DISTRIBUTION OF COBALT IN *KANKAR* AND SOILS OF VINDHYAN REGION OF MIRZAPUR (INDIA)

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Total cobalt in the soils and *kankar* nodules and available cobalt in the soils do not show any definite relationship with depth of soil profiles. Total and available cobalt in the soils show a higher significant positive correlation. Total cobalt content in *kankar* does not show any relationship with *p*H, organic carbon, and silt plus clay fractions of soils whereas total and available cobalt in soils decrease with increasing organic carbon content.

INTRODUCTION

Although not yet established as an essential element in plant nutrition, cobalt has favoured growth and yield of crops, especially on deficient soils (Bolle-Jones and Mallikarjuneswara 1958; Thacker and Beeson 1958). It is also important in animal nutrition.

Cobalt in concretions plays an important role in its colouration and it bears some correlation with soil cobalt (Brooks, 1965). This study concerns with the distribution, availability and importance of cobalt in soils and concretions, and their relationship with soil cobalt in the Vindhyan soils of Mirzapur.

EXPERIMENTAL

Total cobalt in the soil and *kankar* samples (2 g) was extracted with perchloric acid (Sandell 1950) and available cobalt (20 g) with 2.5 per cent acetic acid adjusted to *p*H 2.5 (Reddy and Mehta 1962). Estimation of cobalt in the extract was made colorimetrically using 2-nitroso-1-naphthol as colour developer.

RESULTS AND DISCUSSIONS

The data on the total and available cobalt in the soil profiles and total cobalt in the *kankar* nodules are given in Table I. Other soil properties such as *p*H, $CaCO_3$, organic carbon, silt plus clay and iron contents which generally influence the cobalt distribution in a soil, are also included.

In general, available cobalt in the soil profiles appears to follow no definite trend of distribution with depth. Similar is the case with total cobalt in soil and *kankar*

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except in the profile V where it shows a positive relationship with depth. The surface horizons contain low amount of total cobalt except in profile IV (Table I). A similar trend was observed with available cobalt excepting in profiles II and III. Kabata (1954) also reported that upper layers of soils contain less amount of cobalt than the sub-layers. The lesser amount of cobalt in the upper than lower layers could be due to leaching losses during the precipitation. Rana and Ouellette (1967) reported that extractable cobalt in surface soil is significantly related to total cobalt.

TABLE I

Distribution of cobalt in kankar *and soils, and other characteristics of soils*

Depth (cm)	*p*H	$CaCO_3$ (%)	Organic carbon (%)	Silt + clay (%)	Fe_2O_3 (%)	Total cobalt in *kankar* (ppm)	Total cobalt in soil (ppm)	Available cobalt in soil (ppm)	Available cobalt in soil (% of total)
				Profile I					
0—20	8.6	3.6	0.52	50.0	3.57	—	15.1	0.17	1.13
20—45	9.3	10.0	0.29	45.7	3.86	20.3	16.8	0.26	1.55
45—75	9.4	10.0	0.15	60.2	4.04	—	19.9	0.20	1 00
75—105	9.0	7.6	0.11	60.5	4.04	—	19.7	0.32	1.62
105—135	8.6	8.4	0.15	59.0	4.34	23.1	13.3	0.16	1.20
				Profile II					
0—20	8.2	1.9	0.81	35.5	3.29	—	9.4	0.13	1.38
20—40	8.5	2.1	0.60	28.7	3.33	—	11.0	0.11	1.00
40—60	9.0	1.5	0.11	26.5	3.57	—	18.9	0.18	0.95
60—105	8.6	1.3	0.11	38.5	4.16	26.0	17.3	0.13	0.75
105—150	8.7	2.1	0.14	39.0	3.57	24.0	18.2	0.21	1.15
				Profile III					
0—30	7.9	3.1	0.30	32.0	3.80	—	8.3	0.10	1.20
30—60	8.0	3.3	0.52	47.2	4.29	—	13.2	0.09	0.70
60—90	8.0	6.2	0.45	47.0	4.46	29.0	14.3	0.16	1.12
90—120	7.9	6.1	0.40	54.2	4.46	30.2	7.8	0.17	2.18
120—150	7.9	6.8	0.37	56.2	4.76	32.3	8.9	0.21	2.36
				Profile IV					
0—30	8.3	3.0	0.41	49.5	3.33	—	22.9	0.22	0.96
30—60	9.9	6.1	0.13	56.7	3.57	28.2	20.2	0.32	1.58
60—90	9.6	5.1	0.09	62.0	4.16	—	27.2	0.28	1.03
90—120	9.4	3.0	0.11	59.7	4.34	—	14.3	0.26	1.81
120—150	9.2	2.1	0.07	62.2	4.16	—	20.0	0.16	0.80
				Profile V					
0—18	7.7	1.4	0.30	51.0	4.76	—	9.9	0.17	1.72
18—48	7.9	2.8	0.24	58.2	4.34	28.8	13.5	0.29	2.15
48—90	8.0	1.2	0.18	57.0	4.64	—	17.8	0.38	2.13
90—115	7.9	1.4	0.12	61.7	4.64	—	28.1	0.30	1.07
115—145	7.9	1.5	0.12	70.2	4.16	—	28.8	0.32	1.11

