Chapter - 2

Review of Literature
2. REVIEW OF LITERATURE

2.1 Effect of Pesticides on soil physico-chemical properties

Modern farming techniques involving improved irrigation, high yielding varieties and agrochemicals are adopted in India to meet the growing needs, demands and food production of increasing population density. Increasing crop loss due to pests is a major constraint in sustaining agricultural productivity and production. Pesticide is an essential ally in the farmer's struggle to protect their crops. Pesticide use is high in the regions with good irrigation facilities and in the areas where commercial crops are grown. For instance, cotton and paddy are grown in 5% and 24% of cropped area and receive about 45% and 20% of total pesticides respectively (Shetty, P.K., 2003). Pesticides are often applied several times during one crop season and a part always reaches to the soil. The behavior of pesticide in soil depends upon the physical and chemical properties such as moisture, pH, redox status, organic matter, available nutrients and interactions between solid, liquid and gaseous phases of the soil (Komal Vig et al., 2001). The crop yield is influenced by the soil physico-chemical properties such as salinity, soil texture, soil structure, soil depth, organic matter, fertilizers and pesticides (Black, 1968 ; Thornley and Johnson, 1990 ; Hanks and Ritchie, 1996 ; Tanji, 1996). Bullock and Bullock (2000) pointed out that soil physico-chemical properties are important for precision agriculture.

2.2 Effect of Selected Pesticides on Bacterial and Fungal Population

The Microorganisms contribute to the formation of stable soil structure (Gupta and Germida, 1988) Microorganisms mediate processes such as mineralization, nitrogen fixation, ammonification, Carbon storage and maintenance of the over all equilibrium of soils (Embley et al., 1999 ; O’Donnel et
al., 1994). The productivity and health of agricultural systems are, in part, dependent upon the functional processes of soil microbial communities (Doran and Zeiss, 2000; Killham, 1994, Pankhurst, 1997).

Soil bacteria occupied a key position in the global cycling of carbon and other elements because of their abundance in the range of $10^6$ to $10^9$ per gram of soil (Alexander, 1977). Fungi with a population of $10^4$ to $10^6$ per gram of soil account for as much as 70% by weight of the biomass (Alexander, 1977). High inputs of inorganic fertilizers and pesticides cause change in soil bacterial and fungal densities (Boddington and Dodd, 2000; Gorlach-Lira et al., 1997). Pesticide cause suppression or promotion of microbial growth and activity (Boldt and Jacobson, 2001; Haney et al., 2000). Pesticide addition did not significantly affect bacterial number or heterogeneity, but it led to major shifts in the active soil bacterial community structure (Martina et al., 2004). Pesticide addition had a negative effect on the culturable bacterial numbers in the samples, but there was no such effect for the total bacterial community (Martina et al., 2004). The pesticides have been shown to adversely affect the numbers of organisms in the microbial community only when they are applied at the rates that far exceed the recommended rates (Ghani and Wardle, 2001; Gigliotti, 1998; Rebecchi et al., 2000; Tu et al., 1995).

The low amounts of pesticides applied to the clay loam is unlikely to have detrimental effects on soil microbes (Tu, 1981). Imidacloprid had no significant effect on fungi and actinomycetes (Singh and Singh, 2005), however significant increase in bacterial and azotobacter population was observed (Singh and Singh, 2005). The pesticide treatments had significantly different effects on the
rhizosphere microflora and their activities, depending on the kind of pesticide and the model of application, individually or in combination (Banerjee and Dey, 1992).

2.3 Soil enzyme activities

Enzymes are catalysts, that is, they are substances without undergoing permanent alteration cause chemical reactions to proceed at faster rates. In addition they are specific for the types of chemical reactions in which they participate (Tabatabai, 1994). Physico-chemical measurements indicate that enzyme catalyzed reactions in soils have lower activation energies than non enzyme catalyzed reactions and therefore have faster reaction rates (Browman and Tabatabai, 1978 ; Dick and Tabatabai, 1978). Enzymes in soil are similar to enzymes in other systems in that their reaction rates are markedly dependent on pH, ionic strength, temperature and the presence or absence of inhibitors (Burns, 1978 ; Tabatabai, 1982). Soil enzymes are produced from microorganisms, plants and animals but production from the plants and animals is limited for several reasons. Micro-organisms seem the main choice for supplying the most of soil enzyme activity because of their large biomass, high metabolic activity and relatively larger amount of extra cellular enzymes than can plants or animals (Speir and Ross, 1978 ; Burns, 1986). Enzyme activity in soils reflects not only enzymes in soil solution and living tissue but also enzymes bound to soil colloids and humic substances (Skujins, 1976 ; Nannipieri et al., 1990). Enzymes have been suggested by some researchers as potential indicators or monitoring tools to assess soil quality (Dick, 1994 ; Bandick and Dick, 1999) and bioremediation activities (Margesin et al., 2000). Hofmann and Seegerer (1950) proposed the activity of enzymes as an index of the fertility status of the soil. Soil climate, cultivation and amendments are the indices of the enzyme activity (Skujins,
Enzyme activity is influenced by soil conditions such as organic matter content (Pancholy and Rice, 1973; Lalande et al., 1998; Kandeler et al., 1999a), moisture (Bergstorm et al., 1998; Ross and Speir, 1984), temperature (Tscherko et al., 2001), cultivation (Bandick and Dick, 1999; Kandeler et al., 1999b) and fertilization (Ross et al., 1995; Ajwa et al., 1999).

