Adsorption and Desorption of zinc in soil and its implication

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Zn availability mostly regulated through adsorption-desorption on soil (or adsorbent). Fly ash (FA) application influence on zinc adsorption-desorption in recommended chemical fertilizer (RDF) and farmyard manure (FYM) treatments of acidic Inceptisols of Assam. Zinc adsorption was better explained by Freundlich over the Langmuir adsorption equation. Adsorption was greatest in the treatment receiving FA only at 15 t ha\(^{-1}\) and least in the treatment receiving RDF 50 percent + FYM 5 t ha\(^{-1}\) + FA 5 t ha\(^{-1}\). Ni and Zn co-sorption to aluminium oxides (\(\gamma\)-Al\(_2\)O\(_3\)) in binary-sorbate systems were compared to their sorptionin single-sorbate systems as a function of pH using both macroscopic batch experiments and synchrotron-based X-ray absorption fine structure spectroscopy. At pH 6.0, Ni and Zn were sorbed as inner-sphere surface complexes and competed for the limited number of reactive sites on \(\gamma\)-Al\(_2\)O\(_3\). In binary-sorbate systems, Ni had no effect on Zn sorption, owning to its lower affinity for the metal oxide surface. In contrast, Zn had a higher affinity for the metal oxide surface and reduced Ni sorption. The influence of P on the Zn adsorption capacity of eight surface horizons in soils on granite and amphibolites materials. The presence of P, especially at high concentrations, was found to boost Zn adsorption. The effect was more marked in the soils on amphibolite, which contained increased concentrations of Fe and Al oxides relative to those on granite. The increased adsorption of zinc by effect of the presence of phosphate is ascribed primarily to the formation of a P–Zn complex in colloid surfaces. Studies should be undertaken while considering adsorption and desorption capacities of Zn for soils as well as ionic interactions for better Zn management in soils.

KEYWORDS
Adsortion, Desorption, Hysteresis, Mechanistic Model, Speciation

HOW TO CITE THIS ARTICLE

 Mostly discover yet 17 essential nutrients for the plants to their growth, Zinc is an essential micronutrient out of total. Indian soils are mostly show the Zn deficiency to the crop plants, deficiency show mostly in maize, rice, cotton, etc. Zinc applying to soil as various types of organic and inorganic materials, manure/ compost and fertilizers respectively but availabilities is depended on various type of physical, comical as well as biological properties of soil. In a complex system such as the soil, especially those contaminated by heavy metals, chemical and also mineralogical properties regulate the speciation, mobility and bioavailability of these contaminants (Covelo et al., 2004). Generally, Zn concentration range of non-contaminated soils varies from 10 to 300 mg kg\(^{-1}\) soil (Ohnesorge and Wilhelm, 1991). This form of Zn consist as mineral form, organic form and little quantity in solution, first and second forms are not available to crop plants as solution form. In this situation, recommended the use of chemical fertilizers and Zn availability mostly depended on pH, O.M., temperature, texture, surface area and oxides/hydroxides of Al and Fe etc. The pH is major factor that governs adsorption of the heavy metal and its availability, due to shift in the metal species in solution and to the net charge in adsorption surface (McBride and Blasiak, 1979, Kuo and Baker, 1980, Harter, 1983, Machado and Pavan, 1987, Casagrande et al., 2004).
Adsorption of the Zn to soil surface increases with increasing in pH, initial concentration of Zn in solution, oxide / hydroxides of Fe and Al, specific surface area etc. Colloidal constituents, common of soils with variable charges, such as kaolinite, Fe, and Al oxo (hydro) oxides have been indicated as the apparatus dependable for the chemical behavior of Zn in this medium (Duker et al., 1995). The calcareous soils of Bihar occupying a sizeable area are deficient in zinc to the extent of up-to 80 per cent of tested soil samples and Symptoms of Zinc deficiency are frequently observed on many crops. The sorption isotherms of Zn\textsuperscript{2+} on the untreated soils and the treated soils to eliminate CaCO\textsubscript{3}, organic matters and oxides were respectively determined, the results of the sequential extraction of Zn sorbed on the calcareous soil were reported and it was concluded that at a high pH range the contribution of CaCO\textsubscript{3} on Zn sorption was near about 70% of the total amount sorbed by a yellow fluvo-aquic soil (content of CaCO\textsubscript{3}, 12.4%) and at low pH the contribution became less significant (Tessier, Campbell and Bisson, 1979). FYM alone or conjoint with green gram and ZnSO\textsubscript{4} treatments varied from 69.95 to 88.01% at 15\degree C temperature whereas, 72.94 to 89.75% at 30\degree C temperature. The maximum amount of Zn adsorbed (3468.20 mg kg\textsuperscript{-1}) was noted at 30\degree C temperature which may be due to the fact that free energy of zinc adsorption becomes increasingly negative with increase in temperature (Adhikari and Rattan, 2002 and Kamini et al., 2015).

