Supplementary Information

The role of particulate matter in reduced visibility and anionic composition of winter fog: A case study for Amritsar city

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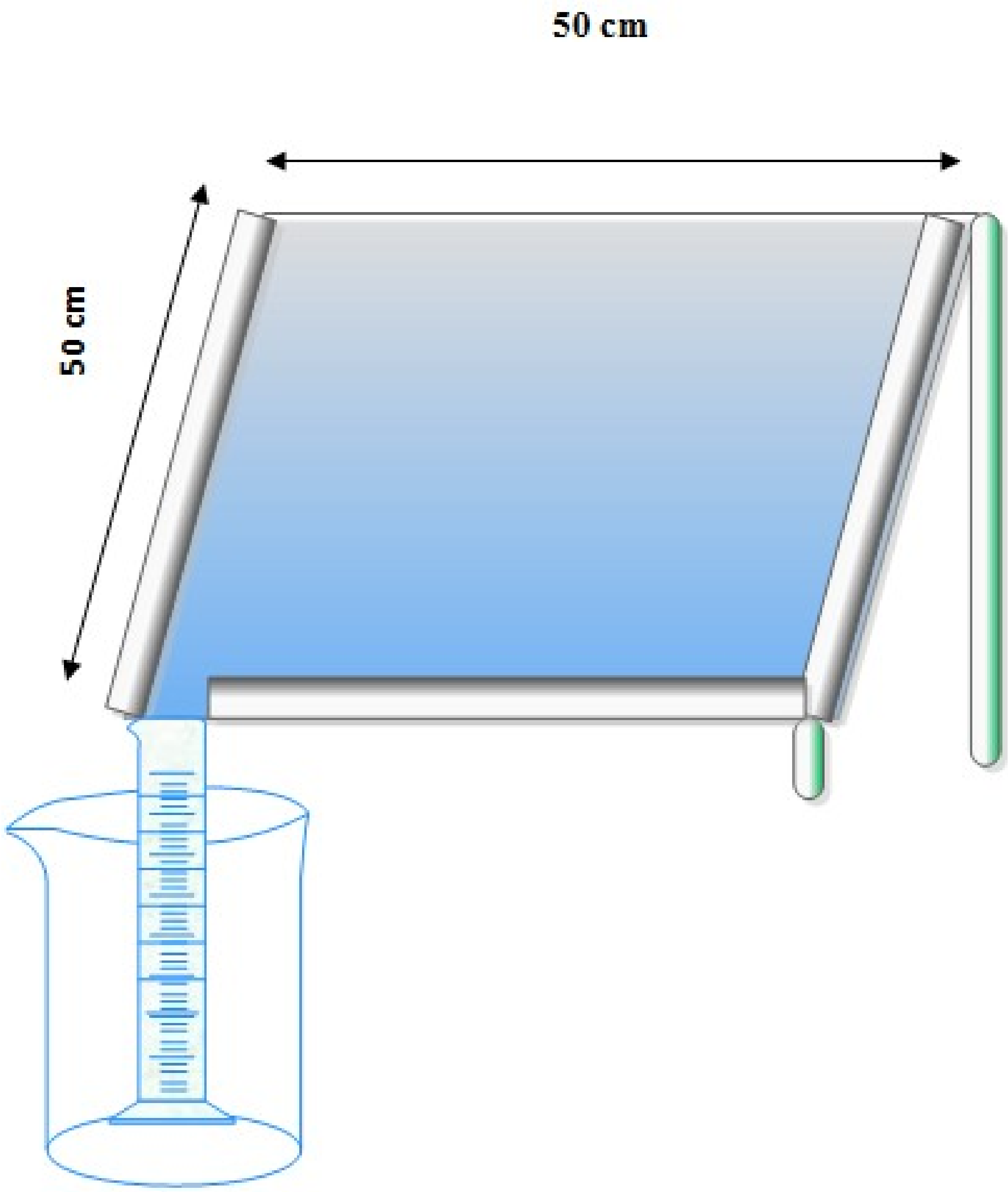
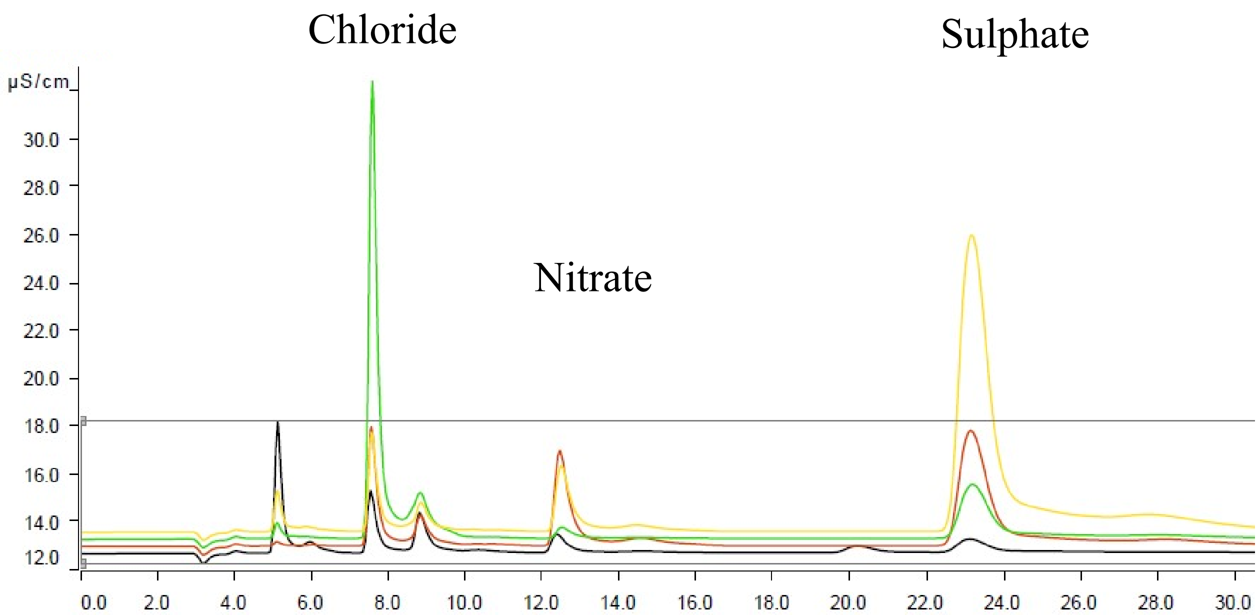
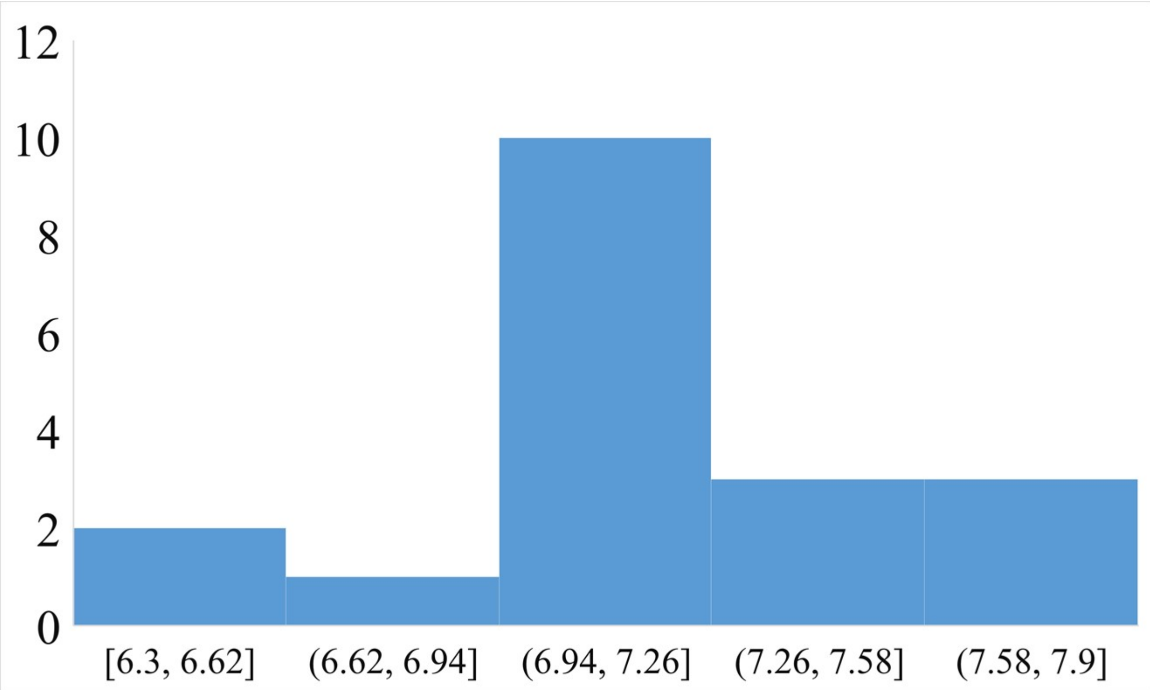


