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ZEOLITE FARMING: A FUTURE ASPECT IN AGRICULTURE

Anshul Gupta* and R.B. Solanki

Ph.D. Scholars

Sri Karan Narendra Agriculture University, Jobner, Rajasthan-303329

***Email of corresponding author: anshulgupta2803@gmail.com**

In many parts of the world food security is being affected due to declining quality and/or quantity of the soil resource base and climate change. In this context, farming with zeolites has drawn attention. Zeolites are natural aluminosilicates present in rocks different part of the world. Use of zeolite has gained a momentum in the recent past owing to multitude of benefits accured from them. Zeolites are useful in agriculture because of their large porosity, cation exchange capacity and selectivity for ammonium and potassium cations. They can be used both as carriers of nutrients and as a medium to free nutrients. Although considerable research has been advanced, further research needs to carried out for their efficient utilization in farming.

Introduction

Zeolites are a large group of (cluster silicates) aluminosilicate minerals with different chemical composition. Structurally, zeolites are tectosilicates exhibiting an open three-dimensional structure containing cations needed to balance the electrostatic charge of the framework of silica and alumina tetrahedral units. Pores and voids are the key characteristics of zeolite materials. The pores and interconnected voids are occupied by cations and water molecules. The internal surface area of these channels are reported to reach as much as several hundred square meters per gram of zeolite, making zeolites an extremely effective ion exchangers. The Si/Al ratio is an important characteristic of zeolites. The charge imbalance due to the presence of aluminium in the zeolite framework determines the ion-exchange property of zeolites and is expected to induce potential acidic sites. The Si/Al ratio is inversely proportional to the cation content, however directly proportional to the thermal stability. Cations can be exchanged by ion exchange and water can be removed reversibly by application of heat. The unique physical and chemical properties of zeolites, coupled with their abundance in sedimentary deposits and in rocks derived from volcanic parent materials, have made them useful in many agricultural applications. Due to their unique physical and chemical properties (high sorption capacity and ion-exchange, ion-exchange selectivity and structural thermal stability), they can be used for example in the production of mineral fertilizers. (Kulasekaran *et al* 2015). Zeolites can also be used as a medium of the active substances i.e. pesticides, herbicides, fungicides or pesticides. Zeolite application is that unlike other soil amendments (gypsum and lime) it does not break down over time but remains in the soil to help improve nutrient and water retention permanently. With subsequent applications the zeolite will further improve the soil's ability to retain nutrients and produce improved yields. Their addition increases plant production levels and biological activity of the soil. Also zeolite's excellent sorption properties can be used for the remediation of soils contaminated with heavy metals.

Structure of Zeolite:

Zeolites are minerals naturally formed in the reaction of volcanic ash with surface water or groundwater. They can also arise in the non-volcanic environment during an interaction between the saline soil particles with strong basic solutions. They are crystalline, hydrated aluminosilicates of metals, including calcium, magnesium, sodium, potassium, strontium and barium. Due to their inner structure they are characterized by unique physicochemical properties: high and cation exchange sorption capacity, ion-selectivity, molecular sieving, catalytic activity and high thermal stability up to 750°C

Zeolites of India

Natural zeolite minerals in India were reported in amygdaloidal vesicles in the Deccan lava flows, but are restricted to certain localities around Mumbai (Bombay), Vadodara (Baroda), Pune (Poona), and Nasik Heulandites (most popular zeolites of the world) zone was found in the highlands of plateau in the region around Pune (Maharashtra), which is the top-most region up to the highest point Kalsubai. In this region, around 30% of the rock is occupied by zeolites. In addition to Maharashtra, zeolite occurs as filling in the amygdular cavites in deccan trap basalts of Gujarat, Madhya Pradesh and Karnataka too.

Agricultural uses of zeolite:

Organic manure handling and management

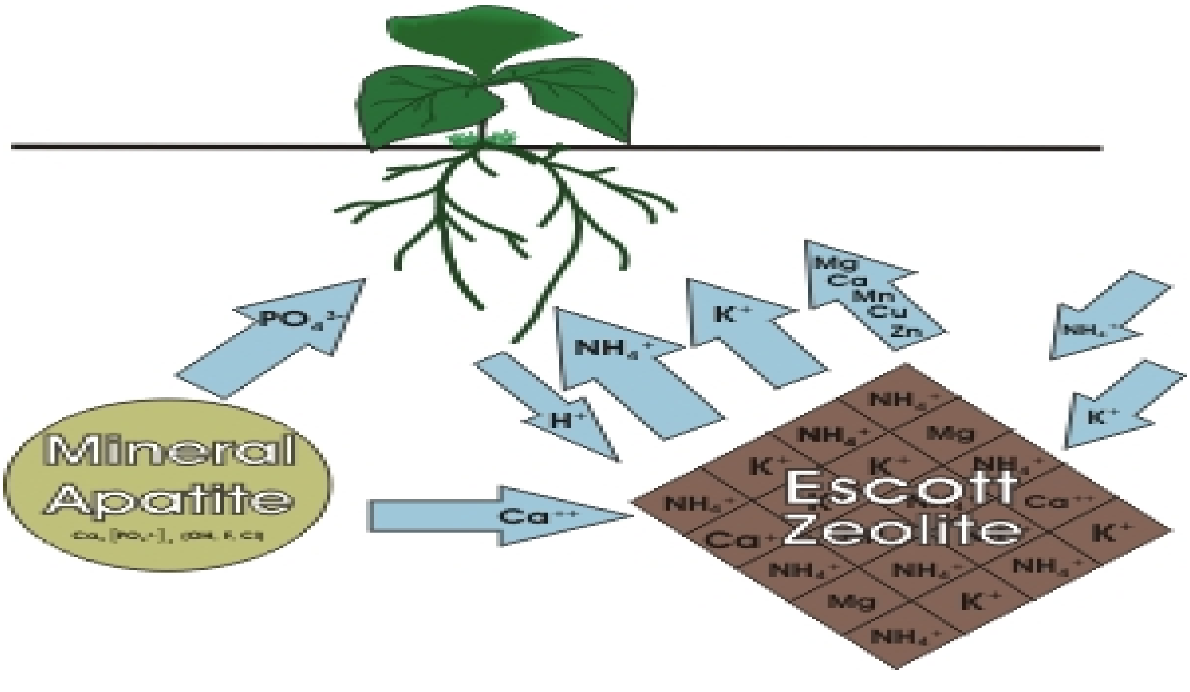
Handling organic and animal manure is a recurrent problem, besides severe loss of valuable nutrients through leaching and volatilization, particularly for nitrogen. Release of volatile compounds from various animal manures is a deterrent for their usage in farming. Zeolites could be used as an effective additive to control the odour as they could absorb the volatile substances like acetic acid, butanoic acid, isovaleric acid, indole, and skatole and enhances effectiveness of the manure. Surface application of zeolite has potential for mitigating feedyard manure NH3 losses thereby reducing losses of nitrogen to the environment, but specific zeolite properties influenced its effectiveness. Nitrifying bacteria could not use the manure-ammonia in the zeolite due to small pore (**Sangeetha and Baskar 2015)**

