REVIEW OF THE LITERATURE:

The problematic encounterment resulting from enrichment of soil nitrogen status with the application of urea intended at higher productivity has drawn global attention of researchers in the field. Their first objective has been to study the soil enzyme urease that converts urea into carbon dioxide and ammonia. In nature, the level of activity remains in a stable state under the influence of a variety of soil conditions. The relationship of this enzyme under different soil conditions and its stability are reviewed.

(i) Enzyme activity under different soil physico-chemical characteristics:

(a) Organic carbon, total nitrogen, pH, CEC, specific conductance, and surface area:

Koepf (1954) found urease activity to be positively correlated with clay percentage and organic matter content for the samples of Germany soil.

Hofmann and Kesseba (1962) could also note a close correlation between clay percentage and urease activity for the surface samples from Egypt.

McGarity and Myers (1967) from their study of 100 surface soils from New South Wales found that the heavier textured soils contain higher levels of organic carbon which in turn bears a positive correlation with urease activity. They observed organic matter to be a general factor, influencing the overall activity and that for the surface soils examined, changes in environmental and nutritional aspect may alter the expression of this relationship. The correlation with pH is weak. Neither soil colour nor texture had close relationship with urease activity.

Gould et al.(1973) could note a close correlationship of urease activity with organic carbon content for the Albartan soils. The relationship of urease activity with pH activity was weak and positive. They suggested that the enzyme urease is adsorbed on the surface of the clay particles.

Pancholy and Rice (1973) basing their observations on Oklahoma soils varying in vegetation types noted no significant correlation of urease activity with organic carbon and pH.They suggested that the types of vegetation and thus the types of organic matter added in soil during successional stages are the chief determiners of the activity gradients of the enzymes that were under study.

Dalal (1975) studied urease activity in 15 different surface soils from Trinidad with relation to soil moisture content, percentage of clay and organic carbon, cation exchange capacity, amourphous Fe and Al and found high and significantly

positive correlation with organic carbon and cation exchange capacity, significant correlation with Fe and Al. He could not obtain any correlation of the urease activity with pH and clay content.

Dutzler-Franz in 1977 from his study of 17 soil profiles from West German was unable to detect a correlation of urease activity with organic matter,but there was a positive correlation with pH.

Tabatabai (1977) studied six surface soils from Iowa varying in pH ,texture and organic matter content with relation to urease activity alongwith eight profile samples. In both the groups of soils he found a significant positive correlation between organic carbon and urease activity and concluded that organic carbon had a special influence in determining urease activity.

Zantua et al.(1977) based their investigation on 21 Iowa soils. They found urease activity to have a highly positive and significant relationship with organic carbon, total N and CEC, significant relationship with clay,sand and surface area. There was no correlation with $CaCO_3$ content and pH. From the multiple regression values they suggested that most of the urease activity would be accounted for by organic matter content (assessed by total N or C analysis) pH surface area and two of the three possible interactions of these properties.

Verstraeten (1978) studied 79 soil samples from different parts of Belgium to establish the interaction between urease activity and soil characteristics. His findings, he quotes confirm the figures obtained for the 21 Iowa soils (Zantua et al., 1977) in a remarkable way. He suggested that not just the organic matter, but rather the form in which it occurs in the soil such as free organic material in a more or less humified grade or organic C might be the regulatory factor. This organic C fraction bound to soil inorganic particles is known as clay-carbon complexes. There was a high and significant relationship of this enzyme with cation exchange capacity. The relationship with clay was positive and significant and with sand it was not significant and negative respectively.

Beri and Brar (1978) studied the sub-tropical alkaline soils from India, one of their objectives being the evaluation of urease activity of different soils with a wide range of soil characteristics. They noted organic matter to have a significant effect. The relationship with clay percentage and pH were negative and not significant.

Mishra et al. (1979) studied the activity of different soil enzymes , such as amylase, cellulase , invertase protease and urease in eleven different sub-tropical pasture soils from western part of Orissa with relation to different soil properties, such as, moisture organic matter , total nitrogen, CO_2 evolution etc. They could find urease activity to be strongly supported

by the activities of cellulase and invertase. The correlations
of urease with moisture content,pH, reducing sugar and organic
matter were weak.