Figure S1. Line diagram of fog collector

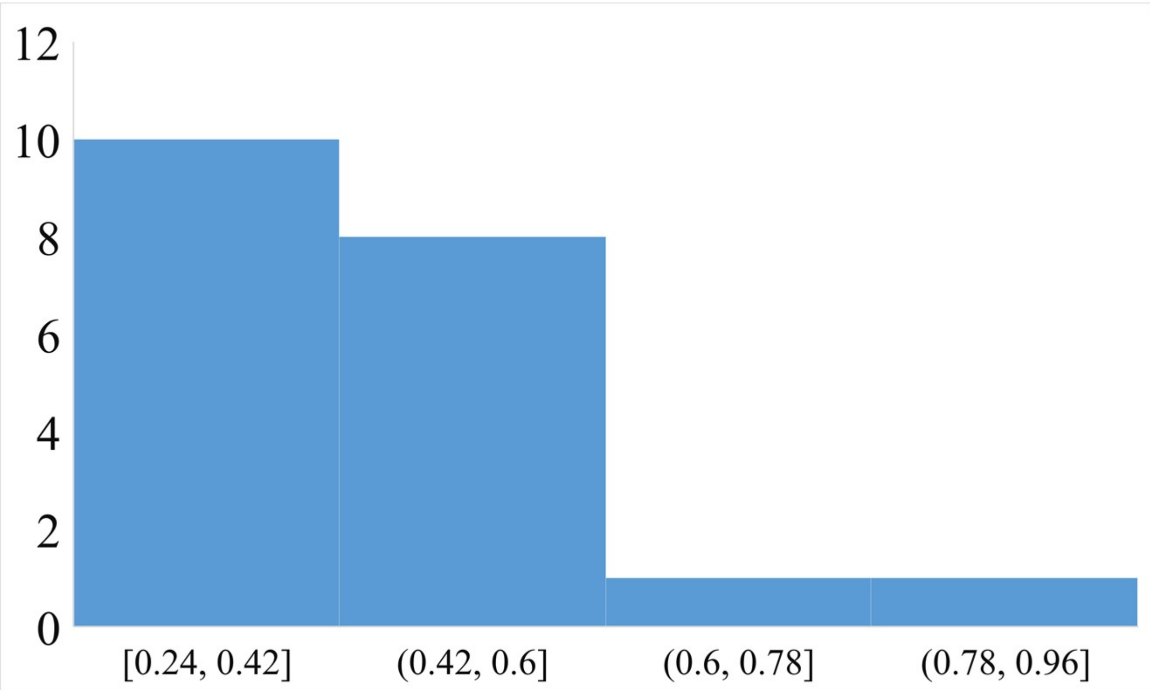


Line colour	Date of Sampling	Chloride (ppm)	Nitrate (ppm)	Sulphate (ppm)
(red line)	6 Nov. 2017	20.2	51.8	83.1
(green line)	29 Dec. 2018	71.8	6.6	39.5
(orange line)	5 Jan. 2018	16.7	36.6	271.0
(black line)	Mixed 5 ppm standard	5.01	5.03	4.99

Figure S2. Chromatogram showing overlay plot of different fog water samples (*details see Table S1*).X-axis= Retention time (min) and Y-axis=Conductivity (µS/cm)



[A]



[B]

Figure S3. Histogram of A) pH B) conductivity measurements in fog water of Amritsar

