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Element Composition of the Atmospheric Depositions in Bangladesh

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Abstract

Compositions of dry and wet atmospheric depositions vary depending on geographic locations and industrialization. Fog waters were collected from different regions of Bangladesh along with rain, sub-surface irrigation water and dust particles from Gazipur and compositions were analyzed. The compositions of fog water varied greatly among locations. The ammonium nitrogen (NH_4^+-N) content was the highest (36 - 37 ppm) in Gazipur district and the lowest in Sylhet district (3.2 - 3.6 ppm). Phosphorus (5.2 - 5.5 mg/L), K (29.5 - 30 mg/L), S (11.0 - 11.5 mg/L), Zn (2.9 - 3.3 mg/L), Na (11.7 - 12.5 mg/L), Ca (22.0 - 23.3 mg/L) and Cd (0.14 - 0.17 mg/L) contents were also higher in Gazipur district. Dust particles, rain and sub-surface irrigation water of Gazipur district contained considerable amounts of macro and micro elements. We conclude that dry and wet atmospheric depositions varied depending on locations and industrial development. Such study needs to be correlated with ecological consequences and soil fertility management.

Keywords

Water, Dust, Chemical Composition, Regions

1. Introduction

Fog as mist or liquid or solid hydrometeor particles or a near-surface cloud in the air [1] contains different suspended or dissolved materials. It is a very complex and dynamic medium allowing both reorganization and removal of particle mass [2]. The sources, formation processes and transport corridors of these particles in moist air [3], their dissolution, evaporation and eventual deposition to the surface determine the chemistry of fog. In addition, the deposition of fog droplets to the underlying surface has an impact on the average chemical composition of liquid water as does the evaporation during the dissipation phase of a fog event [4]. The field of fog research is comparatively young, while first studies on fog water chemistry started in the beginning of the 1900s [5] and have received more attention since 1980s [1]. Fog water and cloud play an important role to the atmospheric chemistry, air quality and atmospheric pollutants due to the intense combustion of fossil fuels and higher industrial emissions in some areas of East Asia [1] [6] [7] [8] [9].

Fog droplets with very high concentrations of particles and acidic gases (e.g., SO_2 and NO_2) are characteristics of polluted fog events in densely populated areas having serious negative effects on human health [10] [11] [12]. Aerosol components, such as sulfates, are air pollutants and can have long term health impacts [10] [11] [13]. Besides, fog water also deposits significant amounts of nutrients into the ecosystem and thus it can play a crucial role in ecosystem maintenance and degradation [14] [15].

Dust from different sources mixed with clean or dirty air and thus can affect climate, global biogeochemical cycles and human health [16]. Dust-laden air masses mixed with urban air pollutants also impair human health in megacities such as Beijing, China [17] [18] [19], Delhi, India [20] and Dhaka, Bangladesh [21]. Build up of dusts in air is increasing because of urbanization and industrial development. It can be deposited with rain water, fog or dry deposition and their chemical compositions vary seasonally. Generally the highest concentrations of dust occur in winter-spring months [16] depending on geographic location. Characterization of wet and dry depositions is important for regulators and researchers because of their potential impact on climate forcing and global warming [22] along with ecosystem management. As industrialization and urbanization are increasing in Bangladesh, we speculate that different materials are depositing in different parts of the country. However, no report is available in this part of the world regarding deposition through wet and dry methods. So, a study was undertaken to determine chemical compositions of dust particles and fog water for different regions of Bangladesh.

2. Materials and Methods

2.1. Sample Location and Collection

Fog waters were collected in winter seasons of 2015-2016 from Habiganj, Rangpur, Sylhet, Sonagazi, Rajshahi, Gazipur and Comilla regions of Bangladesh. Dust particles, subsurface irrigation water and rain water were collected only from the campus of Bangladesh Rice Research Institute (BRRI), Gazipur during 2017. Dust particles and subsurface irrigation water (deep tubewell) were collected in April, and rain water in August, 2017. Fresh white polythene was placed in the field for collection of fog water. The polythene size was 1-x1-m with three replications. After collection of fog water it was transferred into 50 ml plastic bottles. Similarly, deep tubewell water was also collected. Plastic pot was used for collection of rain water at BRRI farm area. All water samples were filtered (glass A/E filter) within a day of collection and refrigerated at 4˚C until analysis. Dust particle were collected from Bangladesh agricultural research institute (BARI) and BRRI farm areas. Dust particles were collected in fresh polythene sheet placed beneath 50 trees at 30 cm above soil surface through shaking of tree branches. After collection, dust particles were mixed and keep in polythene bags for chemical analyses.

2.2. Chemical Analysis

Dust particle was analyzed for total N (Jeldhal methods) and organic carbon content (Walkley and Black method; [23]. One g dust sample was digested using a strong di-acid solution nitric acid and perchloric acid (HNO_3 and $HClO_4$) for quantifying total P, K, S, Zn, Ca and Na contents by using atomic absorption spectrophotometer (AAS; Shimadzu Model AA-7200, Shimadzu Corporation, Tokyo, Japan) flame photometer (Sherwood Model 410, UK) and Spectrophotometer (V-630 UV, USA). Fog, rain and subsurface irrigation waters were quantified using inductively coupled plasma-optical emission spectrophotometer (GBC model X-100, Australia, [24]).

