ABSTRACT

Escalating food demand with ever-increasing population has forced agricultural scientists and farmers to increase crop yield in lesser cultivated areas. Higher yields of crop are being ensured through a widespread use of fertilizers and pesticides, however release of relevant additional chemicals is adversely affecting the atmosphere thus endangering the environmental safety. Commercially available fertilizers now a days are readily soluble in water giving a burst of nutrients of which more than half of their nutrients are lost to environment without giving any benefit to plants. Large scale fertilization results in irreparable damage to mineral balance and structure of soil. In addition, it is also responsible for increase in emission of greenhouse gases as well as contaminating the underground water. It is necessary to practice more efficient fertilization strategies which would be more beneficial to plants and less harmful to environment. Recent advancement in fields of nanotechnology and nonmaterial is expected to make a positive impact on agriculture and fertilizer sectors while minimizing the damage to environment. Focus of this study is to develop slow release fertilizers which can deliver nutrients over longer period of time thus increasing its effectiveness and in turn reducing excessive use of fertilizers.

A variety of nanoporous aluminum silicates i.e. zinc aluminosilicate, manganese aluminosilicate, iron aluminosilicate, calcium aluminosilicate and potassium aluminosilicate were synthesized by employing the hydrothermal. As silica source, rice husk was used to make the synthesis process cheaper and environment friendly. Characterization was done using Fourier transform infrared spectroscopy, thermo gravimetric analysis, X-ray diffraction, scanning electron microscopy and BET. Urea was

loaded on as synthesized nanocomposites to check its urea adsorption capacity of nanocomposites. Amount of urea released in water from the nanopores of nanocomposites used was also calculated by employing UV-visible spectroscopy.

Three different nanocomposites of manganese aluminosilicate were synthesized by varying the concentrations of manganese and aluminum in synthesis mixture. Hydrothermal treatment at 180 °C was employed for 24 hours to prepare each nanocomposite. Nanocomposites were then calcined at 550 °C for 3 hours before the required urea loading. To conclude the best synthesized sample for the occlusion of urea, XRD and FTIR was used for structural characterization. BET was employed to evaluate the surface area of as synthesized nanocomposites. UV-visible spectroscopy was used to investigate the release of urea from nanocomposites in water. Larger surface area leads to higher urea adsorption on nanocomposite. Nanocomposite synthesized with manganese, aluminum and silicon ratio 0.05:0.07:1 respectively was determined to possess the highest surface area of 432 m^2 g^{-1}.

Three different nanocomposites of iron aluminosilicate were prepared having different initial concentrations of aluminum and iron. Porosity of synthesized nanocomposites were investigated through BET. Urea was loaded on all nanocomposites and subsequent urea release in water was investigated for a period of 14 days by utilizing UV-visible spectroscopy. Release of iron was also investigated by employing inductively coupled plasma mass spectroscopy. Urea adsorption on the nanocomposite was found to be lesser than manganese aluminosilicate.

Calcium aluminosilicates were also synthesized on the same pattern as discussed above for manganese aluminosilicate synthesis. XRD was employed to conclude the structural

morphology and it showed poor crystallinity of the synthesized material. Surface area was determined through BET. Due to poor crystallinity and particle morphology of synthesized nanocomposite, the surface area of 46 m^2/g was remained highest in the sample synthesized with calcium aluminum and silicon ratio 0.05:0.07:1 respectively.

Zinc aluminosilicate was prepared by using silica from rice husk to make the process green and economical. Different nanocomposites were synthesized by keeping the initial elemental ratio of zinc, aluminum and silicon as a) 0.1:0.14:1 b) 0.1:0.07:1 c) 0.05:0.07:1. Characterization was done by employing BET, FTIR, SEM, XRD and TGA. After urea adsorption urea loaded zinc nanocomposite was further compared with commercial urea. Among micronutrients zinc concentration is lower in the soil taken for pot experiment however other micronutrients found in adequate quantity. A pot experiment was designed to investigate the nitrogen use efficiency (NUE) of synthesized fertilizers in comparison to commercial fertilizers and tested on *Oryza sativa* L. (rice). Six different treatments with different concentration of applied nitrogen were used in the experiment with replication of three. It was observed that in case of lower concentrations of source nitrogen, commercial urea is better in nitrogen use efficiency but it has lower yield. However in case of treatments where higher concentration of nitrogen is applied, both yield and NUE is significantly better in urea loaded zinc aluminosilicate than commercial urea.

Potassium aluminosilicate was synthesized by the same method as discussed for the zinc aluminosilicate. Urea adsorption was found highest with highest surface area. Commercial urea and urea loaded potassium aluminosilicates were used as source of nitrogen and tested on *Oryza sativa* L. (rice). It was noted that nitrogen use efficiency of plants is significantly higher in the plants fed with urea loaded potassium aluminosilicates.