Repeated applications of a single pesticide or a chemically similar pesticide may lead to the pesticide being so rapidly degraded. Soil enzymes are involved in enhanced biodegradation of pesticides, has been reported for the insecticides insofenfos and fonofos (Murphy and Minor, 1986; Sikora and Kaufman, 1987). Enhanced biodegradation by phosphatases has been reviewed by Racke and Coats (1990). The involvement of soil enzymes in the degradation of organo phosphorous insecticides and acylanilide herbicides has been reviewed by Burns and Edwards (1980). Organo phosphorous insecticides were found to degrade faster in irradiated soils than in those that had been autoclaved (Burns and Gibson, 1980; Getzin and Rosefield, 1968). Soil enzyme involvement in the transformation of organic compounds comes from the studies in which soils are first extracted with a buffer and the extract is then used as a crude source of enzyme activity (Bartha and Bordeleau, 1969). Getzin and Rosefield (1968, 1971) extracted a cell free enzyme able to degrade malathion from soil. Bollag et al., (1987) studied the extraction and purification of peroxidases from soil.

Transformation of organic compound in soil by enzymes can involve several different types of processes. Enzymes protect soil against the accumulation of harmful organic compounds by catalyzing degradation, polymerization, synthesis, coupling and incorporation into humic substances (Philip and Preusse, 1985). Direct additions of purified or partially purified
enzymes to soil, increased the rates of transformation of organic compounds but the effect is temporary (Dick and Tabatabai, 1983; Shannon and Bartha, 1988). Free enzymes in a partially purified form are immediately and effectively inhibited when added to soil (Dick and Tabatabai, 1983; Hope and Burns, 1987).

Measurement of enzyme activities are of great value in screening the susceptibility of soil processes to agrochemical amendments (Nannipieri, 1994; Weaver et al., 1994; Alef and Nannipeiri, 1995). Assay of soil enzymes like amylase, cellulase, dehydrogenase, invertase, phosphatase, Protease and Urease indicate the importance of their role in complement of chemical and microbial analyses (Nannipieri and Landa, 2000). Soil enzyme activity is considered as an index of microbial activity in the soil (Sriramachandrasekharan and Vaiyapuri, 2002).

2.3.1 Amylase activity

Amylases are widely distributed in soils with a wide range of activities (Ladd, 1978). Amylase catalyzes the hydrolytic depolymerisation of polysaccharides in soil (Tu and Miles, 1976). Starch hydrolyzing enzymes are usually extracellular and inducible but the activity of microorganisms to form amylolytic enzymes depends on the type of starch (Alexander, 1977). α- and β-amylases may be concerned in the breakdown of starch and related oligo – and polysaccharides to D-glucose units (Schaffer, 1993). Amylase activity is correlated significantly with bacterial and fungal population (Joshi et al., 1993). Activity of amylase is enhanced by the pesticides in clay soil (Tu, 1990). Fensulphothion, Diazinon, Malathion, Terbufos, Carbofuran and Permethrin stimulated the activity of soil amylase (Tu, 1990). Monocrotophos, Quinalphos, Cypermethrin and Fenvalerate stimulated soil amylase activity significantly.
(Rangaswamy and Venkateswarlu, 1992a). Chlorfenvinphos, Chlorpyrifos, Diazinon, Ethion, Ethoprophos, Fonofos, Leptophos, Malathion, Parathion, Phorate, Thionazin, Triazophos, Trichloronate, Terbufos, Pernethrin and glyphosate showed stimulatory action on soil amylase (Tu, C.M., 1982).