2.3. Statistical Analysis

Statistical analyses were conducted using SAS software [25]. Fisher's protected least significant difference (LSD) was calculated at the 0.05 probability level for making chemical composition mean comparisons.

3. Results

3.1. Fog Water Composition

In 2015, fog water pH of Rajshahi (7.52) and Comilla (7.44) was significantly higher than other districts (6.62 - 7.03), while the lowest pH was found in Habiganj district (**Table 1**). Similar results were observed in 2016. In both the years, the electrical conductivity (Ec) was the highest in Gazipur (~1.0) and the lowest in Habiganj district (~0.09). Dissolved organic carbon (8500 - 8600 mg/L), NH_4^+-N (37-5-37 mg/L), P (5.26 - 5.46 mg/L), K (29.5 - 30.0 mg/L), S (11.33 - 11.51 mg/L), Zn (2.99 - 3.30 mg/L), Na (11.65 - 12.50 mg/L) and Ca(22.58-23.25 mg/L) contents were significantly higher at Gazipur than other studied areas of Bangladesh (**Table 2**). Manganese (Mn) content was the highest in Comilla (2.02 - 2.06 mg/L) and that of Fe in Sylhet district (2.31 - 2.55 mg/L) compared to other districts. Cadmium contents (0.12 - 0.17 mg/L) were similar among studied locations.

3.2. Dust Particle Composition

Chemical compositions of dust particles from Gazipur site are shown in **Table 3**. Among the studied elements, Ca concentration was the highest (16,124 ppm) than other elements. However, Mn concentration was the lowest (575 ppm) compared to other elements. About 0.57% total N and 1.2% organic carbon was

Table 1. pH and Ec of fog water at different regions of Bangladesh.

Year	Parameters	Location						
		Habiganj	Rangpur	Sylhet	Sonagazi	Rajshahi	Gazipur	Comilla
2015	pH	6.62e	7.03d	7.14c	7.25b	7.52a	6.98d	7.44a
	Ec (dS/m)	0.09f	0.33c	0.21e	0.25d	0.24e	1.01a	0.37b
2016	pH	6.66e	7.01d	7.10c	7.22b	7.48a	6.92d	7.39a
	Ec (dS/m)	0.088f	0.32c	0.20e	0.26d	0.23e	1.00a	0. 35b

Small letter in a column compare means at 5% level by Turkey's test.

Table 2. Elemental compositions (mg/L) of fog water at different regions of Bangladesh.

Year	Element	Location						
		Habiganj	Rangpur	Sylhet	Sonagazi	Rajshahi	Gazipur	Comilla
2015	DOC	800d	900d	800d	1700b	600c	8600a	1300c
	NH^+_4-N	10.10d	18.44c	3.60f	5.35e	18.40c	35.97a	25.53b
	P	3.10b	2.35c	0.30e	2.18c	2.17c	5.26a	1.40d
	K	6.27e	16.35d	4.96f	18.10c	6.05e	29.50a	26.17b
	S	6.31d	2.57e	2.10f	6.10d	8.05c	11.51a	8.59b
	Zn	0.82c	2.15b	0.30d	0.28d	0.28d	3.30a	0.14e
	Na	4.65c	1.52g	2.00f	6.98b	2.60d	12.50a	2.35e
	Ca	4.43d	8.14c	0.25g	4.02e	9.00b	22.58a	2.65f
	Mn	1.10c	0.15f	0.15f	1.61b	0.46e	0.53d	2.06a
	Fe	1.08e	2.43b	2.55a	2.00d	0.89f	2.32c	0.54g
	Cd	0.12a	0.12a	0.13a	0.12a	0.12a	0.17a	0.13a
2016	DOC	850d	880d	860d	1759b	650c	8500a	1220c
	NH^+_4-N	9.60d	19.01c	3.20f	5.02e	18.50c	37.00a	25.93b
	P	3.02b	2.75c	0.39e	2.39c	2.24c	5.46a	1.35d
	K	6.35e	15.89d	5.00f	17.87c	6.22e	30.03a	25.95b
	S	6.45d	2.64e	2.00f	6.30d	8.16c	11.33a	8.85b
	Zn	0.74c	2.01b	0.30d	0.30d	0.35d	2.99a	0.16e
	Na	4.85c	1.40g	2.24f	7.15b	2.40d	11.65a	2.46e
	Ca	4.53d	8.12c	0.20g	4.22e	8.86b	23.25a	2.61f
	Mn	1.01c	0.14f	0.11f	1.55bb	0.48e	0.54d	2.02a
	Fe	1.00e	2.25b	2.31a	2.15d	0.92f	2.21c	0.52g
	Cd	0.13a	0.13a	0.12a	0.12a	0.12a	0.16a	0.14a

Small letter in a column compare means at 5% level by Turkey's test.

