PHYSICAL AND CHEMICAL STUDIES ON MAGNESIUM AFFECTED SOILS

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C O N T E N T S

INTRODUCTION

Magnesium affected soils are observed to occupy a large area around the lakes in the northern part of Nile Delta. Reclamation of these alkali soils represent one of the major agriculture expansion projects. The role of Mg in the physical and chemical properties of soils has been studied though contradictory results were obtained. Magnesium was found by some investigators to behave like a monovalent cation with high hydration and less replacing power on the exchange complex when compared with other divalent cations particularly Ca, and thus reflecting poor physical condition and causing alkalinity in some soils. On the other hand, some investigators reported that Mg behaves very similar to Ca and may even be more strongly adsorbed and less easily leached than Ca. Such conflicting results may be due to the different exchangers and the different Ca : Mg ratios used.

The aim of this work was to study the physical and chemical properties of a number of representative profiles of such Mg - affected soils, the effect of cation saturation percentages of Ca, Mg and Na on such properties. The relative replacing power of these cations and reclamation of these soils using different techniques were also studied.

Concerning the formation of Mg-affected soils a theory was introduced and discussed .

II. REVIEW OF LITERATURE

Alkalization of soils is known to be due to the increase of soluble sodium in the soil, which leads to the increase of the exchangeable sodium. Recent studies believed that magnesium may play a similar role on alkalization of soil specially in soils which are located near the lakes. The role of exchangeable magnesium in alkalization of soil is not completely understood.

II.1. Effect of magnesium on physical properties of soils:

Several investigators studied the effect of magnesium on physical properties of soils. Smith *et al.* (1949) reported that the soils saturated with magnesium did not exhibit poor physical conditions. It was concluded that the low productivity of these high magnesium soils is not due to their high exchangeable magnesium content, but to their heavy texture and the high montmorillonite content of the colloidal clay, which in turn is responsible for poor structure and lack of internal drainage. The results obtained by Lock (1967) agreed with that fact.

Fabry and Kramer (1959) noted that there was a general relationship between adsorbed calcium and magnesium in the profile in some alkali soils. They revealed that the accumulation of magnesium in soils is associated with the magnesium content of ground waters or parent rocks, and has generally no determental effect on the physical properties (texture, cappillary, and moisture rise) of the soils,

Svorikin (1953) studied the formation and behaviour of Greek alkaline soil rich in exchangeable magnesium and sodium. He concluded that continental salty underground waters usually produce black alkali soils of solonetz type with low ratio of calcium to magnesium. Such soils are too hard and compact when dry, and plastic when wet and therefore, present unfavourable structure.

Brooks et al. (1956) pointed out that there was a slight increase in modulus of rupture with increasing exchangeable magnesium which is similar to exchangeable calcium in its effect on stability of soil structure. On the other hand Antipov and Mameave (1958) revealed that exchangeable magnesium tends to increase dispersion, swelling, and shrinking characteristics and cohesion as compared with calcium saturation. They suggested that the profile of a magnesium-solonetz is only a relict of a previous stage of a sodium-solonetz. Amer (1960) found that a significant positive correlation existed between magnesium plus calcium content and hydraulic conductivity on one hand and a significant negative correlation existed between clay plus unbound silt and hydraulic conductivity on the other.

Muller and Fastabend (1963) studied the influence of sorbed magnesium on the water permeability and structural properties of march soils, and pointed out that high magnesium sorption lowered the stability of aggregates and that a narrow Ca/Mg ratio caused a considerable decrease of water permeability. Taking the permeability of calcium soil to be 100, that of magnesium-soil and sodium-soil were 49 and 21 respectively. Klages (1966) reported that high exchangeable sodium and exchangeable magnesium at the levels found in the solonetz samples were each capable of increasing dispersion and decreasing permeability. On the other hand Cairns and Van Schaik (1967) in their studies on solonetzic soils and their physical properties as influenced by different cations, found that the addition of calcium, magnesium and NH_4^+ increased the rate of water movement and improved the structure of the B horizon of various solonetzic soils and that the addition of sodium had an opposite effect. El-Swaify (1970) pointed out that sub-surface soils underwent no structural change as a result of treatment with sea water and chlorides of sodium, calcium and magnesium in a concentration range of zero to 0.6 (N). The structure of surface soils, previously noted to be less stable than that of subsurface soils during hydraulic conductivity measurements, was also un-affected by any of these chemical treatments.

II.2. Effect of magnesium on chemical properties :

Builov (1965) studied the role of adsorbed magnesium in the formation of solonetses of the Turgai hollow. He found that soluble and exchangeable magnesium increased with increasing solonetsicity and the concentrations and percentage of sodium and magnesium were greatest in the B horizon of solonetses. Sinha and Singh (1966) on their study of the relationship between magnesium and calcium in Bihar soils, noted that total magnesium and exchangeable magnesium were generally highest in alluvial soils. They stated that exchangeable magnesium was decreased by the application of $CaSO_4$ and was increased by that of dolomite. Equilibration studies showed that magnesium caused greater alkalinity in soils than equivalent amount of calcium did .

