SOIL CONDITIONERS AND BEHAVIOUR OF CERTAIN NUTRITIONAL ELEMENTS IN CALCAREOUS SOILS

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1. INTRODUCTION

Calcareous soils are usually the most dominant in both arid and semiard regions. They are characterized with certain problems such as deficiency of micronutrients (lime-induced chlorosis) and phosphorus retention that are correlated with presence of calcium carbonate, such problems being of special interest in the ARE due to agricultural expansion programs. In fact, phosphate retention along with availability of micronutrients in calcareous soils seem to be a vector of different forces closely correlated with both percentage and particle size of calcium carbonate fraction.

During the last few years, great attention has been paid to soil conditioners as a technique for creation of stable and well structured soils. Besides, certain limited trials have been introduced to evaluate behaviour of such materials in modifying soil reaction and status of nutritional elements in soil.

The current study has been performed as a trial to throw light on the role imposed by indicated conditioners on behaviour of certain nutrients in calcareous soils. The study involves both polyacrylamide and locally produced acid sludge petroleum wastes, both phosphorus representing the macronutrients and manganese representing the micronutrients being included. Evaluated behaviour of concerned elements involves investigations for both adsorption and desorption mechanisms using both artificial system containing $CaCO_3$ and natural calcareous soil samples.

2. REVIEW OF LITERATURE

For the sake of clarity, the review of literature is thought to be introduced under three main headings dealing with conditioners, phosphorus and manganese.

2.1. Soil Conditioners

Creation of a stable soil structure is considered very important in obtaining soil conditions favourable for crops. In the last few years, many investigators have paid attention to synthetic soil conditioners, as a field of research and practical application.

Soil conditioning means improving soil properties, particularly for agricultural and productivity purposes, by using small amounts of artificial or natural products in order to make air, water, and heat movement optimal.

The most important aspect of soil conditioners is to create a stable and well structured soils. Soil conditioning gives soils the needed physical properties to allow plant growth, fight erosion, or save water, De Boodt (1975).

For a polymer to be useful as a soil conditioner, Schamp (1976) suggested that it has to satisfy the following requirements:

a) Good adhesive properties.
b) Polymer has to be homogeneously introduced into the soil as powder or distributed in water either as a solution or as an emulsion.
c) After conditioning, soil aggregates should be stable in water.
d) Products should not be phytotoxic.
e) Life-time has to last long.
f) Its price and cost of application should be reasonable.

Gebriels (1975) reported that the important aspects of soil conditioning are as follows:

a) If the soil is poorly aggregated, aggregates can be formed by mixing the conditioner with the soil.
b) If unstable surface clods are formed, the soil conditioner can be sprayed over the surface to act as a protective film against runoff.

2.1.1. Conditioning and linkage mechanisms of soil conditioners

The linkage mechanisms, involved on a molecular level, between the soil particles and long chains of the polymers have been studied extensively by Greenland (1965, 1972). He concluded that cationic or anionic soil conditioners have the property of making an electrostatic linkage with either the negatively charged clay surface or the adsorbed divalent or trivalent cations on the clay particles. Non-ionic conditioners have been also reported to make linkage with the soil particles, either through hydrogen bonds or Wander Waal's forces.

Polyacrylamide (PAM) was mentioned to act through hydrogen bonding between the edge hydroxyl group of soil particles and polymer amide, the interaction between clay-domains and polymer being as follows:

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              H    O
              |    ||
edge - CH  -  N  - C - R
              |
              H
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Besides, Wander Waal's attraction exists between edge or face of the clay particles and polymer, in addition to the electrostatic bonds possibly existing between the amide group and negative charge of the clay particles. With long-chain polymer at different spots on clays, cross linkage occurs so that the bonds are strengthened.

De Boodt (1972) showed that polyacrylamide (PAM) also bonds to quartz particles by adhesion, thus electrostatic adsorption and adhesion are both involved in this kind of soil conditioning. The author added that the adsorption of PAM on clay minerals is a bimodel process: an immediate adsorption on the external surfaces of the clay followed by a much slower penetration into the cavities of clay aggregates.