Table 3. Chemical compositions of dust at Gazipur region of Bangladesh.

Parameters	Nutrient composition								
	OC (%)	N (%)	P	K	S	Zn	Mn	Ca	Na
			ppm						
Dust particle	1.20	0.57	1131e	4206c	3528d	5657b	575f	16,124a	1208e

Small letter in a column compare with dust particle means at 5% level by Turkey's test.

found in dust particle.

3.3. Rain and Sub-Surface Irrigation Water Composition

In Gazipur site, the rain water and sub-surface irrigation water were collected and analyzed. Among studied elements, K concentration was the highest (41.79 mg/L) followed by S (2.82 mg/L) in rain water compared to other elements (**Table 3**). In sub-surface water, Sodium concentration was the highest (32.44 mg/L) followed by Ca (2.61 mg/L) and NH_4^+-N (2.39 mg/L) than other elements. Sub-surface irrigation water contained significantly higher amounts of Ca (2.61 mg/L) and Na (32.44 mg/L) than rain water. Similarly, pH, P, K, S, Ca, and Na values were significant different between rain and sub-surface irrigation water in Gazipur district. Rain water had about two thousand times higher K concentration than sub-surface irrigation water, while P and S also showed about 268% and 131% times higher values (**Table 4**).

4. Discussion

In Bangladesh, fog is generally observed during later part of November to February. In general, dense fog is observed in December and January, especially North and Southern regions of Bangladesh. Fog is nothing but cloud of condensed water vapor at ground level that forms visible water droplets. It mostly occurs when moist air is cooled below dew point after contact with cold land surface having clear skies at night and gentle breeze (<5 knots). It plays an important role in the earth's ecosystem for the exchange of water and pollutants between atmosphere and biosphere [26]. Our results indicated that a considerable amounts of DOC, NH_4^+-N, P, K, S, Zn, Na and Ca are depositing through fog water (**Table 2**) and might influence crop production in different regions of Bangladesh [27] [28]. In Gazipur site, fog had higher nutrients load than other regions of Bangladesh (**Table 2**) might be because of rapid industrialization [29] (**Table 5**).

In Gazipur, higher amounts of S, K and Na were found in rain water (**Table 3**) of Gazipur site might be because of industrial development including higher number of brick kilns. [21] mentioned that brick kilns are the important sources of K, Ca, Pb and trace elements deposition and thus influences plant response to

Table 4. Chemical compositions of water at Gazipur region of Bangladesh.

Parameters	Nutrient composition											
	pH	Ec (dS/m)	OC (%)	N (%)	NH_4^+-N	P	K	S	Zn	Mn	Ca	Na
					mg/L							
Rain water	8.10a	0.0	-	-	2.10b	1.60a	41.79a	2.82a	0.06a	0.12a	1.43b	2.35b
Subsurface water	7.10b	0.22a	-	-	2.39a	0.64b	1.81b	2.15b	0.057a	0.12a	2.61a	32.44a

Small letter in a raw compare with rain water and subsurface irrigation water means at 5% level by Turkey's test.

Table 5. Industrial set ups in different regions of Bangladesh.

Regions name	CMI 1995-96	SMI 2005-06
Barisal	233	44
Patuakhali	109	95
Chittagong	2034	2768
Comilla	1452	1095
Noakhali	556	364
Sylhet	411	612
Tangail	1900	3693
Jamalpur	287	295
Mymensingh	598	657
Faridpur	224	60
Dhaka	10401	11392
Khulna	818	1369
Jessore	375	593
Kushtia	1584	707
Bogra	886	1198
Pabna	8841	5158
Rajshahi	540	1864
Dinajpur	1662	589
Rangpur	672	1804
Gazipur	-	1773*

Source: SMI 2005-06 and author calculation; Source: CMI 1995-96 and author calculation. *Source: BBS, 2013.

added nutrients. Our previous findings also showed no added benefit of S and Zn fertilization in rice crop [30].

Dust emission increases because of agriculture, industry, over grazing, deforestation, construction and military activities [31] [32] and thus impairs human health [31] [33]. Besides, trans-boundary movement of air pollutants also contribute to dry and wet depositions [16] and thus play an important role in manipulating environment. [31] reported that Ca content increased during twentieth century due to dust emissions from anthropogenic activities in regions vulnerable to desertification. We have also found increased amounts of Ca, S and Zn in the dust, although Gazipur site has no sign of desertification. Besides, vehicle movements has also been increased in Gazipur site since 1990s and thus emission and deposition of SO_x through dust has been elevated dramatically [34] [35].

5. Conclusion

Industrial development and vehicle movements have increased tremendously in

Gazipur district, Bangladesh and thus the highest amounts of different elements were present in fog water, rain water and dust particles. The consequences of such depositions on ecology and crop performances need to be evaluated.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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