Total cobalt in the *kankar* and soil samples ranges from 20.3 to 32.3 and 7.8 to 28.8 ppm, respectively. The corresponding figures for available cobalt in soils were 0.09–0.38 ppm. Fujimoto and Sherman (1950) and Kidson (1937) found a very wide range of total cobalt in Hawaiian and New Zealand soils, respectively. Reddy and Mehta (1961) reported a range from 4 to 78 ppm in the North Gujarat soils and even higher in the South Gujarat soils. Ranges of total cobalt from 4.2 to 37.0 ppm in Missouri (Johnson and Graham 1952), 4 to 41 ppm in New Jersey (Hill *et al.* 1953) and 3.6 to 21.0 ppm in Nova Scotia (Wright and Lawton 1954) soils have been reported. Vinogradov (1959) reported that sedimentary rocks contain about 23 ppm of cobalt whereas the earth crust contains only 8 ppm.

Davidson and Mitchell (1940) and Walsh *et al.* (1956) suggested a classification for total cobalt in relation to nutritional diseases among animals fed on grasses. According to them, soils with more than 5 ppm of total cobalt indicate sufficiency but less than 5 ppm cause moderate deficiency. On this basis, the experimental soils could cause deficiency among cattles. In general, all the soils could cause deficiency if compared with the standards suggested by Mitchell (1945) and Stewart (1953) on the basis of available cobalt. They suggested that the soils show deficiency or sufficiency as they contain less than 0.25 ppm or more than 0.30 ppm of acetic acid extractable cobalt. The above findings suggest that total cobalt can hardly serve as an index of its availability.

The data in Table I indicate that the available cobalt, expressed as per cent of the total, ranges from 0.70 to 2.18. The available and total cobalt in the soils showed a highly significant positive correlation ($r = +0.5981$). Singh and Singh (1966) reported a significant positive correlation between available and total cobalt in some alkali and adjoining soils of Uttar Pradesh. Reddy and Mehta (1962) reported a similar result for calcareous soils of Rajkot and Surendranagar districts of Gujarat. On the other hand, total cobalt in *kankar* and the respective mother soils showed a significant negative correlation ($r = -0.6500$).

Results (Table II) indicate that the average amount of total cobalt in soil increases with increasing *p*H, except in the *p*H range of 8.1 to 8.5, whereas the total cobalt in the *kankar* and available cobalt in the soils have no definite relationship. Reddy and Mehta (1961) and Thompson (1957) found that *p*H has no effect on the availability or plant uptake of cobalt.

From the results in Table II, it can be seen that average amount of total cobalt, in general, decreases with increasing calcium carbonate content but there is no marked effect on the available cobalt in the soils and total cobalt in the *kankar* nodules. Boddie (1947) reported that soils containing high amount of calcium carbonate failed to furnish cobalt in available form, but Singh and Singh (1966) observed no definite relationship between $CaCO_3$ and available cobalt in alkali and adjoining soils of Uttar Pradesh.

