



Sulphur Retention and Release in Alfisols and Ultisols of Jharkhand

¹Brajandra, ²L. M. Shukla, N. Sailaja³, MBB Prasad Babu⁴ and Sumanth Kumar, VV⁵

^{1&3} ICAR-Indian Institute of Rice Research, Hyderabad, Telangana

²Division of Soil Science and Agricultural Chemistry, IARI, New Delhi-11

ABSTRACT

Surface soil samples (0-15 cm) from twenty different sites covering four districts of Jharkhand belonging to Alfisols and Ultisols soil order were selected for studies on Sulphur retention and release in Alfisols and Ultisols of Jharkhand. The average equilibrium SO_4^{2-} application decreased from 4.49 mg/l to 7.01 mg/l at 10 ppm added sulphur, whereas the percentage of sulphate adsorbed increased from 5.01 to 29.94 percent. The average amount of sulphate adsorbed varied from 5.1 percent at a time interval of 2hrs to 29.94 percent at a time interval of 24 hrs for 10ppm added S. Similarly, it ranged from 8.13 percent to 29.33 percent at different intervals of time for 20 mg/kg added S. In case of 30mg/kg added S, the percentage of adsorbed sulphate was found to vary from 5.87 to 24.54 at different intervals of time. The adsorption parameters $1/n$ and K values ranged from 0.397 to 0.739 and 1.012 to 1.400, respectively. The constants n and K , however are empirical constants in the Freundlich adsorption equation and do not provide the basis of description of the reactions.

Received 18.07.2017

Revised 09.08.2017

Accepted 24.08.2017

INTRODUCTION

Sulphur retention in acid soils usually occurs in 2 phases: a fast reaction process followed by continued slow removal from solution (Parfitt and Smart, 1978). Inorganic and organic anions compete to varying extents for P sorption sites. The extent to which these anions can compete with sulphate retention sites is a function of soil pH and sulphate saturation. The initial fast reaction of SO_4^{2-} involves ligand exchange of sulphate with surface OH and OH_2 groups (Parfitt and Smart, 1978). This reaction is thought also to occur in soils. The slow retention of SO_4^{2-} has not been well characterized, but is attributed to precipitation of SO_4^{2-} . These mechanisms are associated with addition of large concentration of sulphate (Parfitt and Smart, 1978). Changes in pH are likely to reflect major shifts in the dominating reaction retaining S. The initial retention of S is associated with the release of salts of weak acids into the solution. The change of pH may signify the onset of a shift to another set of s retention reaction. Ungarish, and Aharani, (1981) suggested that with a constant concentration of P is the input, adsorption of P will become constant, any further retention could be attributed to the formation of a separate P solid phase. The soil solution to be supersaturated with several Al Phosphate compound. Low soil pH and high Fe and Al oxides concentration are the striking features of Alfisols and Ultisols of Jharkhand. These soils can absorb large amounts of sulphur and then release it in a speed which may not match the plants absorption. At higher concentration and a time period beyond 12 hrs of shaking period can be aid better in S fertilization to soils. The large SO_4^{2-} concentrations and upto 24 hrs of shaking period used in the present study will closely match condition that will exist near the interface between a fertilizer granule and the soil even at rates applied in agriculture. These adsorption and desorption kinetics of sulphate affects availability to plants. Understanding these reactions in Alfisols and Ultisols of Jharkhand will help in better understanding of fate of fertilizer sulphur. Increasing crop yield depend heavily on input of sulphur addition in soils. Specific adsorption of sulphur is generally considered to increase as the pH decreases. These adsorption and desorption kinetics of sulphate affects availability to plants. Understanding these reactions in Alfisols and Ultisols of Jharkhand will help in better understanding of fate of fertilizer sulphur.

The objective of the present study were

- 1) To estimate amount and percentage of retention and release of sulphate at varying concentration and time period.
- 2) To relate the retention and release pattern to various adsorption-desorption models.

