

Status and Forms of Sulfur in Soils of Allahabad District

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Abstract

A soil survey work was conducted to study the different forms of sulfur (total-S, organics, SO₄-S, heat soluble-S, water soluble-S and non-SO₄-S) in soils of Allahabad district. Allahabad district has wide expanse with an area of 7381.47 sq km ; 20 soil samples were collected from each soil association from 0–15 cm depth representing intensive agriculture area of various soil associations of Allahabad district. The soil samples from the different soil associations viz. Khadar, Recent alluvium, Ganga upland, Jamuna upland and Heavy black soil were analyzed for total-S, organic-S, SO₄-S and non-SO₄-S. Heavy black soil has maximum concentration of total-S, organic-S, SO₄-S and non-SO₄-S followed by recent alluvium, Ganga upland, Khadar, Jamuna upland while water soluble and heat soluble-S were found in higher concentration in heavy black soil followed by recent alluvium, Ganga upland, Khadar, Jamuna upland respectively.

Key words : Soil association, Organic-S, Total-S, SO₄-S, Non-SO₄-S.

Sulfur is an essential element for micro-organisms and plants ; it is continuously being cycled between organic and inorganic forms. The nature of the compounds formed and their transformations are strongly influenced by biologically mediated processes, which in turn are affected by environmental conditions. More than 95% of the total S in most aerobic soils occurs as organic S. But organic sulfur is unavailable to plants and must be converted to inorganic sulfur (SO₄) before plant assimilation. There is increasing concern about sustainable soil productivity and developing ecologically sound farming practices. Alternative cropping systems that have reduced levels of conventional input and increased inputs of plant residues and organic wastes have been proposed as a mean of achieving these goals. The transformation of soil organic sulfur to inorganic sulfate sulfur i.e. sulfur mineralization, and the reverse process, the incorporation of sulfate sulfur into soil organic compounds, play important role in the cycling of sulfur within the soil. Since no systematic information is yet available on status of different forms of sulfur in soils of Allahabad district, the present study was conducted to assess the status of different forms of sulfur in some soil of Allahabad district.

Methods

A soil survey work conducted at Allahabad dis-

trict. The district of Allahabad is located between the parallels of 24°47' and 25°47' north latitude and 81°09' and 82°21' east longitude. The district has wide expanse with an area of 7381.47 sq km. Soil samples were collected from 0–15 cm depth of various soil associations from the agricultural areas of Allahabad district. We obtained 20 composite samples from each soil association from 20 villages of particular soil association groups is shown below :

Soil associations	No. of samples	Location (village)
Khadar soils	20	Durgapur, Krchaa, Fatehpur Ghatampur, Rasulpur, Kasia, Sipaha, Ghatpur
Recent alluvium soils	20	Jarai, Ghurpur, Ghatva, Deeha, Panasa, Bانشالي, Birpur, Badculi
Ganga upland soils	20	Lalpur, Theta, Judapur, Beur, Mahubabad, Kamipur-Gawara, Lakshagrih
Jamuna upland soils	20	Shaspur, Andhapur, Uthava, Badauli, Dhakva, Basuhar, Burkhara, Gorajji
Heavy black soils	20	Rampursaria, Sajji, Panthara, Dihikurdkhuta, Peprao, Kasrakala, Dharhal

The soil samples were analyzed for mechanical components of soils viz. sand, silt and clay by international pipette method (Jackson 1973), pH was ana-

Table 1. Physico-chemical characteristic of soil associations.

Soil association	pH	Org. carbon (%)	CaCO ₃ (%)	Sand (%)	Silt + Clay (%)
Khadar soil	7.4-8.8	0.19-0.39	0.35-1.24	34.60-73.76	26.10-34.40
Average	8.02	0.25	0.67	70.08	29.7
Recent alluvium soil	6.8-7.6	0.32-0.48	0.30-0.60	56.70-65.40	34.5-43.79
Average	7.20	0.40	0.40	60.45	38.01
Ganga upland soil	6.8-8.1	0.26-0.52	0.28-0.74	65.28-74.60	25.20-33.72
Average	7.50	0.41	0.56	68.82	30.00
Jamuna upland soil	7.42-8.1	0.18-0.30	0.61-1.02	72.50-83.25	16.70-27.40
Average	7.64	0.24	0.74	77.25	21.56
Heavy black soil	7.50-8.60	0.30-0.54	0.45-0.84	20-35.65	64.0-78.7
Average	7.90	0.44	0.59	30.15	68.01

lyzed in 1 : 2.5 soil water suspension, organic carbon by Walkley and Black (1934). Calcium carbonate was estimated by rapid titration method (Piper 1966) and different forms of sulfur were analyzed by Butter and Chenery (1959) (5% magnesium nitrate) of total sulfur, organic sulfur by oxidized with H₂O₂ and finally extracted by 1% NaCl (Williams and Steinbergs (1959). Sulfate sulfur was estimated by sodium acetate acid method of Chesnin and Yien (1951). Heat soluble sulfur was estimated by 1% NaCl after heating soil at 98 C of Williams and Steinbergs (1959), water soluble sulfur was estimated by 1% NaCl turbidimetric method of Williams and Steinbergs (1959) and non-sulfate sulfur was obtained by the calculation of total sulfur to the organic sulfur +sulfate.

