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Forms of Sulphur in Some Soils of Jaunpur District, Uttar Pradesh

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Abstract : *Distribution of sulphur and its fractions was studied in six soil series of Jaunpur district of Uttar Pradesh. In surface horizons total, available organic and non-sulphate sulphur ranged from 152 to 307 ppm, 10 to 39 ppm, 73 to 155 ppm and 66 to 155 ppm, respectively. Most of the soil samples were deficient in available sulphur. There was no definite pattern of depthwise distribution of total and available sulphur. Organic sulphur decreased and non-sulphate sulphur increased with depth. Highly significant positive correlation of total sulphur with clay (r=0.56), and sulphate-sulphur with EC. (r=0.51); organic sulphur with organic carbon (r=0.60) were recorded. The ratio of C:N, C:S , N: Sand C:N:S of surface soils averaged as 9.4:1; 38.5:1; 4.1:1 and 37:3.9:1, respectively. (**Key words:** available sulphur, sulphur fraction, organic carbon, soil horizon, sulphur distribution).*

The review on sulphur status of Varanasi region revealed that, about 60 per cent soil samples tested were found deficient in plant available sulphur (Tiwari & Pandey 1990). However, the information on sulphur and its fractions in soils of Jaunpur district is lacking. The attempt has, therefore, been made to study the distribution of sulphur fractions and their relationship with soil properties in six soil series representing Vertic Haplaquepts, and Udic and Typic Ustochrepts occuring in Jaunpur district Uttar Pradesh.

MATERIAL AND METHODS

Six profiles (Sadruddinpur, Haderpur, Jangipur, Parpur, Belcha and Ibrahimabad) representing prominent soil series of district Jaunpur were examined. Horizonwise samples were collected, processed and analysed for pH, EC, Organic carbon (Walkley & Black method), $CaCO_3$ (rapid titration method), total nitrogen (modified Kjeldahl method) and mechanical composition (international pipette method).

Total sulphur was determined in the nitric-perchloric-phosphoric acid digest following the procedure of Beaton *et al.* (1968). Available sulphur was determined in 0.15 per cent $CaCl_2$ extract (Williams & Steinbergs 1959), and organic sulphur by the procedure of Evans and Rost (1945) as modified by Williams and Steinbergs (1959). The estimation of sulphur in the extract was done turbidimetrically (Chesnin & Yien 1951). Non-Sulphate sulphur was calculated by deducting sum of organic and sulphate sulphur from total sulphur (Evans & Rost 1945).

RESULTS AND DISCUSSION

Soils generally have pH below 8.5 and EC less than 0.32 dsm^{-1}. They are low in organic carbon. The surface texture is generally silt loam (Table 1).

Total Sulphur : Total sulphur content in the profiles, ranged from 77 to 363 ppm with a mean of 233 ppm. Its distribution does not follow any definite trend with depth but generally increased with increase in clay conetnt in sub-soils. A positive highly significant correlation (r = 0.56) between total sulphur and clay content was found (Arora *et al.* 1988, Pandey *et al.* 1989). In general B horizon has higher value of total sulphur which elucidated its relation with texture as well as translocation and deposition. Significant positive correlation of total sulphur with organic sulphur ($r = 0.34^{*}$) and non-sulphate sulphur fractions ($r = 0.83^{**}$) were recorded.

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TABLE 1. Physico-chemical properties of the soils