The superior values of ‘K’(adsorbability) in green manuring as well as FYM, treatment as compare to control and ZnSO\textsubscript{4} application showed superior adsorbability of the compound in surface with a minute Zn-concentration (Kumar, 2017). The kinetics of Zn release may be controlled by the combined effects of Zn desorption/re-adsorption reactions and varying Zn speciation in soil, and it requires a comprehensive understanding on the dynamic Zn speciation in soil. The adsorption of Zn from aqueous solution by hydrated aluminum oxide (Al\textsubscript{2}O\textsubscript{3}) and iron oxide (Fe\textsubscript{2}O\textsubscript{3}) was highly pH dependent and increased markedly with increasing pH. Fe\textsubscript{2}O\textsubscript{3} had greater Zn adsorption capacity, at equivalent pH values, than Al\textsubscript{2}O\textsubscript{3} (Kalbasi, Racz, and Loewen-Rudgers, 1978). Fly ash (FA), the inorganic residue from the ignition of powdered coal, is a waste material produced in large quantity has already been recognized as a potential source for rising the availability of mineral nutrients for plant growth (Mitra et al., 2005, Lee et al., 2007, Pandey and Singh, 2010). Fly ash having more content of organic carbon than soil can enhance soil microbial activities nutrient availability, and plant productivity, In combined with various type of manures (Lee et al., 2006, Jalaand Goyal, 2006, Pandey and Singh, 2010). Fly ash provide the high specific surface area and oxide and hydroxides of Al and Fe to adsorption of Zn. High P concentration reduced the availability of Zn, The occurrence of phosphate can either increase (McBride, 1985, Thakur et al., 2006) or decrease (Clark and McBride, 1984) the mobility of metal ions. For example, phosphate increases or reduces the mobility of Zn in acid soils depending on whether it raises or lowers their pH (Barrow, 1987). Zn can hold backthe Ni sorption onto montmorillonite (Bradbury and Baeyens, 2005) while another the coexisting Cu and Cr could suppress Zn sorption by 62% (Flogae et al., 2007). Ni and Zn could form a mixed Ni and Zn precipitates in the form of layered double hydroxide (LDH) during sorption onto soils at pH 7.4 by Using EXAFS (Voegelin and Kretzschmar, 2005).

In dissimilarity, Enlarge X-ray absorption fine structure spectroscopy (EXAFS) is a cutting-edge technique to find out atomic-scale sorption mechanisms of trace metals in single-sorbate systems (Scheidegger et al., 1996, Scheidegger 1997, Ford and Sparks 2000, Lee et al., 2004) providing local structural information (typically within 5 Å) such as coordination number, (Bond length) bond distances (Lombi and Susini, 2009). Soil organic matter (SOM), metal (hydro) oxides, and clay minerals are among those most hasty soil components responsible for Zn partition between soil and solution, and SOM has been considered as the most important soil component controlling soil Zn speciation (Gustafsson et al., 2003, Tipping et al., 2003, Duffier et al., 2014). This review will supporting in Zn management to Indian soils, because those soils have mostly Zn deficiency.

**Adsorption**

Is a phenomena in which adsorbates (atoms or molecules or ions) are adsorbed or bind to adsorbent (Soil particles or solid surface) from the soil solution by chemical or physical binding is
mostly control the availability of Zn to plants from the soil solution or soil environment.

**Desorption**

In which adsorbates are live to surrounding or soil solution from adsorbent or solid surface, reverse of adsorption, is also control the Zn availability to plants.

**Hysteresis**

It is generally observed that the ions which are adsorbed by a colloidal surface by ionic interaction, through non-specific retention mechanisms, are desorbed during desorption cycle by the expenditure of the same amount of energy as was released during the adsorption pathway. The specific Zn adsorption leads to irreversibility of the adsorption and desorption processes, depending on the nature of soil colloids and ions concerned. The hysteresis effect in Zn\(^{2+}\) ionic adsorption-desorption processes depends not only on the clay minerals but also on the state of weathering of minerals. The more weathered minerals (Alfisol, Oxisol) will be less to the extent of hysteresis, as compared to that in the soil more recent origin (Inceptisol, Entisol).

