

Chemical composition of rain water over Lucknow in 1980

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सार - जून 1980 से दिसम्बर 1980 की अवधि के दौरान एकत्रित वर्षा जल के नमूनों के विश्लेषण से पता चला है कि लखनऊ में अम्ल वर्षा की कोई घटना नहीं हुई है। वर्षा जल के रासायनिक संघटन में एक बौछार से दूसरे बौछार में अन्तर था और वह अधिकांशतः अल्कलाइन अथवा बाइकार्बोनेट प्रकार का था। कुछ ही मामलों वर्षा में जल के नमूनों में नाइट्रेट की अपेक्षित उच्च सान्द्रता (6 से 8 मि० ग्रा० प्रति लिटर) पाई गई थी। विरले घटकों में लोहा सबसे अधिक (औसत 26.5 माइक्रोग्राम प्रति लिटर) प्रचल था। उसके बाद जस्ता, स्ट्रॉन्शियम, मैंगनीज आदि की मात्रा क्रमशः घटती जाती थी।

ABSTRACT. The analysis of rain water samples collected during the period June-December 1980 showed that there was no incidence of 'acid rain' over Lucknow. The chemical composition of rain water varied from shower to shower and was mainly of the alkaline earth bicarbonate type. In a few cases relatively high concentrations of NO_3 , 6-8 mg/l were obtained in rain water samples. Amongst the trace constituents iron was the most predominant (av. 26.5 microgram/l) followed by zinc, strontium, copper, manganese etc in that order.

1. Introduction

With increase in industrialization as well as increase in the use of fossil fuels, the pollution of the environment, through release of waste gases has reached menacing proportions. The important pollutants include interalia oxides of sulphur, nitrogen and carbon, hydrocarbons and various metallic salts. A major portion of these impurities may fall back on the surface of the earth as 'dry fallout' and/or is brought down by rain and may affect the terrestrial and aquatic vegetation and biota. In the present paper a brief outline of the chemical composition of rain water, including that of trace elements over Lucknow in 1980 is given.

2. Experimental

Rain water samples were collected in polyethylene bottles fitted with large diameter plastic funnels. These sampling bottles were placed on raised platform (about 1 metre from the ground) to prevent contamination of collected rain water through splashes from the ground. After the rainfall was over, the sample was filtered immediately (if not clear) through Whatman No. 542 filter paper. The water sample was then analysed for pH, EC, HCO_3 , CO_3 , Cl, NO_3 , Ca, Mg, Na, K and SiO_2 by standard methods described in literature (Handa 1974, 1976). A few rain water samples were acidified to pH 1.5 with reagent grade HNO_3 and con-

centrated at low temperature to about 50 times, cooled and then the exact volume made up with deionized water. These concentrated rain water samples were then analysed for Ag, Cu, Zn, Co, Mo, Cd, Sr, Li, Rb, Cs, Fe and Mn using atomic absorption spectrophotometer (Handa 1974, 1976).

3. Results

The chemical composition of rain water samples is given in Table 1, while the ranges and mean values have been given in Table 3. In Table 2 the trace element content of rain water samples is given and in Table 4 the ranges and mean values have been tabulated.

4. Discussion of results

The chemical composition of rain water in Lucknow is likely to be affected by the following factors:

- (i) Chemical composition of the sea salt nuclei brought by the monsoon clouds,
- (ii) Waste gas emission by local industries,
- (iii) Burning of fossil fuels, wood, coal, gas, petrol, diesel as well as cowdung,
- (iv) Emanations from land, particularly agricultural lands and lands submerged for varying periods resulting in anaerobic conditions,

TABLE 1

Chemical composition of rain water samples collected at 4, Sapru Marg, Lucknow during 1980 monsoons

