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Zinc Adsorption in Relation to Soil Properties, Analysed with Langmuir and Freundlich Models in Soils of Kashmir Valley

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Abstract

The phenomenon of fixation of added zinc in soils considerably affects the availability and efficiency of applied zinc. Pertaining to this situation, different land-use soil samples across the valley were analysed for various physico - chemical properties and adsorption capacities. The results showed that the soils were slightly acidic to alkaline in reaction and differ far and wide in other soil properties. Cation exchange capacity (CEC) of the soils showed little variation between the samples and varied from 13.3 to 17.2 cmol (p^+) kg^{-1} with an average value of 15.1 cmol (p^+) $kg^{-1}$of soil. The maximum of zinc adsorption were greatly influenced by soil organic matter, clay content and CEC of the soils. The data was fitted to Langmuir and Freundlich equations and the results yielded that the Freundlich equation showed better fit to the sorption data at higher zinc concentrations. However, both the models were having satisfactory results for the obtained data.

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Introduction

Zinc (Zn) is essential for the normal growth and development of plants however its content in soils is low compared with that of other essential nutrient elements.[1] The deficiency of zinc is more common in calcareous than in non-calcareous soils, and its deficiency is having a profound economic impact in terms of yield loss.[2] Various factors including pH,[3] ionic strength as well as clay mineralogy have been shown to affect Zn availability[4] however, zinc accessibility is likewise directed by adsorption-desorption procedures and its parcelling between the arrangement and strong phases.[5] Most examinations on Zn sorption and desorption by soils have been founded on balance conditions. Be that as it may, because of moderate compound responses, plant

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take - up, manure expansion and different variables, horticultural soils are once in a while in a balance state concerning Zn sorption and discharge. Adsorption isotherms can be utilized to depict the equilibrium connection between the measures of adsorbed and broke down species at a given temperature[6] which considers force, amount and limit factors that are essential for anticipating the measure of soil supplement required for most extreme plant development.

Materials and Methods

Ten Surface soil samples (0-25 cm) were collected from the major agricultural based land uses (paddy, apple, maize, saffron and vegetables) of Kashmir based upon location, elevation, soil complexion, texture and vegetation (Table-1) using Global Positioning System (GPS). Soil was analysed for various physico-chemical properties *viz.* soil reaction (pH), electrical conductivity (EC), organic carbon (OC), calcium carbonate ($CaCO_3$) content, cation exchange capacity (CEC), and particle size distribution (Figure-1) by following standard laboratory protocols. For Zn adsorption, 2.5 g of processed soil samples in triplicate were equilibrated with 20 mL of 0.01 M KNO_3 containing 0, 5, 10, 20, 40, 60, 80, 100, 150, 200 and 250 mg ml^{-1} of Zn as $Zn(NO_3)_2$ for 24 hours at room temperature (25 ±

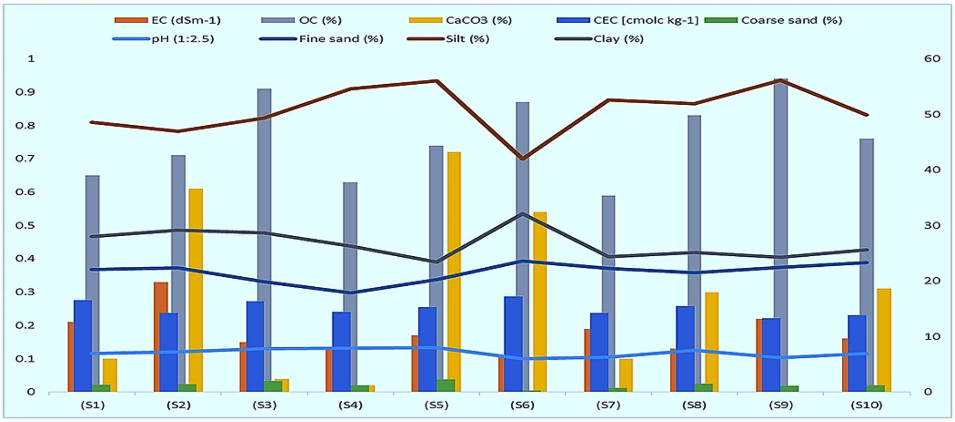

Fig. 1: Physico-chemical characteristics of different soils of Kashmir

Table 2 : Coefficients of zinc adsorption by different soils

	Langmuir coefficients				Freundlich coefficients		
Soils	b (µg Zn g^{-1})	K (ml ug^{-1})	R^2	Soils	1/n	k (µg g^{-1})	R^2
S_1	52.631	0.025	0.959	S_1	0.499	3.467	0.984
S_2	52.631	0.018	0.959	S_2	0.572	2.223	0.983
S_3	55.555	0.027	0.966	S_3	0.511	3.556	0.98
S_4	52.631	0.019	0.953	S_4	0.561	2.376	0.979
S_5	41.666	0.035	0.986	S_5	0.489	3.228	0.966
S_6	76.923	0.015	0.965	S_6	0.634	2.36	0.984
S_7	55.555	0.018	0.904	S_7	0.552	2.558	0.981
S_8	55.555	0.022	0.896	S_8	0.506	3.388	0.98
S_9	45.454	0.018	0.887	S_9	0.51	2.546	0.982
S_{10}	45.454	0.037	0.988	S_{10}	0.497	3.499	0.952