**Factors Influence the Adsorption-Desorption of Zn**

**pH**

pH is mostly control the Zinc availability by the adsorption-Desorption processes. Commonly it is observed that Zn adsorption increases with increase in pH (varying from 20 to 90 % adsorption investigated in a small pH interval from 4 to 6). Casagrande et al. (2008) were study that Zn adsorption increases with pH in case of surface soil and subsoil of Anionic “Xanthic” Acrudox (XA), Anionic “Rhodic” Acrudox (RA) and Rhodic Hapludalf (RH), Rhodic Hapludalf soil having more Zn adsorption about 80 % at pH 4.5 in case of surface soil but in case of subsoil 50 % of adsorption at pH 3.5, because result of the appearance of permanent charge did not depended on the pH variation but there is some amount of Zn adsorption in low pH due to manifestation of permanent charge and adsorption below ZPSE (zero point of salt effect), is the pH value at which the magnitude of the variable surface charge is not changed due to variation in the ionic concentration of the soil solution) due to specific adsorption mechanisms specially in case of oxisol soils (Kuo and baker, 1980). At highly weathered soils there is 100% metal adsorption above pH 6 because value of 1st Zn hydrolysis constant (pKa1) is around 9. In case of subsoils around 20% of Zn was adsorbed instantly at pH 3 in every one of the subsoil samples. Soil pH is the main factor that determines Zn adsorption, because it is related to the hydrolysis constant of the metal ions (Harter, 1983, Covelo et al., 2004). Casagrande et al. (2004) were achieved that at the highest pH values, the occurrence of the ZnOH\(^+\) species was advised, whereas the Zn (OH)\(^2\) species was considered of limited occurrence. The ZnOH\(^+\) species concentration increase ten time with increase in one unit of pH and, since ZnOH\(^+\) act as a monovalent ion, the energetic barrier that must be overcome, when it comes closer to the surface of the particle, is smaller than in the case of the Zn\(^{2+}\) ion. Moreover, the quantity of adsorption sites with greater affinity for Zn increase with the rise in pH. Gou et al. (2018) reported that the adsorption versus precipitation of Ni and Zn to γ-Al₂O₃ are chiefly affected by pH values. Inner-sphere adsorption of Ni and Al appears to dominate at pH 6 and as pH increases the major species become LDH and LTH precipitates.

**Co-sorption of Ni and Zn in Binary Sorbate Systems at pH 7.5**

Ni and Zn sorption kinetics in a binary-sorbate system with that in a single-sorbate system at pH 7.5. Similar to the sorption kinetics in the single sorbate system, Ni and Zn sorption continuously increase with time in the binary-sorbate system. There is also a similar two-phase sorption trend, with an initially rapid sorption period followed by a slower sorption period. Ni and Zn adsorption almost overlap in binary system (Ni-Zn-Al or Zn-Ni-Al), did not exhibit a measurable competitive sorption influence on each other in binary-sorbate systems at pH 7.5.

**Co-sorption of Ni and Zn at pH 6.0**

At pH 6.0, after reacting of a sample for 48 hours was collected to compare with its sorption behaviours, approximately 6.4% of the initial Zn removal from solution or outer sphere in single-sorbate system, resulting in a surface density of 0.25 \(\mu\text{mol m}^{-2}\); in disparity, 6.2% (0.24 \(\mu\text{mol m}^{-2}\)) of the
initial Zn removal in binary-sorbate system. This means no difference is found for Zn sorption between the single and binary-sorbate systems, which proposes that coexisting aqueous Ni cations have no measureable effect on Zn sorption. Contrarily, the presence of Zn reduces Ni sorption from a surface density of 0.22 μmol m$^{-2}$ in single system to 0.17 μmolm$^{-2}$ in the binary-sorbate systems, indicating that coexisting aqueous Zn cations can have an inhibitory influence on Ni sorption by 22.7%.

**XANES analyses for Ni and Zn sorption at pH 6.0**

All normalized Ni and Zn K-edge XANES spectra of the sorption samples and model compounds are presented in Fig. (5). Figure 5a parallels the normalized Ni XANES spectra of the sorption sample (Ni Alox and Ni + Zn Alox) to those of Ni−Al LDH, Ni−Zn−Al LTH, and the aqueous Ni in solution. This comparison revealed that surface precipitates as Ni-rich LDH are not a dominant species during Ni sorption at pH 6.0 in the single sorbent system that the mechanism of Ni sorption at pH 6.0 neither out sphere surface complexion nor co-precipitation but rather inner-sphere surface complexion. This split is more pronounced in the binary Ni + Zn Alox sorption sample than in the single metal Ni Alox sorption sample and the LDH/LTH standards. The large split in Ni + Zn Alox at about 8400 eV indicates Ni is bound either as an inner sphere surface complex or completely incorporated into the octahedral layer of a gibbsite-like sheet.