Mamaeva (1966) studied the role of exchangeable magnesium in soil alkalization, and reported that exchangeable magnesium often occurs in the illuvial compacted horizon and therefore a magnesium solonetz soil is postulated. Rice and Kamprath (1968) noted that the exchangeable magnesium generally increased as the total increased. They pointed out that soils containing an expansible lattice clay had the highest magnesium content per gram of clay and the soils which released the highest amount of non-exchangeable magnesium per gram of clay also were the ones containing some expansible clay minerals. Le Poutre and Sauvageat (1969) investigated the role of hydromorphism during the hot-season as a cause of magnesium saturation of clay minerals in soils. They showed that a high magnesium saturation of the exchangeable complex and the presence of $CaCO_3$ concentrations approximately at the level of the water table, were attributed to precipitation of $CaCO_3$ following surface evaporation of the water table and the subsequent concentration of magnesium in the soil solution. A new equilibrium was then established, magnesium passing from the soil solution to the exchangeable complex and the released calcium precipitating as $CaCO_3$ in the alkaline medium in the presence of CO_2. These process occured at high temperatures and strong alkalinity, the presence of Na_2CO_3 and an ample supply of magnesium in these circumstances are proposed as criteria of hydromorphic conditions.

Riecken (1943) studied the magnesium cycle of weathering in solonetz soils and pointed out that the exchangeable magnesium is more easily replaced than the exchangeable calcium. Later studies with montmorillonite clays, showed that magnesium ions are less readily adsorbed than calcium or barium ions. This study indicated that magnesium ions are less readily adsorbed than calcium even at pH up to 7.5. Conclusion seemed valid therefore that the magnesium ions are not accumulating in the B horizon of the solonetz soils because of the greater affinity of the magnesium ions than the calcium ions for clay colloidal. Rest and Chang(1941) found that where the amount of gypsum were the highest, the entrance of the magnesium ion into the exchange complex is depressed. After the amounts of gypsum become reduced the magnesium ion could retain a more permanent position in the exchange complex. Beckett (1965) showed that in natural soils there was a number of exchange sites with a specific affinity for calcium ions and a smaller number with an affinity for magnesium. When these sites are occupied there is little difference between the affinities of remaining exchange surfaces for magnesium and for calcium.

Thus the ionic exchange equilibria between calcium and magnesium should obey the simple relationship $\frac{[Ca]}{[Mg]} x \frac{(Mg)}{(Ca)} = K$. He suggested that the exchangeable magnesium is held less tightly than exchangeable calcium. This suggestion is similar to that indicated by Kelley (1964) who pointed out that the replacing power of magnesium is much closer to that of calcium than of sodium and the relative abundance of these cations in replaceable form in normal soils is a reflection of their exchange activities. He stated also that the replacing power of magnesium is substantially greater than that of sodium is showed by the fact that soils leached with, or recently overflowed by sea water contain about as much adsorbed magnesium as sodium despite the fact that sea water contains approximately 4.3 equivalents of sodium to each one equivalent of magnesium. The results obtained by Dukhnina et al. (1967) agreed with that fact. They found that the isotherms describe the relationship between the ratio of adsorbed calcium to adsorbed magnesium at equilibrium and their ratio in the equilibrium solution and they also noted that when the solid phases were saturated with magnesium, the systems obeyed the low of mass action, without magnesium-saturation the isotherm were S shaped and these systems did not obey the law of mass action. Mate (1955) also attributed the accumulation of magnesium on the adsorption complex of soils in the region beyond the Tisza River to the law of mass action and not due to the magnesium content of parent rock.

Dolcater *et al.* (1968) studied the cation exchange selectivity value for many clay minerals by equilibration of each exchanger with a mixed, equinormal solution containing two competing cations. They pointed out that the cations affinity of Na-saturated materials increased in the order $Mg < Ca < Ba$ for montmorillonite and the soil clays, $Mg < K < Ca < Ba$ for biotite, $Mg < Ca < Ba$ for muscovite and $K < Ba < Ca < Mg$ for vermiculite. Rao *et al.* (1968) studied the Na - Ca and Na - Mg ion exchange equilibria in soils. They showed that the appearent equilibria in terms of concentrations were different for the anions chloride or sulphate. The differences were reduced but not eliminated by ion activity corrections based on ionic strength. A more satisfactory agreement between the results in chloride and sulphate systems was obtained when allowance was made for solution.

Carlson and Overstreet (1966) in their studies on the ion exchange behaviour pointed out that in considering the cation-exchange equilibrium of soils with neutral or alkaline reaction, account must be taken to the possible existence of these incompletely dissociated hydroxides in the exchange phase .

Arany (1956) in his study of the role of magnesium in the formation of Alkali soils reported that in the solodization process associated with an increase of exchangeable sodium in the soil colloids, magnesium may play an intermediary role by replacing Al^{+3} and leading to a further accumulation of sodium by fixation on the free valence. He pointed out that at equivalent concentration more magnesium than calcium is fixed by the soil. Besedin (1964) studied the effect of various ratios of adsorbed calcium and magnesium on some properties of soils and he pointed out that as the proportion of adsorbed magnesium in the mixture increased and of adsorbed calcium decreased the following increase : total alkalinity and alkalinity of alkaline bases (1.5 times) content of water soluble magnesium in the aqueous extract and pH. When the proportion of calcium was 52 % and of magnesium 48 % the content of water soluble magnesium in soil was twice as great as the water soluble calcium.