1°C). After equilibration samples were centrifuged at 2500 rpm for 15 minutes and filtered. The Zn concentration in filtrate was determined by atomic absorption spectrophotometer.[7] The amount of

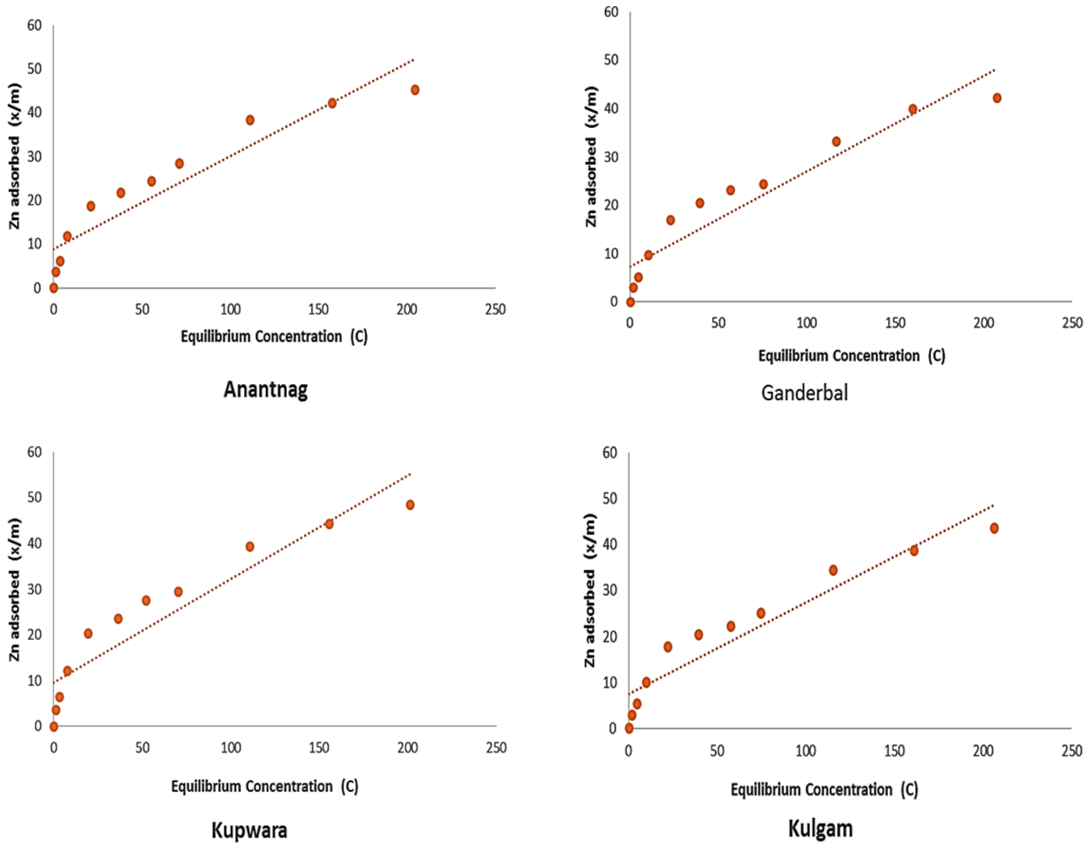

Fig. 3: Adsorption isotherms obtained for different soils of Kashmir

Table 1: Classification and location of soil samples

Sample Code	District	Latitude	Longitude	Elevation (m amsl)	Land use
S_1	Anantnag	33°45'5.26"	75°11'38.63"	1623	Paddy
S_2	Ganderbal	34°15'31.57"	75° 5'43.49"	2115	Maize
S_3	Kupwara	34°23'54.89"	74°21'28.37"	1593	Paddy
S_4	Kulgam	33°39'0.54"	75° 0'17.09"	1763	Paddy
S_5	Shopian	33°42'33.85"	74°49'33.19"	2088	Apple
S_6	Baramulla	34° 4'3.03"	74°25'56.07"	2107	Apple
S_7	Bandipora	34°11'34.43"	74°39'57.70"	1582	Maize
S_8	Pulwama	33°57'0.22"	75° 7'43.68"	1791	Saffron
S_9	Budgam	34° 2'9.90"	74°32'51.84"	1806	Vegetable
S_{10}	Srinagar	34° 9'49.99"	74°51'35.52"	1586	Vegetable

adsorbed Zn was calculated from the difference in the initial and final Zn concentrations taking into account the amount of Zn present in supernatant solution in no Zn treatment. The experimental results were fitted to Langmuir and Freundlich equations.