Either way there is a low amount of transition metal as second nearest neighbors, indicating that no LDH/LTH surface precipitate has formed. This split commonly occurs when a heavier transition metal is surrounded by a lighter element, such as Al, in an octahedral sheet. However, as heavier atoms, such as Ni and Zn, begin to populate the second shell (as would occur in an LDH or LTH type phase), the split begins to disappear a shoulder is seen in previous studies, which suggests the central Zn atom is present in tetrahedral environment, surrounded by four oxygen atoms, corresponding to a typical inner-sphere complexes. The differences between the spectra of the Alox sorption samples and the LDH/LTH precipitates indicate that at pH 6 the principle sorption species are not surface precipitates. Thus, adsorption as inner-sphere surface complexes would to the best extent explain the main mechanism Ni and Zn retention to γ-Al2O3 at pH 6.0. Figure 6b shows the normalized Zn K-edge XANES of sorption samples at pH 6.0 along with the Zn−Al LDH, Ni−Zn−Al LTH, and aqueous Zn cation standards. Different features are observed between the sorption samples and model compounds. For example, the deficiency of the peak intensity at ~ 9686 eV in the sorption samples (dashed black line) versus the solid phase LDH/LTH precipitates implies changes of Zn coordination from octahedral to tetrahedral, and suggested that the sorption mechanisms may not be surface precipitation. In addition, there is a distinct shoulder at ~ 9675 eV (dashed red line), which is absent in the spectrum of Zn− Al LDH, Ni−Zn−Al LTH, and aqueous Zn solution.

**Bonding Structures of Zn Sorption Products as Revealed from EXAFS Spectroscopy**

The normalized, background subtracted and k3-weighted EXAFS spectra of Zn sorbed on γ-Al2O3 at pH values of 6.0–6.5 and/or Zn initial concentrations of 0.1−0.2 mM. Surface coverage from these experiments is in the range of 0.2 to 0.8 μmol m$^{-2}$. The spectra of reference compounds such as Zn (NO$_3$)$_2$ solution and synthetic crystalline Zn−Al layered double hydroxide (LDH) are also shown for comparison. The EXAFS spectra (Figure 6b) of all Zn-sorbed samples and Zn (NO$_3$)$_2$ solution display only one notable shell at 1.5 Å in Fourier transformed spectra, obviously differing from the Zn−Al LDH, which exhibits a second peak at r of 2.4 Å. Additionally, the oscillations in k3-weighted $\chi$ spectra of these Zn sorbed samples differ from those of the Zn (NO$_3$)$_2$ solution. These features suggest that the local structure of the sorbed Zn is different from that of aqueous Zn (NO$_3$)$_2$ and Zn−Al LDH, thus excluding the formation of both outer-sphere surface complexes and surface precipitates.

**Surface Area**

Das and Das, 2015 were reported that Zn adsorption increased with increasing concentration of added Zn for each of the treatments. Regardless of the first added Zn concentration, Zn adsorption by the soils treated with FA 15 t ha$^{-1}$ was the greatest, and the least was recorded in soil receiving treatment RDF 50 percent + FYM 5 t ha$^{-1}$+ FA 5 t
These increases in Zn adsorption due to FA application may be attributed to its having free sesquioxide content. The hydrous and oxide of silica, aluminum, and iron in the surface of FA can form complexes with metal ions by chemical bonding. Yu et al. (2002), Ciccu et al. (2003) and Tsadilas et al. (2009) stated that fly ash may increase the surface area that provided sites to element adsorption, increase pH of acidic soils, and render most cationic metals less mobile. It is remarkable to mention here that application of FA has increased soil pH considerably under field condition from pH 4.3 to a maximum of 6.01. Stevenson (1994) and Borkotoki and Das (2007) have also been reported that organic matter reduced the reactivity of adsorbent by forming coatings on adsorbent surfaces and thereby reduced adsorption.