Schamp et al. (1975) reported that:

1. Water soluble polymers must become insoluble in the soil. This can be achieved by adsorption on clay or through chemical reaction.
2. Soluble polymers yield much higher dry mechanical strength than emulsified polymers.
3. Both mechanical strength and water stability index increase markedly with molecular weight of water-soluble polymers.
4. Some emulsified polymers give good results comparable with those obtained from soluble polymers in permeability tests.

Moisture is a major factor affecting the optimum conditions for calcareous soil conditioning. El-Hady and Tayel (1981) found that before soil treatment, its initial water content should be raised to 5-10%. Bitumen should be diluted in such a way that the final soil moisture enables the emulsion micelles to migrate to the contact points between soil particles and strengthen their weak linkages.

The mechanism of conditioning phenomenon is also affected by polymer molecular weight. El-Hady et al. (1986)

found that low application rates of PAM at optimum molecular weight are more effective than higher ones at unsuitable molecular weight. A problem of higher molecular weight is the rapidly increasing viscosity of the polymer solution, which may make application difficult. The authors added that polymer solutions with viscosity between 0.79 and 0.91 poise have the highest effect, the molecular weight of these polymers being variable between 1260000 and 1740000 and are able to be sprayed with the ordinary pesticide sprayers without noticeable technical problems.

One of the factors affecting mechanism of conditioning action is clay fraction. El-Hady et al. (1987) studied the adsorption mechanism of PAM on bentonite for improving sandy soils structure. They found that sandy soils treated with PAM have high mechanical strength and stable structure in the dry state; they, however, loose their strength and the structure is destroyed by wetting as a result of washing the water soluble polymer. The authors added that adsorption of the polymer on bentonite clays turns the soluble polymer in the soil into an insoluble form which prevent it from dissolving in water and thus, water stable structure of the soil can be formed through bentonite action.

The interactions between $CaCO_3$ and PAM, regarding the structure stabilization process in sandy soils, are summarized by El-Hady *et al.* (1987) as follows:

- Neither $CaCO_3$ up to 10% nor PAM is enough because soil structure looses its stability by wetting, the interaction between PAM and $CaCO_3$ being able to solve this problem through complexation of PAM molecules with the released Ca^{++} ions and the adsorption of them on aggregate surface.
- Using polymers having higher molecular weight accompanied with low percentages of $CaCO_3$ not exceeding 2% is enough to obtain water stable structure in sandy soils free of $CaCO_3$, even with the lower concentration of 0.1% polymer.
- Cross linker needed for polymer insolubilization can be saved if a sandy soil has low percentages of active $CaCO_3$.

2.1.2. Classification of the synthetic soil conditioners

De Boodt (1970) classified the soil conditioners according to their use, as follows:

1. Slowly breaking bitumen emulsion which makes the soil more hydrophobic.
2. Polyacrylamide solution which makes the soil more hydrophylic.
3. Products for increasing soil surface temperature such as mulches of fast-breaking bitumen emulsion.

4. Products to stabilize soil structure and to render them more penetrable by plant roots.
5. Products to increase the CEC such as emulsion with aluminium, magnesium, silicate solutions or zeolites.

De Boodt (1979) also classified polymers, proposed for soil conditioners, according to their nature as follows:

A) Polymers soluble in water (hydrophylic soil conditioners).
   a) Non-ionized polymers: polyvinylalcohol (PVA).
   b) Polyanions: vinylacetate maleic acid copolymers (PAMA), polyvinyl acetate (PVAc).
   c) Polycations: dimethylaminoethyl metacrylate (DAEMA).
   d) Strong dipole polymers inducing positive or negative bonds: polyacrylamide (PAM).
B) Polymers emulsified in water (hydrophobic soil conditioners) such as Bitumen emulsion.

2.1.2.1. Polyacrylamide as a soil conditioner

Polyacrylamide has proved to be effective in improving the physico-chemical properties of soils, reducing the requirements for irrigation and increasing crop yields. The success of PAM in modifying the calcareous nonfertile land in France has been the reason for the vast application of PAM in Europe and some developed countries, Azzam (1980). It is in fact one of the important water soluble products