For the description of the relationship between a dissolved substance and its adsorbed form, various model equations are used such as the Langmuir, Freundlich and Temkin. Various Electrostatic models take into account the charge of the reactive surfaces and the charge of the desorbing substances.

MATERIALS AND METHODS

Surface soil samples (0-15 cm) from twenty different sites covering four districts of Jharkhand belonging to Alfisols and Ultisols soil order were air dried and crushed with a 2mm sieve. In USDA soil taxonomy soils were classified as Typic Haplodaef to Typic Haplustuls. Neither soil sample was known to have received fertilizer prior to sampling. The sulphate adsorption describes the solid and liquid phase interaction affecting the availability of sulphur to plants and leaching of SO_4^{2-} and associated cations. The release and fixation of SO_4^{2-} are also reflected by the SO_4^{2-} adsorption behavior of soils. The soils varying widely in their characteristics were selected for adsorption studies. The extrapolation of SO_4^{2-} sorption capacities and predicted absorption reaction in Alfisols and Ultisols is limited because most of the reported experiments were done using small additions of sulphur in the range of 5-30 ppm. The amount of sulphur adsorbed was calculated by subtracting the equilibrium concentration from the sulphate added. The basic data of sulphate adsorption on different soils were fitted into different linear adsorption equation to describe the adsorption behavior of sulphate. For the description of the relationship between a dissolved substance and its adsorbed form, various model equations are used such as the Langmuir, Freundlich and Temkin. Out of various adsorption isotherms equations used (Langmuir, Freundlich and Temkin adsorption equation), the adsorption data did not confirm to the Langmuir isotherm over the entire range of equilibrium sulphate concentrations. Therefore, the results on Langmuir adsorption model are not presented. However, the results of adsorption studies pertaining to Freundlich and Temkin models are described.

RESULTS AND DISCUSSION

Sulphate adsorption in soil

The present investigation was planned to study the SO_4^{2-} adsorption-desorption behavior in the soil of four districts of Jharkhand and result obtained are present in the subsequent paragraphs.

The equilibrium SO_4^{2-} constant (mg/l) and percentage of SO_4^{2-} adsorbed at different intervals of time for varying levels of SO_4^{2-} application are presented in tables 1 to 3. The average equilibrium SO_4^{2-} application decreased from 4.49 mg/l to 7.01 mg/l at 10 ppm added sulphur, whereas the percentage of sulphate adsorbed increased from 5.01 to 29.94 percent. Similarly the equilibrium SO_4^{2-} concentration was found to decrease with respect to time at all the concentration of added sulphur. At the same time, there was a gradual increase in the added SO_4^{2-} concentration in equilibrium solution in different soils, even at the same level of added sulphur. The percentage sulphate adsorbed also varied widely at the same interval of time and the same amount of sulphate added to different soils. The average amount of sulphate adsorbed varied from 5.1 percent at a time interval of 2hrs to 29.94 percent at a time interval of 24 hrs for 10ppm added S. Similarly, it ranged from 8.13 percent to 29.33 percent at different intervals of time for 20 mg/kg added S. In case of 30mg/kg added S, the percentage of adsorbed sulphate was found to vary from 5.87 to 24.54 at different intervals of time. It was noticed that at lower levels of sulphate addition, the percentage of sulphate adsorbed was less as compared to higher levels of S application. This suggests the affinity of sulphate towards solution phase at lower concentration whereas at higher concentration, its affinity was more for solid phase. The Freundlich model was found to be best in describing the sulphate adsorption followed by the Temkin model. The results indicated that the Freundlich adsorption equations were the best fit for the sulphate adsorption and the R^2 values varied from 0.84^{xx} to 0.96^{xx}. Similarly, Hasan *et al* (1970) and Singh (1984) found the Freundlich equation to be best suited for describing the sulphate adsorption at low concentration. The adsorption parameters are worked out from Freundlich adsorption equations are presented in table 4. The adsorption parameters $1/n$ and K values ranged from 0.397 to 0.739 and 1.012 to 1.400, respectively. The constants n and K , however are empirical constants in the Freundlich adsorption equation and do not provide the basis of description of the reactions.