Date of collection (1980)	Rainfall (cm)	pH	EC	HCO ₃	Cl	NO ₃	Ca	Mg	Na	K	SiO ₂
4 Jun	0.43	7.45	81	32	4.36	6.4	5.2	1.82	2.9	1.8	—
7 Jun	1.75	7.39	32	11	1.10	3.65	1.9	0.91	0.95	0.18	0.6
16 Jun	0.45	7.20	79	13	3.82	9.0	6.6	1.70	2.60	1.40	—
20 Jun	1.92	7.65	18.	8	0.82	4.25	0.9	0.36	0.25	0.20	0.6
21 Jun	0.70	7.28	22	7	1.10	1.75	1.0	nd	0.15	0.33	2.8
27 Jun	4.36	7.08	20	5	0.14	0.35	nd	nd	nd	nd	0.25
6 Jul	3.49	7.52	13	3	0.67	1.75	nd	nd	0.15	0.08	nd
7 Jul	5.67	6.72	10	2.8	1.10	0.35	nd	nd	0.35	0.11	0.25
8 Jul	0.52	7.58	38	10	1.24	5.20	1.2	nd	0.90	0.28	0.90
9 Jul	2.62	7.29	19	4	1.49	3.20	0.3	nd	0.40	0.08	nd
14 Jul	1.54	7.25	36	6.7	1.23	3.00	1.1	nd	0.55	0.25	0.20
15 Jul	3.50	7.15	23	6.4	1.91	3.90	1.5	nd	0.55	0.20	nd
16 Jul	6.98	6.89	15	0.6	0.95	1.30	nd	nd	0.20	nd	nd
18 Jul	2.62	7.10	11	3.7	0.27	2.20	nd	nd	0.19	0.05	nd
18 Jul	1.75	7.30	16	3.0	0.39	1.00	nd	nd	0.10	nd	nd
19 Jul	6.63	7.47	36	13.7	2.64	3.50	0.23	nd	0.35	0.65	nd
21 Jul	3.05	7.48	9	3.35	0.41	0.20	0.015	nd	0.20	0.05	0.20
23 Jul	2.62	7.08	7	2.40	0.68	nil	nd	nd	0.20	0.25	nd
28 Jul	4.30	6.70	7	1.33	0.41	0.50	nd	nd	0.10	nd	nd
6 Aug	7.85	7.35	11	4.90	1.06	0.20	0.90	nd	0.45	0.40	nd
8 Aug	5.24	6.85	28	14.0	2.13	0.20	3.40	0.12	1.05	0.65	nd
12 Aug	—	6.75	4.5	1.52	1.42	0.20	0.40	nd	0.40	0.20	nd
24 Aug	8.75	7.00	5.0	3.86	0.57	0.35	0.40	0.006	nd	0.23	nd
3 Sep	1.13	6.53	20	7.93	0.99	0.02	1.30	0.18	1.00	0.85	0.25
5 Sep	20.94	6.85	10	4.27	0.50	0.02	0.90	nd	0.70	0.40	nd
—	0.87	7.53	26	—	0.50	0.35	—	—	0.63	0.63	nd
19 Sep	20.94	8.15	82	56	0.50	0.02	17	6.14	0.40	0.23	nd
23 Dec*	—	—	—	—	0.57	—	—	—	—	—	—

EC in microsiemen/cm at 25° C; Concentrations in mg/l; nd=not detected, *winter sample

(v) Emanations from the surface water bodies (Gomti river, drains etc) and

(vi) Transfer of impurities from adjacent and/or far off areas depending upon climatic conditions.

While little information is available on the input from the various sources listed above, only generalized conclusions are being briefly given below :

4.1. *Acidity of rain*—The pH of the rain water samples ranged from 6.55 to 8.15, indicating that

there was no incident of 'acid rain, over Lucknow. This is to be expected as there are no smelters, which emit oxides of sulphur or other industries which emit oxides of sulphur or oxides of nitrogen to the atmosphere either in Lucknow or near Lucknow. The relatively high values of HCO₃⁻ ions perhaps indicate considerable interaction of rain water droplets with atmospheric dust particles, which originates at least partly from the landmass in and around Lucknow.

4.2. *Contrast with sea water composition*—Since, Lucknow is situated several hundred kilometres from the sea, it is to be expected that the effect