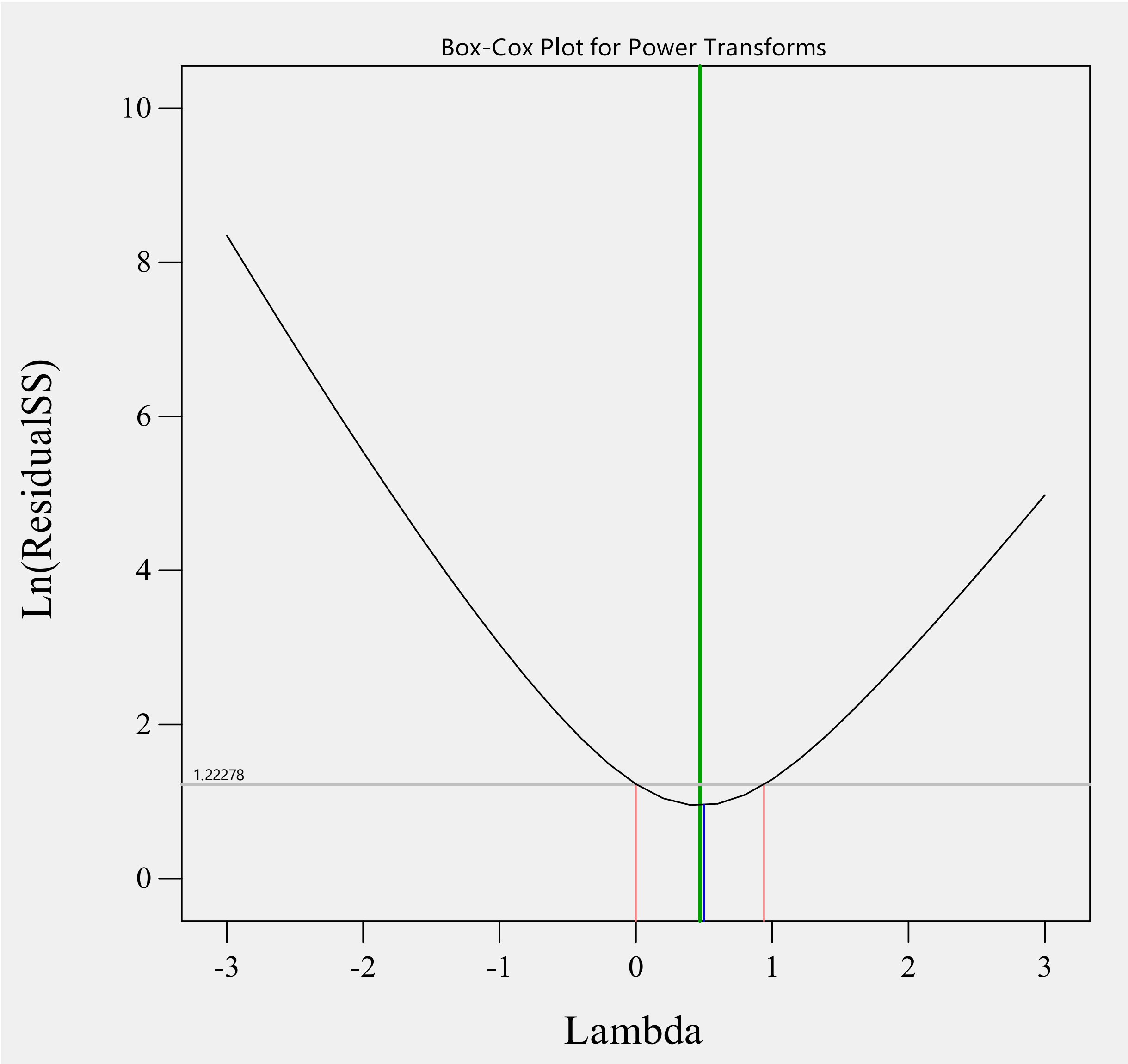


Figure S4. Box-Cox plot for power transforms indicated square root transformation of the response data (visibility) in multiple linear regression modelling