Pal and Chhonkar (1981) studied 30 tropical soils from
India with a view to identify the protective role of soil
constituents on relatively stable soil urease.They found organic
carbon and total N to have significant positive relationship with
soil urease status. They suggested that the variations in the
activity of this enzyme to be mostly due to differences in
organic matter content. Soil pH and urease were found to be
negatively correlated. Soluble salt contents were also found to
have negative relationship with urease activity. They further
suggested that this negative relationship might be due to the
unfavourable action of high salt concentrations on the develop-
ment of urea bacteria.

Frankenberger and Bingham (1982) studied the activity of
different soil enzymes with variable ranges of salinity effected
through salts of $CaCl_2$, NaCl and Na_2SO_4 and found the activities
to decrease with increasing electrical conductance (EC). They
attributed the reduced rate of enzyme activities to osmotic
desiccation of microbial cells releasing their intracellular
enzymes which become vulnerable to attack by (i) soil proteases,
(ii) to the salting out effect modifying the ionic conformation
and (iii) to the specific ion toxicities causing nutritional
imbalances for microbial growth and subsequent enzyme synthesis.

(b) Soil nutrients (phosphorus, sugar and amino acid contents):

Glucose has been isolated as the most abundant simple sugar from different soils. Ross (1968) found appreciable amount of glucose to be liberated from the decomposition of plant residues.

Sinha (1972) attempted to determine the qualitative differences in amino acid composition of different organic matter fractions with a view to determine the possible mechanism involved with their stabilization in soil. He reached the conclusion that the persistence of amino acids in soil was due to their combination with lignin decomposition products, tannin and other polyphenols.

Kiss et al. (1975) in their review observed that many compounds such as urea and ammonium carbonate added to soils determine the increase in nuclease activity. The concomitant increase in the mineral phosphate centre was of practical importance in intensifying the mineralization of soil nucleic acids.

Benzing Purde (1980) from his estimate of organic carbon and sugar in soil found that a parallel trend existed between organic carbon and carbohydrate content. The latter was found to constitute 40% of organic carbon W/W.

Zhou Li Kai et al.(1981) indicated a correlation between urease activity and soil phosphorus content.

En-Feng Chen et al.(1982) pointed out that enzymatic activities of black soils are a good expression of nutrient status and the physical and chemical properties of soil. They found positive and significant correlation to exist between urease activity and available phosphorus content.

Burns (1983) observed that extra-cellular low molecular weight organic molecules such as monosaccharides, amino acids, organic acid and some aromatic monomers constitute a pre-requisite for microbial growth and mineralization.In general, sugars are poorly adsorbed and the presence of amino constituents have clearly pH dependent affects on surface interactions.

(c) Soil colour:

Nagelschmidt et al.(1940) in black cotton soils noted the pH to increase with depth. Their soluble salt content varies from 0.05 - 0.07% and the clay content is about 40%.

Stephens (1949) suggested a name Grumsol for the dark clay soils. Their carbon content reported to be usually 3% at the surface, decreasing with depth.

Ookes and Throp (1951) reporting on black cotton soils from different continents indicated the soil to be black,sticky, heavy clays with greenish or brownish tinge,mostly 1-2 meters

deep that rested on rock materials. Leaching being confined to calcium carbonate that accumulated in the lower layer in the form of concretions.

Simonson (1954) commenting on regur soils (i.e.,black soils) states that they mainly extend between 15-25° north latitude and 175- 80° east longitude. The organic matter content is low, 0.3 - 0.8% and C.E.C. is about 50 m.e.q / 100 gram of soil.

(ii) Soil Elements:

Doak (1952) stated that the inhibition of urease activity by trace elements might lead to the movement of water soluble urea to ground water.

Hughes et al.(1969) in an attempt to correlate the concentration of metal ions required to produce 50% inhibition of urease activity found them to decrease in order of Ni, Co, Zn, Cu and Hg which led them to make a quantitative statement that metal ions forming the most insoluble sulphides are the most potent urease inhibitors.

Tabatabai (1977) found that Na^+ , Ca^{++} , K^+ , Ba^{++} , Zn^{++} , Mn^{++} , Al^{+++} and Fe^{+++} did not inhibit urease activity in soils. Commenting on the role of metallic ions, Sequi (1978) suggested that the metallic ions of soil constituents bear a relevance to soil aggregation and that their mutual arrangement is important for the stabilization of soil structure.