Horizon with depth (cm)	pH	EC (dSm^{-1})	O.C.	$CaCO_3$	Total N	Clay	Texture
			<----------(%)---------->				
P1: SADRUDDINPUR : VERTIC HAPLAQUEPTS							
Ap(0-9)	7.6	0.22	0.61	1.7	0.067	40.5	sic
B1(9-38)	8.3	0.13	0.19	1.4	0.031	41.5	Sic
B21(38-95)	8.8	0.14	0.14	1.4	0.022	45.5	Sic
B22(95-123)	8.8	0.13	0.12	1.1	0.022	42.5	Sic
B3(123-158)	8.8	0.14	0.12	1.7	0.015	35.5	Sicl
C(150-180)	8.7	0.12	0.07	1.6	0.010	21.0	sil
P2 :HADERPUR : UDIC USTOCHREPTS							
Ap(0-11)	8.3	0.11	0.51	1.6	0.057	20.5	sil
A12(11-27)	8.3	0.10	0.22	1.6	0.028	22.2	sil
B1 (27-58)	8.3	0.10	0.16	1.3	0.024	32.3	sicl
B2(58-112)	8.4	0.11	0.15	1.6	0.023	34.5	sicl
B3(112-160)	8.5	0.08	0.08	1.3	0.012	29.5	sicl
C(160-180)	8.3	0.08	0.07	1.3	0.010	25.3	sil
P3 : JANGIPUR : TYPIC USTOCHREPTS							
AP (0-10)	8.2	0.30	0.38	1.8	0.042	19.0	sil
B1(10-23)	8.4	0.13	0.24	1.6	0.035	27.5	sil
B21(23-45)	8.6	0.13	0.23	1.3	0.034	31.5	sicl
B22(45-82)	8.9	0.24	0.16	4.2	0.024	30.5	sicl
B23(82-125)	8.9	0.25	0.14	3.2	0.020	32.5	sicl
B3K(125-158)	8.9	0.19	0.07	4.2	0.013	26.0	sicl
CK(158-180)	8.6	0.25	0.07	2.3	0.013	24.0	sil
P4 : PARPUR : UDIC USTOCHREPTS							
AP (0-10)	8.4	0.32	0.34	1.8	0.041	24.0	sil
A12(12-28)	8.5	0.12	0.26	1.6	0.037	24.2	sil
B1(10-23)	8.3	0.12	0.17	1.6	0.029	30.5	sicl
B21(23-45)	8.4	0.11	0.14	1.6	0.027	31.5	sicl
B22(45-82)	8.4	0.13	0.11	2.0	0.012	30.5	sicl
B3K(125-158)	8.4	0.13	0.09	2.0	0.010	28.0	gsicl
CK(158-180)	7.7	0.32	0.08	2.3	0.010	22.5	sil
P5 : BELCHA: UDIC USTOCHREPTS							
AP (0-13)	7.5	0.24	0.30	0.7	0.028	16.1	sil
A3(13-34)	8.0	0.11	0.18	0.7	0.029	22.5	sil
B21(34-66)	8.2	0.11	0.16	1.4	0.027	21.3	sil
B22(66-110)	8.0	0.11	0.12	1.7	0.026	30.1	sicl
B3(110-159)	7.7	0.15	0.12	1.7	0.022	20.8	gsil
C(159-180)	8.1	0.06	0.06	1.4	0.019	22.0	sil
P6 : IBRAHIMABAD : TYPIC USTOCHREPTS							
AP (0-12)	7.7	0.09	0.32	1.7	0.003	24.5	sil
A3(12-28)	8.0	0.08	0.17	1.4	0.029	26.6	sil
B21(28-54)	8.3	0.09	0.16	1.2	0.017	28.0	sicl
B22(54-106)	8.3	0.09	0.15	1.4	0.015	29.8	sicl
B23K(106-124)	8.5	0.10	0.14	10.6	0.014	32.5	sicl

Sic - silty clay; sicl - slity clay loam; sil - silt loam.

TABLE 2: Profile distribution of different forms of sulphur.

Horizon with depth (cm)	Total sulphur	Avail. able sulphur	Org. sulphur	Non-sulphate sulphur	Per cent of total sulphur			Ratio	
	(ppm)				Avail-able S	Organic S	Non-sulphate S	C:N	C:N:S
P1 : SADRUDDINPUR : VERTIC HAPLAQUEPTS									
Ap(0-9)	307	39	152	116	12.7	49.5	37.8	9.1:1	41.6:4.5:1
B1(9-38)	363	15	120	228	4.1	33.0	62.8	6.1:1	15.8:2.6:1
B21(38-95)	268	13	110	145	4.8	41.0	54.1	6.3:1	12.8:2.0:1
B22(95-123	306	12	88	206	3.9	28.7	67.3	6.0:1	11.0:2.1:1
B3(123-158)	210	13	71	126	6.2	33.8	60.0	5.3:1	10.3:2.1:1
C(158-180)	215	12	70	133	5.6	32.6	61.8	7.0:1	9.0:1.4:1
P2 : HADERPUR : UDIC USTOCHREPTS									
Ap(0-11)	269	13	128	155	4.8	47.6	57.6	9.0:1	40.0:4.4:1
A12(11-27)	202	13	53	135	6.4	26.2	66.8	10.0:1	41.6:4.2:1
B1(27-58)	270	21	51	198	7.7	18.8	73.2	6.6:1	32.2:4.8:1
B2(58-112)	259	19	53	186	7.3	20.5	71.8	6.5:1	28.5:4.8:1
B3(112-160)	221	14	41	165	6.3	18.5	74.6	6.6:1	19.6:2.9:1
C(160-180)	269	15	38	216	5.6	14.1	80.3	6.3:1	18.5:2.9:1
P3 : JANGIPUR : TYPIC USTOCHREPTS									
Ap(0-10)	192	13	78	105	6.7	38.0	54.6	9.0:1	52.6:5.8:1
B1(10-23)	201	13	58	141	4.5	28.8	70.1	6.8:1	41.6:6.0:1
B21(23-45)	264	13	65	186	4.9	41.0	70.4	6.8:1	35.7:5.3:1
B22(45-82)	172	12	61	99	6.9	24.6	57.6	6.6:1	26.3:3.9:1
B23(82-125)	176	26	53	97	14.7	35.5	55.1	7.0:1	27.0:3.8:1
B3K(125-158)	124	11	35	78	8.8	28.2	62.9	5.4:1	20.0:3:7:1
CK(158-180)	77	12	33	32	15.5	42.8	41.5	5.4:1	21.2:3.9:1
P4 : PARPUR : UDIC USTOCHREPTS									
Ap(0-12)	232	14	120	98	6.0	51.7	42.0	8.3:1	28.5:3.4:1
A12(12-28)	202	10	109	83	4.9	83.9	41.1	7.0:1	24.3:3.5:1
B1(28-50)	247	13	102	132	5.3	41.3	53.4	5.8:1	16.6:2.8:1
B21(50-88)	266	10	101	135	3.8	37.9	50.7	5.2:1	13.8:2.6:1
B22(88-135)	287	13	85	189	4.5	29.6	65.8	9.1:1	12.0:1.4:1
B3K(135-160)	229	14	76	139	6.1	33.2	60.7	9.0:1	11.9:1:3:1
CK(160-180)	239	65	72	102	27.2	30.1	42.7	6.0:1	10.3:1.4:1
P5 : BELCHA : UDIC USTOCHREPTS									
Ap(0-13)	152	14	72	66	9.2	47.3	43.4	10.7:1	41.6:3.8:1
A3(13-34)	238	15	85	138	6.3	35.7	57.9	8.6:1	21.2:2.5:1
B21(34-66)	210	15	75	120	7.1	35.7	57.1	5.7:1	21.7:3.8:1
B22(66-110)	217	13	72	192	4.6	29.9	69.3	6.6:1	16.6:2.5:1
B3(110-159)	250	32	72	145	12.8	28.8	58.0	5.4:1	16.6:3.0:1
C(159-180)	221	17	60	143	7.6	27.1	64.7	8.6:1	10.0:1.2:1
P6 : IBRAHIMABAD : TYPIC USTOCHREPTS									
Ap(0-12)	210	10	120	80	4.7	57.1	38.0	10.4:1	27.0:2.6:1
A3(12-28)	220	12	115	93	5.4	52.2	42.2	7.1:1	21.3:2.9:1
B21(28-54)	249	11	60	178	4.4	24.0	71.4	9.4:1	27.0:2.8:1
B22(54-106)	270	13	52	205	4.8	19.3	75.9	9.2:1	29.4:2.9:1
B23K(106-124)	335	11	53	271	3.2	15.8	80.8	9.6:1	27.0:2.7:1