The effect was found to be conspicuous in the current study where treatment involving of FYM caused in lower amount of Zn adsorption. This deviation possibly resulted in an increase in the water soluble organo-Zn-complexes in soil, showing thereby a miserable effect of FYM on Zn adsorption (Deka and Poonia, 2000). Many workers, nonetheless, described the complex nature of Zn–organic matter association and specified that it is challenging to differentiate the effects of organic matter because this property is often related to pH and organic-matter composition tends to vary across soil (McBride and Blasiak 1979, Tsadilas et al., 2009). Hydrous oxides show important role in heavy-metal holding or adsorption by soils.

Shuman (1977) reported that amorphous hydrous oxides had Zn adsorption capacity 10 folds more than gel-hydrous oxides equivalent to crystalline hydrous oxide but another hand (Gadde and Laitinen, 1974) established that no difference in the adsorption capacity of crystalline and non-crystalline Fe and Al oxides for heavy metals but Das and Das (2015) were reported that Zinc adsorption was largely controlled by crystalline Fe and Al oxides rather than their amorphous forms. Saha, Taniguchi and Sakurai (2002) and Agbenin and Olojo (2004) they were stated that this possibly due to formation of metal hydroxide precipitation on the surface of silicate clay, largely kaolinite in the soil (Das, 1999) reported that kaolinite is the dominant clay mineral of these soils.

Soil Organic Matter (SOM)

Low soil pH might have inhibited the deprotonation of potential adsorbing/exchange site of soil organic matter to the extent of checking rise in Zn adsorption with increase in soil organic carbon content. Soil organic matter, clay and carbonates could be expected to render strong binding sites for Zn, wherefrom only chelating agent was able to desorb Zn. The desorption of strongly bound and complexed Zn in 0.005M DTPA (pH 7.3) revealed a significant and positive correlation with soil organic carbon (SOM), carbonate and clay contents, and specific surface area. Up to the present time, most studies investigating the impact of SOM on Zn biogeochemical cycling have chiefly focused on the relative involvement of dissolved organic matter and bulk soil organic matter on Zn mobility (Sauve et al., 2000, Fan et al., 2016, Boguta and Sokolowska, 2016). By difference, the specific role of the stable pool of SOM on Zn biogeochemical cycling residues poorly understood.

The stable isotopes of Zn provide the potential to better understand interactions between Zn and soil components, including metal oxides (Juillot et al., 2008, Balistrieri et al., 2008, Bryan et al., 2015, Pokrovsky et al., 2005) and organic matter (Jouvin et al., 2009, Gelabert et al., 2006, Kafantaris and Borrok, 2014, John and Conway, 2014). From the viewpoint of energy, the presence of SOM decreased the adsorption energies of Zn\(_{2}^{2+}\) to black soil particles through enhancing the binding strength between Zn\(_{2}^{2+}\) and soil particles. In addition, the results of Zn speciation in soil indicated that after SOM removal the proportion of non-specific adsorbed (outer-sphere). Zn increased and the content of Zn-HA decreased almost to zero. In other words, SOM-removal reduced the number of specific adsorption sites and created more Zn to be sorbed on the soil particles as outer-sphere Zn (soil solution Zn). The SOM coated on soil particles as chelator can immobilize Zn and reduce the bioavailability of Zn in soils.

Zn Adsorption in the Presence and Absence of Phosphate Ion

Zn has antagonistic interaction with phosphorus (P). The effect of P on Zn adsorption can be attributed both to P adsorbed on colloids and P in the soil solution. In the absence of P, Zn\(_{2}^{2+}\) was the predominant zinc species, actually, it is
Fig. 1. Isotherms of Zn adsorption (curves) and Zn adsorption reaction parameters (Adsm: maximum adsorption; KL: affinity constant), obtained from the fit of the Langmuir equation to the experimental results (points) for the Anionic “Xanthic” Acrudox (XA), Anionic “Rhodic” Acrudox (RA) and RhodicHapludalf (RH).

Fig. 2. Schematic illustration of the cosorption of Zn and Ni at γ-Al₂O₃ with pH

Fig. 3. Kinetics of Ni and Zn sorption onto γ-Al₂O₃ from 0.8 mM Ni or Zn solutions at pH 7.5. (a) Ni sorption onto γ-Al₂O₃ in the single-sorbate system; (b) Zn sorption onto γ-Al₂O₃ in the single-sorbate system; (c) Ni sorption onto γ-Al₂O₃ in the binary-sorbate system; (d) Zn sorption onto γ-Al₂O₃ in the binary-sorbate system.
Fig. 4. Ni (a) and Zn (b) sorption on γ-Al2O3 from 0.8 mM initial metal concentration solution at pH 6 and a constant ionic strength 0.1 M (NaNO₃) over entire reaction period (48 h) in single- and binary-sorbate systems.