In case of Temkin adsorption isotherm R^2 values varied from 0.58^{xx} to 0.79^{xx} (Table 5). The values of R^2 in Temkin adsorption isotherms are comparatively lower than those of Freundlich adsorption isotherm confirming the best fit of later model. These adsorption isotherms varied from 51.27 to 83.05 and 21.70 to 32.66 respectively.

REFERENCES

1. Freundlich, H. (1926) Colloid and capillary chemistry. Translated from the third German edition by H. Staffor, Hatfield, Method and Co., Ltd., London.
2. Hasan, S.M., Fox, R.L. and Boyd, C.C. (1970) Solubility and availability of sorbed sulphate and Hawai in soils. *Soil Sci. Am. Proc.*, **34** : 897-902.
3. Parfitt, R.L. and Smart, R.S.C. (1978) The mechanism of sulphate adsorption on iron oxides. *Soil Sci. Soc. Am. J.*, **42** : 48-50.
4. Singh, B.R. (1984) Sulphate sorption by acid forest soils : 2. Sulphate adsorption isotherms with and without organic matter and oxides of aluminium and iron. *Soil Sci.*, **138** : 294-297.

Table 1 Equilibrium S concentration (mg/l) and percentage of S adsorbed at different period of shaking for 10 ppm concentration

Soil no.	2hrs	4hrs	8hrs	16hrs	24hrs
1	9.6 (4)	9.4 (4)	9.0 (10)	8.24 (17.5)	7.24 (27.5)
2	9.4 (5.5)	9.4 (4)	9.02 (9.5)	8.22 (17.5)	7.1 (29)
3	9.7 (3)	9.2 (8)	9.3 (7)	7.74 (22.5)	7.24 (26)
4	9.2 (7.5)	9.3 (7)	9.1 (9)	8.14 (18.5)	6.94 (30.5)
5	9.2 (7.5)	9.5 (5)	8.94 (10.5)	7.9 (21)	7.4 (26)
9	9.2 (7.5)	9.4 (6)	8.91 (10.5)	7.7 (23)	6.2 (40.5)
10	9.2 (7.5)	8.9 (11)	8.94 (10.5)	7.76 (22.5)	5.8 (42)
12	9.0 (10)	9.2 (7.5)	9.1 (8)	7.7 (23)	7.24 (27)
18	9.6 (4)	9.3 (7)	9.9 (1)	7.4 (25.5)	8.02 (19.5)
19	9.6 (4)	9.5 (5)	9.7 (3)	7.5 (25)	8.24 (18.5)

Figure in parentheses shows percentage adsorbed

Table 2 Equilibrium S concentration(mg/l) and percentage of S adsorbed at different period of shaking for 20 ppm concentration

Soil no.	2hrs	4hrs	8hrs	16hrs	24hrs
1	18.59 (7.05)	16.65 (16.75)	19.1 (4.5)	16.65 (4.5)	14.8 (26.00)
2	18.15 (9.25)	18.25 (8.75)	19.6 (2.00)	15.35 (23.25)	16.8 (15.75)
3	18 (1.00)	17.35 (13.25)	19.95 (0.25)	15.5 (22.50)	15.75 (21.25)
4	17.35 (13.25)	12.45 (37.25)	18.3 (8.5)	15.95 (20.25)	18.5 (7.50)
5	16.55 (17.25)	12.55 (37.25)	16.8 (15.75)	18.0 (1.00)	15.05 (24.75)
9	16.95 (17.75)	16.85 (15.75)	16.2 (19.00)	17.75 (11.25)	15.5 (22.00)
10	16.45 (17.75)	14.4 (28.00)	15.5 (22.50)	18.8 (6.00)	15.6 (21.00)
12	15 (25.00)	13.1 (34.50)	16.3 (18.5)	16.4 (18.00)	17.5 (11.00)
18	17.6 (12.00)	14.45 (28.00)	15.85 (20.75)	16 (20.00)	15.75 (21.25)
19	16.95 (15.25)	13.25 (33.75)	17.75 (11.25)	15.9 (20.50)	16.15 (18.9)