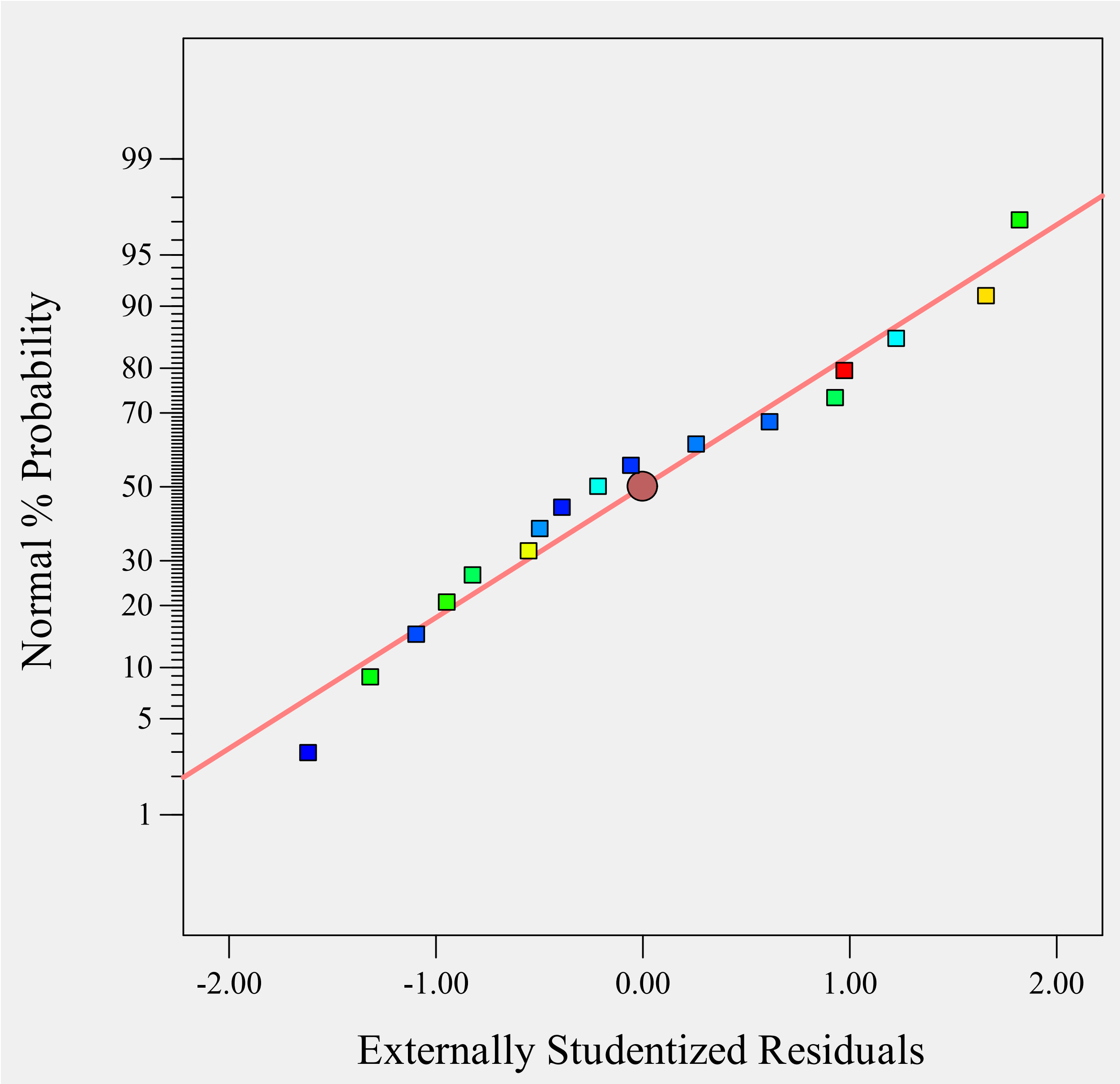


Figure S5. Normal plot of residuals showing the perfect fitting of response variable after square root transformation of the response variable (visibility)