Insecticides DOWCO 429X, DPX 43898 and Tefluthrin did not show any effect on soil amylase activity but activity was enhanced when the pesticides are applied to an organic soil (Tu, 1990). An inhibitory effect was observed on amylase after one week, while significant recovery was observed after 3 weeks by the application of Cyfluthrin and Imidacloprid (Tu, C.M., 1995).

2.3.2 Cellulase activity

Soil cellulase is a core enzyme, consisting of exo-, endo- and β-glucosidases which act on cellulose polysaccharide substrate. Cellulose present in soil ecosystem was hydrolyzed by cellulase (Mallik and Sharma, 2002). Assays of activity have been based on the decomposition of cellophane disks, cellulose powder and the hydrolysis of carboxymethyl cellulose (Ladd, 1978). The products of cellulose degradation are glucose, cellobiose and higher molecular weight oligosaccharides (White, 1982). However, the rate of cellulose degradation in natural organic litter is not exclusively related to extra – and intra – cellular cellulase activity but is also related to the activity of other hydrolytic as well as oxidative enzymes (Eriksson and Wood, 1985; Ljungdohl and Eriksson, 1985).

Enzyme activity of cellulase was stimulated with 500-1000 ppm of γ-HCH (Endo et al., 1982). The cellulase activity increased up to 50% particularly after treatment of fenamiphos (Ross et al., 1984). Cellulose hydrolysis into glucose is mainly achieved by a complex enzyme cellulase produced by fungi (Maile and Linkins, 1978). Liberation of extra cellular enzymes of cellulase by microbes may
be influenced by many factors like temperature, moisture, pH and substrate concentration (Linkins et al., 1984). The cellulase activity was potential correlated with fungal and bacterial population in soil (Joshi et al., 1993).

Cellulase activity in black and red soils was enhanced significantly by tridemorph and captan upto 5kg ha\(^{-1}\) at 10 day interval (Srinivasulu and Rangaswamy, 2006). Malathion an organophosphorous insecticide showed no drastic effect on cellulase activity (Tu, 1990). Benomyl and dithane M-45 reduced the activity of cellulase in culture filtrates (Ashour et al., 1980). Fenamiphos at higher concentrations of 37 and 930mg/kg had deleterious effects on cellulase. 24 to 48% of reduction in cellulase activity is observed even after the incubation of 62 days under laboratory conditions (Ross and Speir, 1985). Metsulfuron – methyl application caused the reduction of cellulase activity in malasian soils (Ismail et al., 1998).

2.3.3 Dehydrogenase activity

Dehydrogenases catalyse oxidative activities in a cascade of events involving specific carriers, electrons are transferred from substrate to oxygen as the final acceptor (Schaffer, 1993). Dehydrogenase activity is a measure of the intensity of microbial metabolism and thus of microbial activity in soil (Tabatabai, 1982; Nannipieri et al., 1990). As oxygen is excluded from the soil, the total anaerobic activity increases and is reflected in an increase in dehydrogenase activity (Ladd, 1978). Dehydrogenase activity was significantly greater with tebupirimphos and Aztec (Tu, C.M., 1995). Dehydrogenase activity was not impaired owing to imidacloprid application in treated mung field (Amrit kaur and Amarjeet kaur, 2005). In imidacloprid seed treated field, the dehydrogenase activity was increased (Sing, J and Sing, D.K, 2004). No inhibition of
dehydrogenase activity with the treatments of chlorfenvinphos, chlorpyrifos, diazinon, ethion, ethoprofos, fensulfothion, fonophos, leptophos, malathion, parathion, phorate, thionazin, triazophos, trichloronate, terbufos and permethrin all at 5 and 10mg/kg with in 7 days in a clay soil (Tu, C.M., 1981).

Significant increase in dehydrogenase activity was noticed with lower concentrations of five pyrethroid insecticides as permethrin, FMC 45498, Shell WL 43467 and Shell WL 43755, after 3 weeks of incubation (Tu, C.M., 1980b). The dehydrogenase activity was significantly increased with increasing concentrations of two organophosphorous insecticides monocrotophos and quinalphos and two synthetic pyrethroids cypermethrin and Fenvalerate at 2.5kg/ha (Rangaswamy et al., 1994). Methyl parathion at 15kg/ha stimulated soil dehydrogenase activity and inhibited at 150-300kg/ha (Naumann, 1970). Methidathion, Methoate and Parathion reduced dehydrogenase activity in alluvial soils (Bayer et al., 1982). Dimethoate and phenmedipham affected microorganisms involved in dehydrogenase activity (Heinonen et al., 1989). Primicarb inhibited dehydrogenase activity at higher concentration (Schustear and Schroder, 1990). DDT at 10-100mg/kg and it’s metabolites affected dehydrogenase activity (Vink and Straalen,1999). Endosulfan at the concentration of 750g/ha inhibited soil dehydrogenase activity (Manisha and Rai,1999). Dehydrogenase activity was severely affected by benomyl,captan and chlorothalonil (Chen et al.,2001a ,b). Soil dehydrogenase activity was negatively affected by chlorothalonil (Singh et al.,2002).