Ross (1973) investigated into the aspects concerning possible effects of 3 different parent materials on the biochemical activities. On an organic carbon basis none of the biochemical activities differed significantly. An exception was recorded in respect of dehydrogenase activity that appeared to be greater in the samples derived from basalt.

(iii) Urease activity and relation to other soil enzymes:

Stevenson (1950) related the dehydrogenase activity to soil micro-organism populations.

Galstyan (1965) studied the hydrolytic enzymes such as invertase, amylase, β-glucosidase and urease to study the significance of toleune treatment and presented in nature of reaction.

Pancholy and Rice (1973) studied the enzymes amylase, cellulase invertase dehydrogenase and urease and concluded the although the evidences indicated the gridient of activity of urease and dehydrogenase to be related to the type of vegetation and thus to the type of organic matter added to the soil, but the probable reason for the relationship was not apparent.

Sørensen (1974) added labelled cellase to soils with varying clay contents and recorded the rate of substrate dissapearance to be similar in all soils but high clay soils immobilized amino acid metabolities and cellular materials and reduced further oxidation of the same.

Ross (1975) reported correlation studies involving amylase invertase, phosphatase, sulphatase and urease.

Sequi (1978) made a review of 65 original presentations concerning properties determing both physical and chemical characteristic contributing to soil fertility and commented that organic matter may be considered an unifying factor in soil dynamics while the inorganic moiety is to be regarded as the determining factor which differentiates the soil on a physical basis.

Zhou Li Kai (1981) presented the activities of catalase, polyphenol oxidase, invertase, urease, alkaline and neutral phosphatase and sought correlation with soil humic substances and other elements of fertility.

En-Feng Cheng (1981) in course of his investigation on the aspect of fertility studied catalase, polyphenol oxidase, invertase urease and alkaline and neutral phosphatase and presented their relationship with soil humic substances.

Hofmann and Pfitscher (1981) with an objective to find out the aspect that was best indicator of biological activities in soil, the possible relationship of enzyme activities to other ecological parameters and the interdependency of different enzyme studied from 17 different alpine and subalpine soils. Their findings revealed that, compared to other enzymes urease

had a lower rank of interrelationship with the rest. The activities of different enzymes were found to be significantly correlated with characteristics like total nitrogen and organic matter. Almost no correlation was found with bacterial count. However, urease activity was found to be strongly correlated with total bacterial count.

(iv) Urease activity in the rhizophere:

Estermann and McLaren (1961) studied the contribution of rhizophere organism to the total capacity of plants to utilize organic nutrients. They noted that phosphatase and invertase activities could not be attributed mainly to enzyme on the root itself whereas urease activity was a function of rhizosphere organisms. No appreciable activity of proteinase, esterase, amidase and asparginase were found in the root and rhizoplane of barley.

According to Skujins (1967) urease activity in general appeared to correlate with the number of microbes and is greatest in the rhizosphere.

Paulson and Kurtz (1969) based their observations on the microbial and adsorbed urease. Their findings revealed that 70-79% of the urease activity could be due to adsorbed urease when its microbial population was in a steady condition. The addition of an energy source however, caused an increase in microbial population and hence there was a temporary decrease in this percent(i.e.,adsorbed urease percentage).

Lloyd and Shaeffe (1973) could find that 17-30% of total bacterial population could hydrolyse urea. Addition of the substrate with urea, low in available carbon did not increase the total urease activity, the size of bacterial population or the ratio of ureolytic to non-ureolytic bacteria. When this soil was supplemented with glucose as a readily available carbon source, then only the addition of urea increased urease activity, the number of ureolytic bacteria and the size of bacterial population. But there was no effect on the ratio of ureolytic to non-ureolytic bacteria.

Spier et al.(1980) compared between planted soil and fallow soils. They found several fold increase in the urease activity of planted soils compared to the fallow ones.

Murtazina (1980) from his observation of grey forest soils found urease to have greater activity under crops then under fallow.

Pal and Chhonkar (1981) compared between urease activity and the total number and efficiency of ureolytic bacteria in cultivated soils. No significant correlation of population density of ureolytic bacteria with the soil characteristics and the amount of urease activity could be detected by them.