Fig. 5. Ni K-edge XANES spectra of reacted samples after reaction of 48 h at pH 6.0 (a) and Zn K-edge XANES spectra of reacted samples at pH 6.0 (b). The spectra of Ni–Al LDH, Ni–Zn–Al LTH, Zn–Al LDH and Zn–Ni–Al LTH.

Fig. 6. Zn K-edge EXAFS spectra of Zn-sorbed samples and model compounds as: (a) k³ weighted functions and (b) the corresponding Fourier transform without phase shift correction. The experimental data are shown as colored solid lines, and the fitted data are shown as black solid lines. (c) Schematic diagram showing the relationship between Zn sorption mechanism and pH and initial Zn concentration ([Zn]ᵢ). [Dashed curves and shaded regions are assigned based on EXAFS spectroscopic analyses of different experimental products. “IS” refers to inner-sphere complexes. “LDH” refers to “layered double hydroxide”]
Table 1. Zinc speciation in the presence and absence of P as done with the speciation software MINTEQA2. Conditions: (A) no P added and 0.155 mM Zn; (B) P:Zn ratio 1:1 (155 μM P and 155 μM Zn); (C) P:Zn ratio 2:1 (310 μM P and 155 μM Zn); (D) P:Zn ratio 1:1 (1550 μM P and 1550 μM Zn); (E) P:Zn ratio 2:1 (3100 μM P and 1550 μM Zn).

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accounted for 98% of all added Zn, and ZnNO$_3^+$ for less than 2%, at both pH 4.5 and 5.0. With the concentration of 155 μM and a P:Zn mole ratio of 1:1, the Zn species in solution identified by the software were similar to those obtained in the absence of P.

This was also the case with a P:Zn ratio of 2:1 except for the presence of a very low proportion of a new species (ZnHPO$_4^-$) – particularly at pH 5.0, where it accounted for 0.2% of all Zn added. The situation was also similar at higher concentrations, but a new species ZnNO$_3^+$ (in addition to ZnHPO$_4^-$) was detected, the two in combination accounting for 2% of all Zn as a maximum. In opposition, the phosphate–zinc complex could be formed on adsorbing surfaces provided P was adsorbed before Zn and the latter reacted with adsorbed P to form the complex.

Simple Correlation Coefficients [r] between Soil Properties and Zn Adsorption-Desorption Parameters

The correlation coefficients between soil properties and mean per cent desorption of applied Zn in different desorbing agents showed that the desorption of weakly and specifically bound Zn in 0.05M Ca(NO$_3^-$)$_2$ and 0.1M Mg(NO$_3$)$_2$, respectively, was in reverse related to silt and carbonate contents and soil pH (Sinha et al., 1975, Tiller et al., 1972). A significant positive relationship between sand and weakly and specifically bound Zn, has been reported in Punjab soils (Sidhu et al., 1977). In this study the desorption of only weakly bound Zn showed a significant and positive correlation with sand content. The desorption of strongly bound and complexed Zn in 0.005M DTPA showed a significant and positive correlation with soil organic carbon, carbonate and clay contents, and specific surface area. Soil organic matter, clay and carbonates could be expected to render strong binding sites for Zn, where from only chelating agent was able to desorb Zn. Singh and Sekhon (1977) reported a similar relationship between DTPA extractable soil Zn and soil organic matter, clay, and carbonate content in Punjab soils. The desorption of Zn bound to minerals in 0.1M HC1 was significantly and positively correlated with clay, silt, and carbonate contents, soil pH, and specific surface area.
Conclusion

At pH 7.5, Ni and Zn do not exhibit a measurable competitive effect, whereas competitive sorption between Ni and Zn was observed at pH 6.0. Freundlich and Redlich-Peterson models provided the best representation of the experimental data, followed by the Langmuir model in Zn adsorption-desorption studies. The amount of Zn desorbed by different extractants was in the order of CaCl₂>MgCl₂>DTPA >HCl. The amount of Zn desorbed decreased in the soils with greater Zn adsorption capacity and vice versa.

Future Aspects

Transmission electron microscope and pair distribution function should be used to look for the simultaneous presence of Ni–Zn–Al in the hydroxide sheet and their reactivity in future. Increases of Zn adsorption by the presence of phosphate could be ascribed mainly to the formation of a P–Zn complex in organic and inorganic colloid surfaces.

References


