca^{2+} and it decreased in the order of K^{+}> NH_4^{+}>Mg^{2+}>SO_4^{2-} >Na^{+}>Cl^{-}>NO_3^{-}. This may be due to surface characteristics (surface roughness) and arrangement of leaves. The percentage contribution of each ion towards total dry deposition was observed to be calcium (16.7%), potassium (15.6), magnesium (13.3%), ammonium (13.6), sulfate (12.4%), chloride (11.5%), sodium (9.9%) and nitrate (6.6%). The dry deposition fluxes of cations and anions contributed 69.3% and 30.7% at the present site.

Table 1. Dry deposition flux ($mgm^{-2}d^{-1}$) on natural surfaces during winter season.

Ionic species	Min	Max	Average	Standard deviation
Cl^{-}	0.98	1.47	1.18	0.14
NO_3^{-}	0.11	1.32	0.68	0.30
SO_4^{2-}	0.24	2.45	1.28	0.58
Na^{+}	0.74	1.45	1.02	0.16
K^{+}	0.75	2.74	1.61	0.53
Ca^{2+}	0.92	2.77	1.71	0.46
Mg^{2+}	0.74	1.92	1.37	0.34
NH_4^{+}	0.42	2.45	1.40	0.49

Table 2. Ratio with respect to Ca in soil and dry deposition.

	Na^+	K^+	Mg^{2+}	NH_4^+
Guava leaf	0.59	0.94	0.80	0.82
Soil	0.85	1.1	1.32	0.81

Table 3. Correlation matrix of dry deposition fluxes.

Species	Cl^-	NO_3^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+
Cl^-	1.00							
NO_3^-	0.21*	1.00						
SO_4^{2-}	0.58**	0.61*	1.00					
Na^+	0.21**	0.28**	0.22	1.00				
K^+	0.10	0.31**	0.21**	0.60**	1.00			
Ca^{2+}	0.32**	0.63**	0.74**	0.69**	0.71**	1.00		
Mg^{2+}	0.19	0.40**	0.61**	0.40**	0.62**	0.82**	1.00	
NH_4^+	0.22*	0.21*	0.55**	0.32**	0.51**	0.41**	0.41**	1.00

* ρ=0.05
** ρ=0.01

It is well known that air borne soil particles are major contributor towards dry deposition fluxes (Saxena et al., 1997; Satsangi et al., 2002). Ca^{2+} is considered as soil tracer, so as to investigate the possible sources of dry deposition, the ratios of various ions with respect to Ca^{2+} were calculated and compared with ratio of local soil are presented in Table-2.

In guava leaves, the dry deposition ratio of NH_4^+/ Ca^{2+}, K^+/ Ca^{2+}, Na^+/ Ca^{2+} and Mg^{2+}/ Ca^{2+} were similar to that in local soil. The deposition flux of SO_4^{2-}, NO_3^- and NH_4^+ are contributed by particulate sulphates, nitrate and ammonium and their gaseous species.

Dry deposition fluxes were examined using correlation matrix to predict potential precursor ions are presented in Table-3. It is evident from correlation matrices that SO_4^{2-} and NO_3^- are highly correlated (r= 0.61) which indicates their likely origin from similar sources. Ca^{2+} and Mg^{2+}deposition fluxes were correlated (r = 0.82) which implies their association and probable origin from soil. $Mg^{2+}$and SO_4^{2-} (r = 0.61), Ca^{2+} and NO_3^- (r = 0.63) were also correlated indicating that SO_4^{2-} and NO_3^- are partly contributed by soil. Meanwhile correlations of $NH_4^+$with NO_3^- and SO_4^{2-} were 0.21 and 0.55, respectively, which indicates that NH_4^+ associated more with SO_4^{2-} than NO_3^-. (Gupta et al., 2004).

Dry deposition flux was the highest for $Ca^{2+}$and it decreased in the order of K^+> NH_4^+>Mg> SO_4^{2-}> Na^+> Cl^-> NO_3^-. Overall dry deposition flux was higher which may be due to surface characteristics (surface roughness) and arrangement of leaves. The deposition flux of cations and anions contribute 69.3% and 30.7%. The soil is major contributor towards dry deposition flux at tropical region. The high correlation between SO_4^{2-} and NO_3^- indicates their likely origin from similar sources. Ca^{2+} and Mg^{2+} are significantly correlated, which imply their association

and probable origin from soil. The depositions were attributed to leaf characteristics, in particular the rougher surface of guava leaves.

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