- Langmuir equation: C/(x/m) = 1/b (C) + 1/b K
- Freundlich equation: Log (x/m) = l/n Log C + Log K

Where, C= equilibrium concentration, x/m = adsorbed Zn, b = adsorption maxima, k = a constant related to

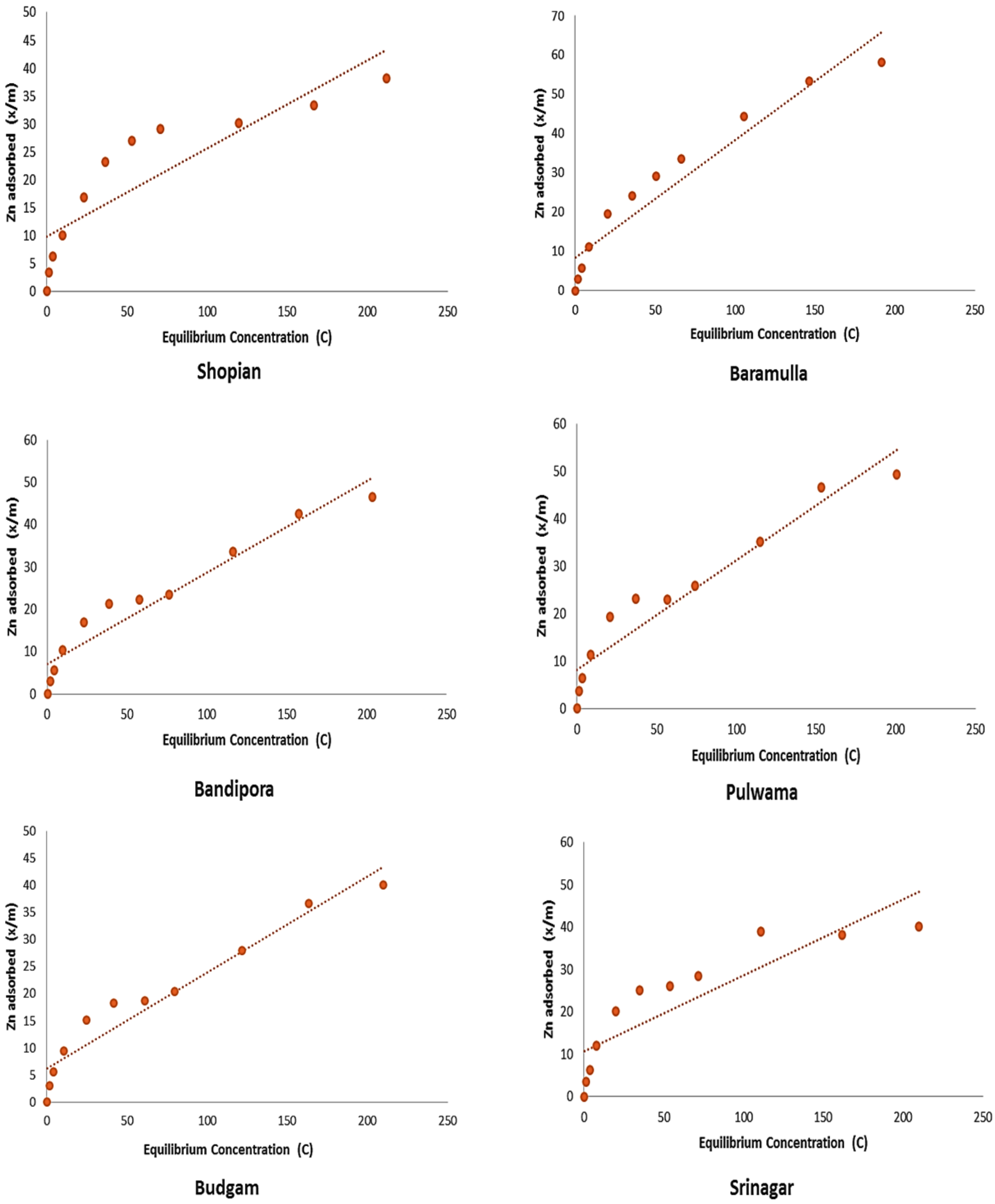

Fig. 3: Adsorption isotherms obtained for different soils of Kashmir

bonding energy, l/n = slope of the regression line, K and n = empirical constants

Statistical analysis was done by standard statistical procedures. The least square regression equation was used for modelling. Value of coefficient of determination (R^2) was chosen as the criteria of goodness of fit. The model/equation with highest value of coefficient of determination (R^2) was chosen as the best in describing the zinc adsorption behaviour of soil.