TABLE 2

Trace element composition of rain water samples in Lucknow during 1980 monsoons

Date of collection (1980)	Total rainfall (cm)	Ag	Cu	Zn	Co	Mo	Cd	Sr	Li	Rb	Cs	Fe	Mn
7 Jun	1.75	0.33	2.40	2.75	0.75	nd	nd	10.60	0.75	0.50	1.10	16.30	1.25
20 Jun	1.91	0.33	3.00	12.50	0.75	2.50	nd	4.40	0.75	0.50	1.10	47.50	5.75
27 Jun	4.36	nd	2.10	6.25	0.75	nd	nd	3.10	0.75	0.63	0.88	34.40	1.83
6 & 7 Jul	3.49	nd	1.18	1.38	0.38	nd	nd	3.80	0.38	0.44	0.56	11.30	1.50
7 & 8 Jul	5.67	nd	0.60	0.50	0.40	1.00	nd	0.50	0.30	0.33	0.45	0.50	0.15
9 & 10 Jul	2.62	nd	3.10	2.50	0.50	11.80	nd	1.80	0.38	0.44	0.31	0.30	2.50
14 Jul	1.34	nd	1.30	1.25	1.00	2.50	nd	12.50	0.75	0.88	0.63	1.30	2.50
14 & 15 Jul	3.30	nd	1.40	10.30	0.38	nd	nd	4.40	0.38	0.63	0.88	37.50	4.38
16 Jul	6.98	0.12	0.67	5.37	0.20	3.50	nd	0.13	0.15	0.18	0.25	8.10	1.00
16 & 18 Jul	2.62	0.16	1.18	12.30	0.38	nd	nd	1.23	0.25	0.44	nd	17.50	1.25
18 Jul	1.75	nd	2.00	13.25	0.50	nd	nd	2.50	0.75	0.50	nd	28.70	2.50
19, 20 & 21 Jul	6.63	nd	0.40	1.63	0.25	0.5	nd	10.25	0.20	0.53	0.23	3.30	0.56
21 Jul	3.05	nd	2.10	8.75	0.75	nd	nd	2.18	13.00	0.63	0.88	83.80	0.56
23 & 24 Jul	2.62	0.58	2.37	19.37	1.50	2.50	nd	1.25	0.75	0.88	0.63	75.00	3.00
27 & 28 Jul	2.62	4.30	6.00	46.25	1.50	nd	nd	6.25	1.50	1.75	1.25	85.00	6.50
28 & 29 Jul	4.80	0.19	1.56	9.63	nd	nd	0.28	2.00	nd	0.31	nd	14.70	1.40
8 Aug	7.85	0.17	2.33	9.00	nd	nd	0.25	2.16	nd	1.00	nd	18.80	2.50
8, 9 & 10 Aug	5.24	0.50	10.80	9.60	nd	nd	2.50	1.83	nd	1.25	nd	29.20	1.90
12 & 14 Aug	—	0.38	1.00	5.60	nd	nd	0.28	3.75	nd	0.31	nd	18.80	0.75
24 & 25 Aug	8.75	nd	0.75	3.90	nd	nd	0.38	1.50	nd	0.38	nd	10.80	0.88
5 & 6 Sep	21.00	1.50	18.60	22.80	2.60	nd	0.30	1.20	nd	0.30	nd	19.50	12.2

Concentrations in microgram/l ; nd=not detected.

TABLE 3

Average chemical composition of rain water over Lucknow in 1980

	Parameter										
	Rainfall	pH	EC	HCO ₃	Cl	NO ₃	Ca	Mg	Na	K	SiO ₂
Range	.43-20.94	6.55-8.15	4.5-82	1.83-56	0.27-4.36	0.0-8.0	0.0-6.6	0.0-6.14	0.0-2.9	0.0-1.6	0.0-2.8
Mean	4.65	7.20	24.9	8.83	1.14	2.12	1.70	0.43	0.59	0.32	0.24
No. of samples	28	28	26	28	29	26	26	27	27	27	26

Concentrations in mg/l; EC in microsiemen/cm at 25°C; Rainfall in cm

TABLE 4

Average trace element content of rain water over Lucknow in 1980

	Parameter											
	Ag	Cu	Zn	Co	Mo	Cd	Cs	Sr	Li	Rb	Fe	Mn
Range	0.0-4.30	0.60-18.6	0.5-46.3	0.0-2.6	0.0-11.8	0.0-2.5	0.0-1.25	0.13-12.5	0.0-13.0	0.18-1.75	0.3-85	0.15-12.2
Mean	0.41	3.08	9.74	0.60	1.10	0.19	0.41	3.63	0.96	0.61	26.5	2.45

Concentrations in microgram/l ; No. of determinations=21

of sea salt nuclei on the chemical composition of rain water should be small. This is borne out by the data given in Tables 1 and 3. In sea water, the K/Na ratio is extremely low, 0.0362, whereas in rain water the K/Na ratios were much higher, the highest value being 1.86, which is almost 50 times the value in sea water. Similarly the Ca/Mg ratios in rain water are much higher than in sea water. However, the greatest contrast seems to occur in the HCO_3/Cl ratio, which is around 0.0075 in sea water but in rain water it is sometimes over one thousand times this value. Similarly the NO_3/Cl and other ion ratios differ markedly, indicating the influence of landmass and anthropogenic activities on the chemical composition of rain water.

4.3. *Trace elements*—The concentrations of trace elements too show considerable variations. The highest concentration present was that of iron (0.3-85 microgram/l) with an average of 26.5 microgram/l, followed by zinc (0.5 to 46.3 microgram/l with an average value of 9.74 microgram/l (Tables 2 & 4). Of the remaining trace elements, the cadmium content was most interesting; the highest value being 2.5 microgram/l. This value may be compared with the limit for cadmium in potable waters recently recommen-

ded by the European Economic Committee, *viz.*, 5 microgram/l, while 0.2 microgram/l of Cd is known to affect zooplankton communities adversely. In irrigation water the limit set is 10 microgram/l for cadmium. Considering the fact that a major portion of the rain water is lost by evapotranspiration leading to concentration of solute matter present in rain water, it is obvious that even this value of 2.5 microgram/l of Cd in rain water is extremely disquieting (Handa 1981).

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