Average of surface horizon; C:N -9.41 :1; C:S- 38.5 :1; N:S -4.1:1; C:N:S -37: 3.9:1.

Available Sulphur : Available sulphur content in the profiles varied from 10 to 39 ppm with an average of 16 ppm. Heavy textured Sadruddinpur series have 39 ppm. In other soils it ranged from 10 to 14 ppm in surface horizons. It constitute about 4.7 to 12.7 per cent of total sulphur. Considering 13 ppm (0.15 per cent $CaCl_2$ extractable)(Palaskar & Ghosh 1985), it may be inferred that most of the soils are deficient to marginal in sulphur.

Distribution of available sulphur in profiles does not follow any pattern except Sadruddinpur series where a regular decrease with depth of profile was noted. A highly significant positive correlation (r = 0.51) exists between sulphur and electrical conductivity (Aulakh & Dev 1976).

Organic Sulphur : It ranged from 33 to 152 ppm with average of 77 ppm and constitute to 38.0 to 57.1 per cent of the total sulphur. This form of sulphur decreased with depth and followed the trend of organic matter. A highly significant positive correlation (r = 0.60) berween organic sulphur and organic carbon was recorded. Similar findings were reported by Aulakh and Dev (1976) and Pandey *et al.* (1989).

Non-Sulphate Sulphur : Non sulphate sulphur varied from 32 to 271 ppm with a mean of 142 ppm. It is generally increased with depth in almost all the proflies. A significant positive correlation with clay (r=0.61) was recorded. Evans and Rost (1945) attributed this to adsorved sulphur on clay particles. Reduced condition particularly in horizons having high clay content at lower depth may also be responsible for high content of non-sulphate sulphur. A significant positive correlation (r=0.83) between total sulphur and non sulphate sulphur was recorded.

Carbon, Nitrogen and Sulphur Interrelationship : The C:S ratio varied from 27.0 to 52.6 in surface horizons and become narrower with depth. Arora *et al.* (1988) proposed a C:S ratio of less than 200 as critical for mineralization of organic sulphur. Thus, it may be inferred that organic sulphur is mineralizable and will contribute to sulphur nutrition of plants. Narrower of C:S ratio can be due to low mineralization and higher rate of accumulation of sulphur compounds in the horizons (Dolui & Guhathakurta, 1988).

C:N ratio was higher in surface horizons and decreased with depth. This is indicative of high level of biological activity in surface horizon which results in rapid loss of nitrogen. A narrow value in lower hirozons could be due to some NH_4 fixation by the clay as well as due to stable organic matter in contrast to Ap horizons (Tisdale *et al.*) 1985). In general, organic sulphur was found to decrease with depth.

It may be concluded that surface and subsurface horizons of most of the soil series under study are either dificient or marginal in available sulphur. These soils will respond to sulphur fertilization for shallow and deep rooted crops. Deficient status of sulphur is strongly dependent on content of organic carbon, clay and electrical conductivity of the soils.

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