The data also indicate that as the amount of organic carbon increases, the average quantities of total and available cobalt in the soils decrease but there is little effect on the total cobalt in the *kankar* nodules. The cobalt level in a soil is the function of organic matter content (Johnson and Graham 1952), and its deficiency in soils is due to its binding with organic matter (Bamberg 1959). Reddy and Mehta (1961*b*)

and Singh and Singh (1966) reported that there seems to be no definite correlation between organic carbon and available cobalt in soils. Rana and Ouellette (1967) also reported that organic matter content has not effect on cobalt content.

Results (Table II) apparently show a positive relationship between total cobalt and fine fractions in the soils and so was the case with available cobalt. Several investigators (Atkinson *et al.* 1953; Askew, 1946; Kabata 1954; Wright and Lawton 1954; Wahhab and Bhatti 1958; Singh and Singh 1966) have reported a significant correlation between total cobalt and texture of the soil. Brooks (1965) reported that concretions occurring in silt loam soils contain more iron and cobalt than manganese and titanium.

TABLE II

Total cobalt in kankar *and soil, and available cobalt in soil as affected by various soil factors (Range and average in ppm)*

Soil factors range	Total cobalt in *kankar*		Total cobalt in soil		Available cobalt in soil	
	Range	Average	Range	Average	Range	Average
*p*H						
7.6—8.0	28.8—32.3	30.10	7.8—28.8	15.06	0.09—0.38	0.219
8.1—8.5	—	—	9.4—22.9	14.30	0.11—0.22	0.153
8.6—9.00	23.1—26.0	21.87	13.3—19.9	17.12	0.13—0.32	0.195
>9.0	20.3—28.2	24.25	14.3—27.0	19.67	0.16—0.32	0.246
$CaCO_3$ (%)						
1.0—2.0	26.0	26.00	9.4—28.8	18.60	0.13—0.38	0.230
2.0—4.0	24.0—28.0	26.00	8.3—22.9	15.18	0.09—0.29	0.179
4.0—8.0	28.2—32.3	29.92	7.8—27.2	16.35	0.16—0.32	0.243
>8.0	20.3—23.1	21.70	13.3—19.9	16.66	0.16—0.26	0.206
Organic carbon (%)						
0.07—0.13	26.0—28.2	27.10	14.3—28.8	21.72	0.13—0.32	0.252
0.14—0.30	20.3—28.8	24.05	8.3—19.9	14.71	0.10—0.38	0.221
0.31—0.55	29.0—32.3	30.50	7.8—22.9	13.70	0.09—0.22	0.170
>0.55	—	—	9.4—11.0	10.20	0.11—0.13	0.120
Silt+Clay (%)						
25.0—35.0	—	—	8.3—18.9	12.73	0.10—0.18	0.130
35.0—45.0	24.0—26.0	25.00	9.4—18.2	14.97	0.13—0.21	0.156
45.0—55.0	20.3—30.2	23.17	7.8—22.9	14.30	0.09—0.26	0.180
55.0—65.0	23.1—32.9	28.10	8.9—28.1	16.60	0.16—0.38	0.262
>65.0	—	—	28.8	28.80	0.32	0.320
Fe_2O_3 (%)						
3.20—3.40	—	—	9.4—22.9	14.43	0.11—0.22	0.153
3.40—3.60	24.0—28.2	26.10	15.0—20.2	18.08	0.16—0.21	0.180
3.60—3.80	—	—	8.3	8.30	0.10	0.100
3.80—4.00	20.3—20.30	20.30	16.80	16.80	0.26	0.260
4.00—4.20	26.0	26.00	17.3—28.8	18.81	0.13—0.32	0.208
4.20—4.40	23.1	23.10	13.2—14.3	13.60	0.09—0.26	0.170
>4.40	28.8—32.3	30.10	7.8—28.1	14.30	0.17—0.38	0.240

In the present study there seems to be no apparent relationship between cobalt and iron in the soils. However, a non-significant negative correlation ($r = -0.4702$) was observed between total cobalt and iron and a significant positive correlation ($r = +0.7754$) between total cobalt and mangnese in the *kankar* nodules. This contradicts the earlier findings of Reddy and Mehta (1961 *b*) and Singh and Singh (1966) who reported a significant positive correlation between total cobalt and iron in soils.

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