Figure in parentheses shows percentage adsorbed

Table 3 Equilibrium S concentration (mg/l) and percentage of S adsorbed at different period of shaking for 30 ppm concentration

Soil no.	2hrs	4hrs	8hrs	16hrs	24hrs
1	25.4 (15.33)	28.95 (3.50)	29.5 (1.66)	26.7 (11.00)	24.6 (18.00)
2	23.95 (20.16)	28.3 (5.66)	27.8 (7.33)	27.4 (8.66)	27 (10.00)
3	22.35 (7.65)	27.15 (9.50)	28.85 (3.83)	26 (13.33)	24.25 (19.16)
4	24.85 (17.16)	25.85 (13.83)	28.2 (6.00)	21.95 (26.83)	22.6 (24.66)
5	27 (10.00)	27.1 (9.66)	24.85 (17.16)	25.15 (16.16)	23 (23.33)
7	26.8 (10.66)	26.85 (10.50)	28.2 (6.00)	27.05 (9.83)	22 (26.66)
9	24.45 (18.50)	27.65 (7.83)	24.85 (17.16)	20.15 (32.83)	24.6 (18.00)
10	26.6 (11.33)	27.7 (7.66)	25.95 (6.00)	25.9 (13.66)	25 (16.66)
12	23.25 (22.50)	26.9 (10.33)	24.4 (18.66)	26.8 (10.66)	23.7 (21.00)
18	28.6 (4.66)	25.25 (15.83)	26.8 (10.66)	26.75 (10.83)	21.9 (27.00)
19	29.6 (1.33)	27.7 (7.66)	28.6 (4.66)	26.5 (11.66)	20.5 (31.66)

Figure in parentheses shows percentage adsorbed

Table:4 Adsorption parameter and regression equation of sulphur for different soils in Freundlich isotherm model

Soil no.	1/n	K	Regression eqn.	R ²
1	0.609	1.076	Y=0.609x + 0.8371	0.94
2	0.678	1.240	Y= 0.648x +0.7857	0.94
3	0.739	1.400	Y= 0.739x + 0.67	0.96
4	0.592	1.200	Y= 0.5926x + 0.8187	0.93
5	0.610	1.320	Y= 0.6145 + 0.7226	0.91
9	0.611	1.281	Y= 0.6114x+0.7547	0.88
10	0.527	1.012	Y=0.5278x+0.9863	0.84
12	0.397	1.017	Y= 0.3976x+0.983	0.851
18	0.570	1.119	Y=0.5739x+0.8263	0.93
19	0.550	1.181	Y=0.556x+0.8343	0.95

Table:5 Adsorption parameter and regression equation of sulphur for different soils in Temkin adsorption model

Soil no.	K ₁	K ₂	Regression equation	R ²
1	-59.43	25.67	Y = 25.67 x - 59.43	0.72
2	-55.21	23.39	Y= 23.39 x - 55.21	0.63
3	-53.48	23.05	Y= 23.055 x - 53.48	0.69
4	-78.65	31.05	Y= 31.109 x - 78.65	0.79
5	-56.16	23.67	Y= 23.67 x - 56.12	0.72
9	-51.44	21.70	Y= 21.705 x - 51.44	0.72
10	-51.27	23.75	Y= 23.75 x - 51.27	0.58
12	-83.05	32.66	Y= 32.66 x - 83.05	0.65
18	-58.72	23.59	Y= 23.59 x - 58.72	0.67
19	-60.32	24.28	Y= 24.28 x - 60.32	0.77

CITATION OF THIS ARTICLE

Brajandra, L. M. Shukla, N. Sailaja · MBB Prasad Babu and Sumanth Kumar, VV. Sulphur Retention and Release in Alfisols and Ultisols of Jharkhand .Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue2, 2017: 56-59