



**Biotica  
Research  
Today**

**Vol 2:9** <sup>874</sup> / <sup>875</sup>  
**2020**

# Improvement of Nutrient Use Efficiency with Zeolite Technology

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## Keywords

Nitrogen, Phosphorus, Potassium, Zeolite

## Article History

Received in 07<sup>th</sup> September 2020

Received in revised form 08<sup>th</sup> September 2020

Accepted in final form 09<sup>th</sup> September 2020

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## How to cite this article?

Pandit *et al.*, 2020. Improvement of Nutrient Use Efficiency with Zeolite Technology. *Biotica Research Today* 2(9): 874-875.

## Abstract

**A**t global and national level, the big challenge is to fulfill the requirement of food of increasing population. Fertilizer is one of the most important agriculture input require for crop production. Fifty percent of food grain production is depend on the chemical fertilizer. Cost of food production is increases year by year without increasing farmer income. Farmer income is not increasing due to the more use of fertilizer and less efficient use of fertilizer. There is a need to improve the nutrient efficiency by apply something in soil or preparation of slow release fertilizer. Zeolite is clay mineral have such property can improve nutrient efficiency after application in soil or preparation of fertilizer with zeolite material. Zeolite is not only increase nutrient efficiency but also contribute in climate resilient agriculture.

## Introduction

**C**hemical fertilizers are one of the most important and expensive inputs used in farming to achieve desired crop growth and yields. The consumption of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O was 17.90 million MT, 6.86 million MT and 2.53 million MT are being used annually in India (FAI, 2018-19). Recovery of applied inorganic fertilizers by plants is low in many soils. The efficiency of Nitrogenous, Phosphatic and Potassic fertilizers was 50% or lower, less than 10%, and close to 40% respectively. Leaching, run-off, gaseous emission and fixation processes are responsible for lower efficiency of nutrient. These losses can potentially degrade soil quality, water quality and environment quality. These are compelling reasons of the need to increase NUE. Zeolite has capacity to improve the NUE. Zeolites (clinoptilolite) are crystalline, micro porous, three dimensional alumino-silicate clay minerals with formula (Na,K)<sub>3</sub>(Al<sub>6</sub>Si<sub>30</sub>O<sub>72</sub>)<sub>24</sub>·H<sub>2</sub>O. Zeolite was first identified by Swedish mineralogist, Alex Fredrik Cronstedt in 1756 from copper mine of Sweden. A global level, zeolite deposits are found more extensively in western USA, Bulgaria, Hungary, Japan, Australia and Iran (Mumpton and Rocamagica, 1999). In India, zeolites are found in Maharashtra, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and Karnataka. Zeolite contain in Deccan plateau of Black soil and Indo Gangetic plain region near about 98% and 2% of the area respectively which is approx. 2.8 million (Bhattacharyya *et al.*, 2015). Zeolite deposits mostly found in western part of India, particularly Pune, Nashik, Mumbai and Baroda. The unique properties of zeolites are more CEC, adsorption, and internal surface area, water holding capacity, having more canals, cavities and micro pores because of these properties zeolite used as soil amendments and slow release fertilizer in agriculture. This property of zeolite has improved nutrient use efficiency.

## Mechanism of Nutrient with Zeolite

### Nitrogen

In Nitrogenous fertilizer, Nitrogen present in the form of cation ( $\text{NH}_4^+$ ) and anion ( $\text{NO}_3^-$ ) which can be easily loss by leaching, fixation, denitrification processes. By application of zeolite, these losses can control due to specific and unique properties of zeolite. After application of N fertilizer in soil, it will convert in soil in to form cation ( $\text{NH}_4^+$ ) and anion ( $\text{NO}_3^-$ ) which can absorb on zeolite and enter in canal of zeolite. In short, application of nitrogen fertilizer in zeolite containing soil will fixed for short time due to adsorption process and capturing of nitrogen in the zeolite canal network. The fixed form of nitrogen in zeolite will slowly release in the soil. This process is called slow release of nitrogen. Hence, zeolite is act as slow release fertilizer. Zeolite will increase the nitrogen use efficiency up to 50% in rice and 70% in other crops. The reason of increased of NUF with zeolite is due to the reduction of leaching, denitrification, fixation losses of nitrogen.

### Phosphorus

Phosphorus use efficiency in Indian soil was varies from 10-15 % only and Maximum 20%. The remaining part of phosphorus fertilizer is fixed in soil which can available to plant in next season. This is one of the reasons of increases of high phosphorus soil area in India. Phosphorus use efficiency depends on the phosphorus availability under lowland and upland soil. Phosphorus availability under submerge condition can be increase up to certain time then after it availability reduced. By the application of zeolite, phosphorus availability in submerge in soil can be maintain for long time due to adsorption chemistry of zeolite and micronutrient in soil. In submerge soil, micronutrients like Fe, Mn, Zn and Cu are present in reduced form which is precipitate with  $\text{OH}^-$  ion and  $\text{CO}_3^-$  and decreases the affinity of micronutrient toward phosphorus, ultimately increases availability of soil phosphorus while zeolite has more CEC which can adsorb present micronutrient in soil and reduces the transformation of available form phosphorus to unavailable form or soluble form to insoluble form for longer time. Phosphorus use efficiency with zeolite can be increase up to 32%.

### Potassium

Potassium use efficiency in Indian soil is varies from 50-60 %. Mechanism of K and Zeolite is same like N and Zeolite. Zeolite is act as slow release fertilizer for K. Application of K fertilizer in soil containing zeolite can stored available K in available form. Zeolite can reduce leaching and fixation losses of K fertilizer. This process can help for higher potassium use efficiency. Potassium use efficiency with zeolite can be increase up to 70-75 %.

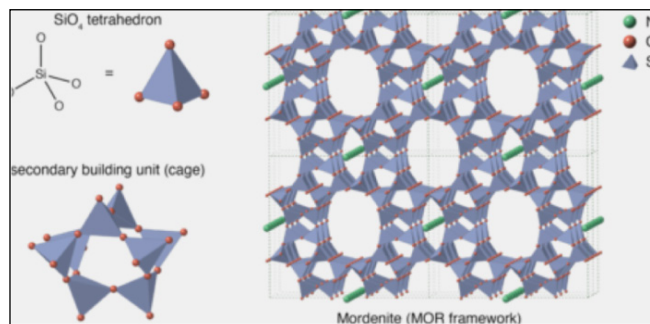


Figure 1: Zeolite Structure (Sodium form)

## Positive Response of Zeolite in Relation to Soil Properties

- Zeolite can increase the cation exchange capacity of soil.
- Water holding capacity and porosity of soil are also increases with the zeolite application.
- Ammonium nitrogen content in soil will increase.
- Soil fertility status will vary.
- Availability of micronutrient can be increase.
- Zeolite is act as amendment material in soil.
- Zeolite can reduce nitrogen emission from submerge soil.
- Soil bulk density will decrease.

## Conclusion

Zeolite is act as slow release fertilizer in soil under both lowland and upland condition. Application of zeolite in soil at certain rate or preparation of zeolite and NPK fertilizer briquettes at proper ratio will increase nutrient use efficiency up to 84%, 35% and 70-75% in case of NPK fertilizer, respectively. Zeolite is not only increase nutrient efficiency but also help in improvement of soil properties like, CEC, water holding capacity and soil fertility etc. In rainfed area or dry land area, zeolite and NPK fertilizer mixture is a good nutrient supplier to crop roots at low moisture condition.

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