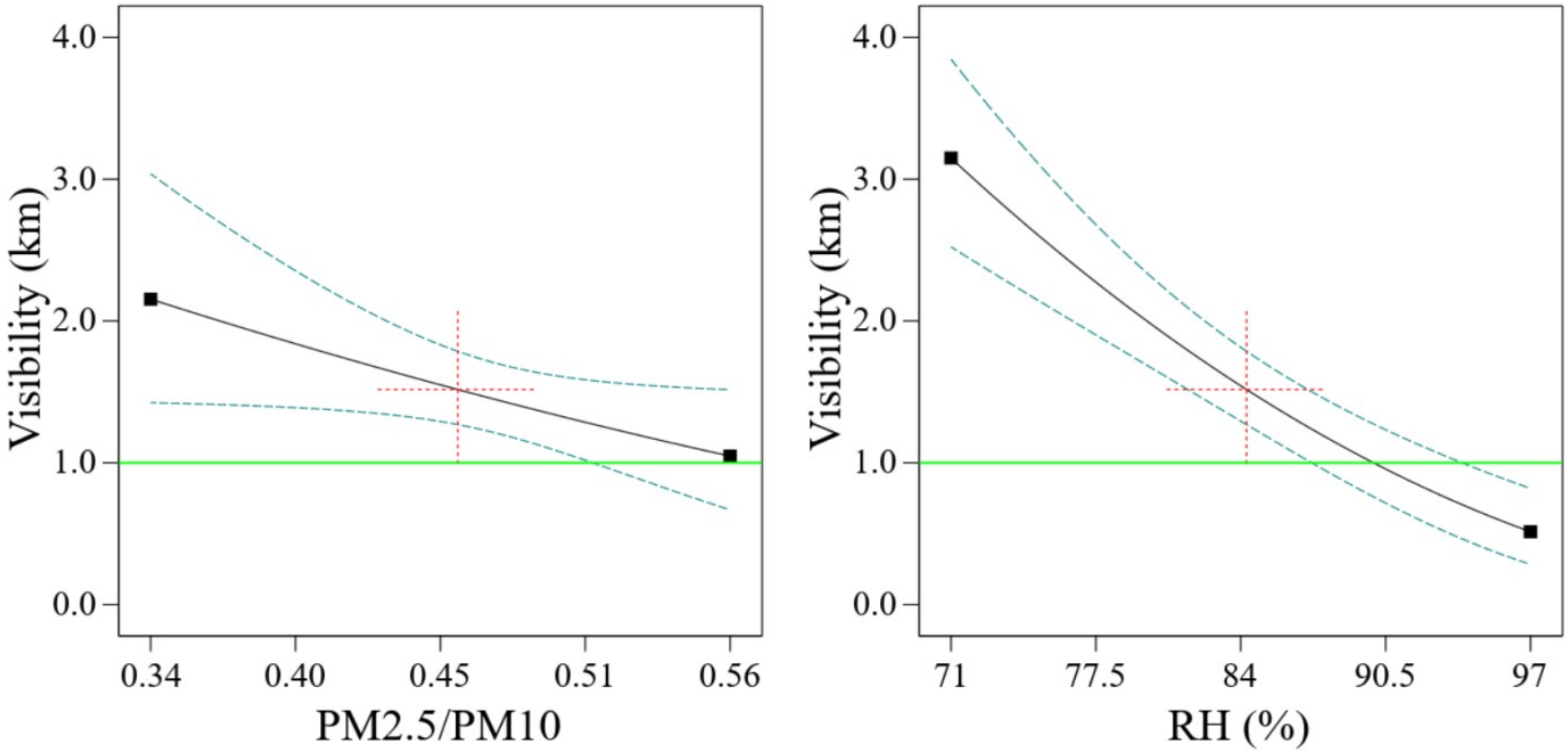


Figure S6. One-factor plot showing the effect of A) $PM_{2.5}/PM_{10}$ ratio on visibility B) relative humidity on visibility

Table S1. Global perspective of fog characterization along with dominant sources of ions