Results and Discussion

Physico-Chemical Characteristics

The soil of Allahabad district of different soil association varied in nature, the soil reaction ranged from neutral to alkaline in nature. Khadar soil has higher pH range than the other soil associations, while recent alluvium showed the minimum pH range among the association. The high pH in Khadar soil was due to higher range of CaCO₃ and lesser range of organic carbon. Therefore, the pH range was maximum in Khadar soil followed by heavy black soil, Jamuna upland, Ganga upland and recent alluvium. The organic carbon percentage was found to be maximum in heavy black soil than the Khadar soil and Jamuna upland. The organic carbon range was found to be maximum in heavy black soil followed by recent allu-

vium, Ganga upland, Khadar and Jamuna upland depending on their alluviate. The CaCO₃ percentage was maximum in Khadar followed by Jamuna upland, heavy black soil, Ganga upland and recent alluvium. The percentage of sand increased in Jamuna upland followed by Khadar, Ganga upland, recent alluvium and heavy black soil. The heavy black soil was showed maximum silt + clay among another soil associations followed by recent alluvium, Ganga upland, Khader and Jamuna upland respectively (Table 1).

Total Sulfur

The total sulfur content among the soil association varied from 90.80 to 222.75 ppm with mean value of 144.52 ppm (Table 2). Thus, the different soil associations had a wide range of total sulfur. The heavy black soil contained highest concentrations of total sulfur, whereas Jamuna upland soil had the lowest. This wide variation in total sulfur, content in Different types of soil might be due to differences in their nature. The highest sulfur contents in soils of heavy black soils as described to their higher clay fractions and organic carbon content (Terelak et al. 1991, Gowrisankar and Shukla 1999, Sakal et al. 2001). According to total sulfur contents the heavy black soil have more total sulfur, followed by recent alluvium, Ganga upland and in Jamuna upland soil.

Organic Sulfur

The organic sulfur content in different soil types of Allahabad district varied considerably (Table 2). It ranged from 18.30 to 98.60 ppm with the mean value

Table 2. Range of sulfur forms in soil association.

Soil associations	Forms of sulfur (ppm)					
	Total-S	Organic-S	SO ₄ -S	Non-SO ₄ -S	Water Soluble-S	Heat Soluble-S
Khadar soil	95.90-140.0	20.80-65.0	4.3-14.3	59.71-71.0	21.2-39.9	22.0-47.6
Average	116.70	42.62	9.04	65.52	29.02	34.09
Recent alluvium soil	121.64-180.7	32.74-82.48	6.30-17.85	77.69-92.0	24.8-49.6	25.8-58.76
Average	160.70	63.04	12.43	83.56	40.40	46.85
Ganga upland soil	110.3-160.75	28.0-76.45	5.2-15.8	65.5-80.7	25.1-50.1	24.3-43.0
Average	146.76	58.70	10.56	67.78	36.28	38.36
Jamuna upland soil	90.80-130.36	18.30-60.0	4.0-13.5	53.53-69.2	20.01-36.0	24.4-47.6
Average	100.44	40.20	10.99	71.18	28.65	34.72
Heavy black soil	148.5-222.75	48.46-98.6	8.30-22.8	77.24-110.1	26.4-56.9	30.76-65.78
Average	198.01	83.59	15.81	98.68	46.96	52.37

of 57.63 ppm. On the average heavy black soils have higher reserve of organic sulfur than the Jamuna upland. The heavy black soils have higher percentage of organic carbon and that organic carbon induce the higher organic sulfur in heavy black soil (Tiwari and Pandey 1990, Bhoyal et al. 1996, Hari Ram and Khan 1993).

Sulfate Sulfur

Sulfate sulfur varied from 4.0 to 22.80 ppm with the mean value of 11.84 ppm. On the basis of average value of sulfate sulfur, the different soil types of Allahabad may be arranged in the ascending order : Jamuna uplands, Khadar, Ganga upland, recent alluvium and heavy black soil. Thus, it is obvious that availability of sulfate sulfur was higher in the soil of heavy black soils as compared to other soil types. The track of heavy black soil has more organic carbon resulted increasing sulfate sulfur with the activation of microbial phenomenon. The sulfate was low in other soil types because they had lower range of organic carbon and organic sulfur content (Arora and Takkar 1988, Ram and Dwivedi 1994).

Non-Sulfate Sulfur

Non-sulfate sulfur constituted the major portion of total sulfur of different soil associations of Allahabad ; on an average it contributed approximately 50% of the total sulfur, it varied from 53.53 to 110.10 ppm with the mean value of 77.34 ppm. Thus, it showed wide variability in its distribution. The

non-sulfate sulfur contents in different types of soil depend on their total sulfur content and microbial action resulted in the transformation of sulfate sulfur. Heavy black soil had more non-sulfate sulfur followed by recent alluvium, Jamuna upland, Ganga upland and Khadar soils have lower range of this form of sulfur due to the lower microbial action in the presence of higher pH ranging.

Heat Soluble Sulfur

Table 2 reveals that the heat soluble sulfur on an average, varied between 22.0 to 65.78 ppm with the mean value of 40.64 ppm. It recorded highest in heavy black soils while lowest was recorded in Khadar soils. The heat soluble sulfur also showed wide variability in its distribution. The content of heat soluble is more in heavy black soil followed by recent alluvium, Ganga upland, Jamuna upland and Khadar soil associations (Bhan and Tripathi 1973, Tiwari and Pandey, 1990, Bhoyal et al. 1996).

Water Soluble Sulfur

Water soluble sulfur was found to be comparatively higher in range than sulfate sulfur in soils of different associations of Allahabad, on an average, the water soluble sulfur varied from 20.01 to 56.85 ppm with the mean value of 35.63 ppm. On the basis of an average mean value, more soluble sulfur was found in heavy black soil followed by recent alluvium, Ganga upland, Jamuna upland respectively

(Bhan and Tripathi 1973, Balanagoudar and Satyanarayana 1990).

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