Result and Discussion

Physico-Chemical Characteristics

The detailed physical characteristics of the soils are represented in figure-2 which reveals that the sand, silt and clay content are in the range of 18.20 to 25.90, 41.97 to 56.10 and 23.40 percent with mean value of 22.76, 50.80 and 26.71 percent, respectively. In general, the soils were slightly acidic to alkaline in reaction with the pH variation from 5.98 to 8.01. EC of the soils showed non-saline nature and ranged between 0.11 to 0.33 dSm-1. The organic carbon content of these soils showed a conspicuous variation and ranged from 0.59 to 0.94 percent with a mean value of 0.76 percent. The higher values in soils may be due to the continuous organic manuring, addition through vegetation and low mineralization rates in these soils.[8] Cation exchange capacity of the soils showed little variation between the samples and varied from13.30 to 17.21 cmol(p^+) kg^{-1} with an average value of 15.08 cmol(p^+) kg^{-1} of soil. The calcium carbonate content was present in meagre amounts in most of the soils with values ranging from 0.00 (S_9) to a maximum value of 0.72 percent (S_5) with a mean value of 0.27 percent in the soil.

Adsorption of Zinc by Soils

The aftereffects of zinc adsorption by the soils under examination obviously demonstrated that every one of the soil have proclivity for zinc adsorption. The measure of zinc adsorbed for every one of the soils was plotted against the equilibrium zinc concentration to get the adsorption isotherms (Figure-3), demonstrating the impact of zinc focus on zinc adsorption. The adsorption isotherm demonstrated that however the adsorption of zinc expanded with expanding focus in the balance arrangement, yet the level of adsorbed zinc diminished. This might be a direct result of an expansion in the proportion of adsorbate to adsorbent.[9] The adsorption isotherms were L-shaped and showed that more destinations in the substrate were occupied[10] and in this way the solute atoms confronted extraordinary trouble to locate any empty site accessible. This prompts a proposal that either the adsorbed atom was not vertically situated or that there is no solid challenge from the solvent.[11] The information on zinc adsorption by various soils demonstrated that the adsorption limit of various soils for zinc was extraordinary and the conduct of adsorption of zinc by various soils was not uniform in the entire focus run. Adsorption of zinc was observed to be most extreme in soils of Baramulla locale and this might be credited to the high soil substance and CEC of the soil. The soils of Shopian locale demonstrated least adsorption limit of zinc which is likely because of coarse surface and low CEC.[12] From these outcomes, it could be inferred that adsorption of zinc was principally represented by soil substance and CEC of the soils which was affirmed factually since these soils demonstrated positive and critical connection with clay content (r = 0.884**) and CEC (r = 0.697**).

Langmuir adsorption isotherm was fitted to the information where a plot of C/(x/m) versus C gave a straight line with incline 1 / b and a block of 1 / kb. The adsorption maxima (b) esteem went from 41.66 to 76.92 µg Zn g^{-1} soil (Table-2). Most extreme value was found for the soils of Baramulla locale and least for Shopian region. The bonding energy constant (k) was most extreme (0.0378 ml g^{-1}) in soils of Srinagar region and least of 0.018 ml g^{-1} in soils of Ganderbal locale.

The plot of zinc adsorbed against balance zinc focus on a log-log scale gave direct relationship in every one of the soils for Freundlich adsorption show. Freundlich k esteems extended broadly among soils, going from 2.22 to 3.55 µg g^{-1} (Table - 2). This model was substantial for more extensive scope of zinc concentrations[13] as at higher groupings of connected zinc, multilayer adsorption and additionally precipitation responses seems to have occurred.[14] In this way this came about a superior occurrence of information in Freundlich isotherms as contrast with Langmuir models.

Conclusion

Zinc adsorption information was tastefully portrayed by both Langmuir and Freundlich adsorption isotherms over the whole focuses utilized however Freundlich isotherms gave a best fit. Adsorption of zinc was principally represented by the clay content and CEC of soils. An endeavour was made in this examination to know the best fit numerical model to comprehend procedure of zinc adsorption which thusly can helps in advancing appropriate administration practices to defeat weaknesses of zinc in soils. Further research should be done to check the conduct of zinc discharge and alleviation to any issue emerging from abundance zinc adsorption process.

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Conflict of Interest

Authors declare no conflict of interest.

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