S. N.	Country	Location	Location type	MSL (m)	Coord-inates	N	Study Period	pH (avg)	Cond. (avg)	NO_3^- (avg)	SO_4^{-2} (avg)	NO_3^- to SO_4^{-2} molar ratio	Sequence of ions	Major sources	Reference
1	Ecuador	El-Tiro	Mountain	2825	3.59 S, 79.09 W	56	Nov 2003-Feb 2004	4.5	31	40	44	0.91	NH_4^+> SO_4^{2-}> NO_3^- > Cl^-	Biomass burning, industry, traffic	Beiderweiden et al., 2005
2	France	Pessac	Urban	17	44.47 N, 0.39 W	4	Jan 2002-Jan 2003	6.2	58	69	83	0.83	Cl^-> NO_3^- >SO_4^{2-}	Industry, transportation, agriculture, soil and dust	Beysen et al., 2006
3	Poland	Zakopane	Semi-Urban	911	49.17 N, 19.58E	4	Jan 2005-Dec 2006	5.1	272	260	460	0.57	NH_4^+> Cl^-> SO_4^{2-} > NO_3^-	Urban agglomeration, agriculture, tranportation, local heating	Blas et al., 2010
4	South Korea	Baengynyeong Island	Semi-Urban	100	37.58 N, 124.37 E	13	June-July 2014	3.9	ND	1260	1460	0.86	NH_4^+> NO_3^- > SO_4^{2-} >Na^+	Marine, biomass burning, long range transport	Boris et al., 2016
5	USA	Casitas pass	Coastal	350	34.38, -119.38	20	June 8-14 2015	5.9	ND	126	56	2.25	NH_4^+> NO_3^- >Na^+> Cl^-> SO_4^{2-}	Urban and industrial combustion, Marine influence	Boris et al., 2018
6	India	New Delhi	Urban	218	28.56 N, 77.09 E	8	Jan-Feb 2016	6.9	1236	900	3700	0.24	NH_4^+> SO_4^{2-} > Cl^-> NO_3^-	Air craft emissions, local sources, Marine and crustal	Ghude et al., 2017
7	India	Kanpur	Urban	142	26.5 N, 80.3 E,		Jan-Feb 2010	7.2	ND	ND	ND	ND	ND	ND	Kaul et al., 2011
8	South Korea	Daekwanreung	Mountain forest	840	37.41 N, 128.27 E	17	March 2002-Sept 2003	4.4	149	493	489	1.01	NH_4^+> NO_3^-> SO_4^{2-}> Cl^-	Local sources, long range transport	Kim et al., 2006
9[a]	India	New Delhi	Urban	218	28.35 N, 77.12 E	50	2010-2011	6.6	ND	51	232	0.22	SO_4^{2-} > Cl^- > NO_2- > NO_3^- > F^-	Coal burning and Vehicular emissions	Kumar and Yadav, 2013

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10	India	Agra	Urban	169	27.10 N, 78.05 E	32	Dec 1998-Jan 2000	7.2	ND	494	691	0.71	$NH_4^+ > SO_4^{2-} > NO_3^- > Cl^-$	Coal combustions activities, agriculture soil and road side dust	Lakhani et al., 2007
11[b]	Morocco	Mirleft	Semi-Urban	43	29.35 N, 10.02 W	178	May 2007-April 2008	7.4	725	240	381	0.63	$Cl^- > SO_4^{2-} > NO_3^-$	sea salts, crustal dust	Lekouch et al.,2011
12	China	Shanghai	Urban	4	31.18 N, 121.29 E	26	March 2009-March 2010	5.9	2050	2416	2830	0.85	$NH_4^+ > SO_4^{2-} > NO_3^- > Cl^-$	Agriculture,factories, traffic, civil construction, long range transport of sea salt	Li et al., 2011
13	India	New Delhi	Urban	218	28.35 N, 77.12 E	14	Dec 2014-March 2015	5.4	3501	4545	11725	0.39	$SO_4^{2-} > Cl^- > NO_3^- > F^-$	Agriculture fields, coal fired power plants, platic burning, fossil fuel combustion, biomass burning	Nath and Yadav 2018
14	China	Ailaoshan Mountain	Mountain	2476	24.54 N, 101.02 E	117	Dec 2015-March 2016	4.1	71	69	185	0.37	$NH_4^+ > SO_4^{2-} > NO_3^- > Cl^-$	Long range transport	Nieberding et al., 2018
15	India	Amritsar	Urban	234	31.63 N, 74.87 E	21	Nov 2017-Feb 2018	7.2	455	324	2465	0.15	$SO_4^{2-} > Cl^- > NO_3^-$	Trash burning	Own study
16	Taiwan	Taipei	Semi-Urban	1150	23.39 N, 120.47 E	69	Sept 2013-Nov 2013	4.1	358	703	682	1.03	$NH_4^+ > NO_3^- > SO_4^{2-} > Cl^-$	Agriculture emissions, fossil fuel combustion, long range transport and Marine	Simon et al., 2016
17	USA	Selinsgrove	Rural	135	40.79 N, 76.88 W	41	2007-2010	4.7	ND	48	141	0.34	$NH_4^+ > SO_4^{2-} > NO_3^- > Cl^-$	Agriculture emission, soil, long range transport	Straub et al., 2012
18	Norway	Hakadal	Semi-Urban	170	60.11 N, 10.83 E	6	Sept-Nov 2011	4.7	ND	61.7	43	1.43	$NH_4^+ > NO_3^- > Cl^- > SO_4^{2-}$	Seal salt, anthropogenic	Wang et al., 2015