(v) Stability of soil urease:

Conrad (1940-43) found that the hydrolysis of the fertilizer urea was enzymatic and postulated that the source of this enzyme was soil micro-organisms. This soil enzyme urease was responsible for the conversion of urea nitrogen to ammonium nitrogen in soils. The location of urease, he concluded,was extra-cellular.

Paulson and Kurtz (1969) in their attempt to determine the location of native urease in soils, i.e., whether the enzyme was associated directly with soil micro-organisms or free from micro-organisms and adsorbed on clay-colloids, were able to note that most of the urease activity was caused by the adsorbed urease.

Pinck and Allison (1961) believed that soil colloids, both clay or organic had high affinity for urease and are able to adsorb and protect the same.

Burns et al.(1972) proposed that urease (and possibly other enzymes involved in mineralization) is immobilized within the organic matter of the organo-mineral complex during humus formation and that the organic matter has pores large enough to allow passage of substrate (urea and H_2O) and product (NH_3 and CO_2) molecules but not of a sufficient size to allow the entry of proteolytic enzymes or the escape of urease itself.

Pettit et al.(1976) from their studies involving the stability of soil urease under the influence of irradiation could note decline in urease activity with increase in dose rate. The

findings led them to suggest that about 60% of total urease are extra-cellular bound, being unaffected by 2.5 Mrad and the reminder composed of intra-cellular and extra-cellular unbound in location.

Burns et al.(1978) made an investigation into the differential stability of four different soil enzymes including urease under the influence of a varying range of irradiation doses. They could note the enzymes to respond differently to irradiation. In general the magnitude of inactivation coefficient was higher in wet soils than in dry soils of the enzymes studied by them. Urease is somewhat less exposed to irradiation, functioning from within the soil organo-mineral complex on its soluble, low molecular weight substrate. A change in accessibility of the enzymes may also occur if and when irradiation alter the humic material with which the enzymes are associated. Burns (1978) further added that the extra-cellular unbound enzyme is rapidly destroyed during irradiation and is released from lysed cells. Subsequent denaturation of bound exo-enzymes may be due either to the direct effects of higher levels of irradiation or to the disruption of their protective organic colloid associations

Sarkar and Burns (1984) made a synthetic approach to understand the relationship between immobilized soil enzyme and their humic support. The β-glucosidase phenolic copolymers prepared by them when compared with naturally occurring humic matter enzyme complexes in soil were found to be analogous in

many ways. This led them to suggest that the copolymerization of enzyme-humic matter formation to be a major factor leading to the stabilization of soil enzymes and that adsorption and entrapment are comparatively insignificant.

Gamma ray induced degradation of polysaccharides were reported by Collinson et al.(1956). Griffith and Burns (1968) could also note similar effect of gamma irradiation on soil polysaccharides helpful in soil aggregate formation. The induced depolymerization causes a loss of viscosity in water soluble polysaccharides.

Irradiation is also known to faciliate increased release of nutrients (Skujins,1978). Sparling and Berow (1985) could note γ-irradiation to markedly increase the level of extractable Mn. and Co. though most of the extractable trace elements were not effected.

Structural stability of soil is due to linkage formation between organic and mineral constituents (Martin et al.,1955). Giovannini and Sequi (1976a) have suggested that iron and aluminium act as cementing substances of soil aggregates. They found water stability of these soil aggregates to decrease after treatment with acetyle acetone in benzene, a reagent that essentially extracts metals bound to the organic matter. The observations led them to suggest that metals behave as bridges of nets composed of polymeric chains of organic matter. In a subsequent report, they (1976b) suggested that the metals are

essentially bound to the organic matter, behave as junctions
of a net composed of polymeric chains of soil organic matter
and that the mesh that exerts a protective action after
extraction with acetyle acetone is weakened at the junctions
of polymeric chains after removal of metals so that the
stability of soil aggregates under disruptive action of water
is decreased.

Wada and Higashi (1976) consider the metal-humus complex
in soil to have important implications in the formation and
transformation of clay minerals.

In his review Sequi (1978) concludes that soil structure
involves the interaction between inorganic component and organic
matter which also includes the living organisms. Organic matter
is considered to be the unifying factor in soil dynamics while
the inorganic moiety is to be regarded as the determining factor
which differentiates the soil on a physical basis.