Nitrogen management

Although nitrogen is regarded as kingpin in agriculture and widely used in all crops and cropping systems, its use efficiency is just 30–40% only. As surface and groundwater contamination have been reported in some countries. its rational use is necessary to enhance nitrogen- use efficiency and reducing environmental contamination. Zeolite also helps in reduction of urease activity.

Slow release of nutrients

When mixed with major nutrients, zeolites with their specific selectivity for ammonium, can take up this specific cation from ammonium-bearing sources and acted as a slow release fertilizer in several crops. It also attracts potassium, calcium & magnesium as well as many trace elements. It has the greatest affinity for ammonium and potassium but when a plant is taking up the ammonium or potassium off the zeolite, the zeolite attracts calcium from phosphorus mineral apatite such as rock phosphate or locked up phosphorus in soil to balance the zeolites negative charge. This reaction releases a free phosphorus. The plant extracts the ammonium, potassium and other nutrients by active uptake from roots. The adsorbed ammonium ion after the second and third year of zeolite application in the soil behaved as an effective nitrogenous fertilizer and improved crop growth. The main use of zeolites is for nitrogen capture, storage and slow release, as they adsorb molecules at relatively low pressure and is considered as nano-enhanced green application. Zeolite as coating material has shown the potential to increase water absorption and water retention of NPK fertilizer. Zeolite applied with urea reduced the ammonia volatilization by 8%.



Phosphorus management

Zeolite/rock phosphate combination acted as an exchange-fertilizer, with Ca2+ exchanging onto the zeolite in response to plant uptake of nutrient cations (NH4 +or K+), enhancing the dissolution of the rockphosphate. Ammonium-charged zeolites have shown their ability to increase the solubilisation of phosphate minerals or animal bone ash and promoted the rockphosphate dissolution in all soil type and reduced fixation in soils.

Slow/sustained release of herbicides

The most hydrophobic solids such as zeolite 'ZSM 5'were found to adsorb atrazine better when organics were present in the compartmentalized intracrystalline void space of zeolites. This has brought a considerable attention on soil clay minerals for slow-release formulation of herbicides. Zeolite (ZSM-5) was found to accommodate herbicide paraquat in the microstructure with restricted mobility. Humic acid zeolites were also found to be sorbents for phenylurea herbicide.

Soil amendment and improving soil water-holding capacity

Zeolitic amendment is an effective way to improve soil condition in an arid and semi-arid environmen owing to its cage-like polyhedral unit and increased water-retention capacity of soils, and so considered as soil activator. They are used extensively in Japan as amendments for sandy soils. It does not breakdown over time and could reduce water and fertilizer costs by retaining beneficial nutrients in the root zone. The higher the average ionic potential of the extra-framework cations, the larger would be the hydration capacity of the clinoptilolite (Natural zeolite). They may hold water more than half of their weight and hysteresis for water molecules could be observed without physical damage. This could assure a permanent water reservoir, providing prolonged moisture during dry periods. This results in a saving in the quantity of water needed for irrigation (Kulasekaran *et al* 2010).

Use of zeolites in soil remediation

Increase of soil pollution by heavy metals is one of the main problems of modern agriculture. The increased accumulation of metals in soils is highly influenced by human activity and the related development of industry and irrational use of fertilizers. The ongoing concern in relation to the purity of the soil and the need to restore its original properties forced us to seek new and alternative ways of the soil cleansing. Natural and synthetic zeolites are being used among other additives to reduce the bioavailability of heavy metals in the soil. The use of zeolites in acidic soils causes an increase in pH that significantly affects reduction in heavy metals solubility and bioavailability for plants. Except of ion exchange reactions, the pH increase promotes the adsorption of heavy metals on the surface of zeolites and their oxides precipitation

Conclusion

Under the present requirements of ecological agriculture there are wide areas of use for a natural, inert and non-toxic material such as the natural zeolite. Due to its structure and properties zeolite may be used as a slow-releasing carrier of agrochemicals of various kinds and fertilizers. Natural zeolites are effective in improving soil properties and treating contaminated soil. A wide range of applications of zeolite promotes the pursuit of other possibilities for their use.

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