a=Atmospheric condensate, b=Dew, ND=Not done

*MSL=Mean Sea Level; N=Number of samples; Cond.= Conductivity in µS/cm; Nitrate (NO_3^-) and Sulphate (SO_4^{-2}) are expressed in (µeq/L)

Table S2. Fog water characterization (N=20) along with particulate matter and meteorological data from 6 November 2017 to 2 February 2018 in Amritsar city

S.N.	**Date**	**pH**	**EC**	**Chloride**		**Nitrate**		**Sulphate**		**NO_2/ SO_4**	**Air Temp.**	**PM_{10}**	**$PM_{2.5}$**	**$PM_{2.5}$/ PM_{10}**	**RH**	**Visibility**
	MM/DD/YYYY		mS/cm	ppm	µeq/L	ppm	µeq/L	ppm	µeq/L	µeq/L/ µeq/L	°C	µg/m^3	µg/m^3		%	km
1	11/06/2017	7.0	0.54	20	571	52	836	83	1731	0.48	20.8	287	129	0.45	92	0.5
2	12/13/2017	7.1	0.27	8	222	19	311	46	956	0.33	11.9	142	66	0.46	96	0.2
3	12/14/2017	7.2	0.48	15	417	37	595	96	1997	0.30	11.5	126	59	0.47	92	1.2
4	12/16/2017	6.8	0.35	11	297	19	308	78	1614	0.19	12.3	130	60	0.46	76	3.4
5	12/17/2017	7.1	0.28	5	139	10	156	55	1148	0.14	13.5	178	60	0.34	74	3.2
6	12/25/2017	7.3	0.58	15	423	-	-	141	2943	-	14.7	216	117	0.54	81	1.3
7	12/28/2017	6.5	0.38	12	351	13	208	101	2108	0.10	14.4	186	99	0.53	91	0.7
8	12/29/2018	7.2	0.24	72	2026	7	106	40	823	0.13	14.6	203	103	0.51	82	2.3
9	01/02/2018	7.0	0.42	8	216	14	232	114	2372	0.10	10.8	243	137	0.56	93	0.4
10	01/03/2018	7.2	0.33	13	373	25	403	118	2464	0.16	9.1	183	89	0.49	97	0.3
11*	01/05/2018	6.3	0.79	17	472	37	591	271	5642	0.10	-	-	-	-	84	1.8
12*	01/06/2018	7.2	0.40	5	155	11	174	73	1522	0.11	-	-	-	-	77	2.4
13*	01/09/2018	7.0	0.63	12	336	26	422	198	4132	0.10	-	-	-	-	76	2.2
14	01/15/2018	7.7	0.55	11	307	9	138	107	2231	0.06	12.8	143	69	0.48	71	2.4
15	01/16/2018	7.9	0.48	12	333	11	178	78	1615	0.11	15.2	154	75	0.49	75	1.9
16	01/19/2018	7.3	0.58	10	280	21	343	202	4212	0.08	15.7	125	58	0.46	72	2.2
17	01/26/2018	7.5	0.39	9	262	19	305	102	2122	0.14	11.5	122	57	0.47	89	0.8
18	01/28/2018	7.1	0.54	11	315	45	731	196	4077	0.18	9.6	111	52	0.47	97	0.6
19	01/29/2018	-	0.40	4	108	14	221	153	3182	0.07	11.5	105	47	0.45	85	1.9
20	02/02/2018	7.6	0.48	8	221	13	215	116	2410	0.09	16.5	100	34	0.34	73	4.3
	Min	6.3	0.24	4	108	7	106	40	823	0.06	9.1	100	34	0.34	71	0.2
	Max	7.9	0.79	72	2026	52	836	271	5642	0.48	20.8	287	137	0.56	97	4.3
	Average	7.2	0.46	14	391	20	324	118	2465	0.15	13.3	162	77	0.47	84	1.7

* Data not taken in multiple regression analysis