2.3.4 Phosphatase activity

Phosphatases are extracellular enzymes that catalyze the hydrolysis of esters and anhydrides of phosphoric acid (Speir and Ross,1978). They are
produced by over 75% of soil microflora. Soil phosphatases play a major role in the mineralization of organic phosphorous substrates which is principally a microbial phenomenon (Appiah and Thompson, 1974). In soils cell-free phosphatases constitute a major proportion of these enzymes and should play a considerable role in the constant mineralization of organic matter (Speir and Ross, 1978). Hoffman (1968) suggested three types of phosphatases – acid, neutral and alkaline. After studying the literature, soil phosphatase activity can be related to soil organic matter (Kiss et al., 1974; Nannipeiri et al., 1973; Jordan and Kremer, 1994; Aon and Colaneri, 2001), total nitrogen (Speir, 1978; Aon and Colaneri, 2001), soil organic phosphorous content (Gavrilova et al., 1973) and moisture content (Harrison, 1981, 1987; Neal, 1990).

In Imidacloprid seed treated field, dehydrogenase activity was increased (Singh, J. and Sing, D.K., 1999) 32 pesticides applied at 2 levels on populations of microorganisms did not inhibit phosphomonoesterase activity in black clay soil (Tu, C.M, 1981b). In unamended soil, rhizosphere phosphatase activity was increased with an increase in phosphorous deficiency caused by increased root density and decreased inorganic phosphorous levels (Hedley et al., 1983). Mg\(^{2+}\) increases and Na\(^{+}\) decreases the activity of phosphatases in soil (Germida and Siciliano, 2003). Phosphatase activity was stimulated with monocrotophos, quinalphos, cypermethrin and Fenvalerate in ground nut soil at 2.5kg/ha for 10 days (Rangaswamy and Venkateswarlu, 1996). Higher levels of phosphatase activities were observed with malathion, pirimiphosmethyl and dimethoate in treated soils (Hasan, 1999). Malathion and parathion at 5mg/kg stimulated the activity of the phosphatase in a clay loam soil (Tu, 1989). In rice crop soils phorate and Fenvalerate released more available phosphorous by the
proliferation of phosphate solubilising microbes (Das and Mukherjee, 1994, 1998a). In an organic soil parathion, triazophos, permethrin and fonofos at 5mg/kg reduced the phosphatase activity by a two fold (Tu, 1981b). Pesticide fenitrothion had no effect on the activity of phosphatase in soil (Nakamura et al., 1990). DDT at 10-100mg/kg inhibited the soil phosphatase activity for 20 days (Megharaj et al., 1999a). Phosphatase activity was reduced with 100ppm of carbofuran in mysore soils (Basavaraj and Siddaramappa, 1991). The fungicides captan and benomyl inhibited phosphatase activity in soils (Chen et al., 2001a and b). Monocrotophos and quinalphos were inhibitory to phosphatase at 7.5kg/ha in four experimental soils (Rangaswamy and Venkateswarlu, 1996).

2.3.5 Urease activity

Urease catalyses the hydrolysis of urea to ammonium and carbon dioxide. Urease activity in soil originates predominantly from microorganisms and is correlated with the soil organic matter content (Beri et al., 1978). Urease activity accumulates in soil to a significant extent (Burns, 1978). Urease, in particular, has attracted a good deal of attention due, in part, to the increasing agricultural importance of its substrate, urea (Cooke, 1969).

Diazinon, significantly reduced urease activity in blue gross sod. Diazinon appears to have a significant and short term inhibitory effect on microbial urease producing community, but that effect depends on type of the soil (Ingram et al., 2005). Neither imidacloprid nor diazinon inhibited urease activity in soil slurry (Ingram et al., 2005).

Glyphosate, paraquat, trifluralin and atrazine did not cause any change in the urease activity (Davies and Greaves, 1981). Pyrethroids like Permethrin, FMC 45498, Shell WL 41706, Shell WL 43476 and Shell WL 43775 were found
to have no effect on urease activity in sandy loam soil (Tu, 1980b). Lower concentrations of carbofuran at 10kg/ha enhanced urease activity in black and red soils (Basavaraj and Siddaramappa, 1991). Profenofos accelerated urease activity after 6 weeks of incubation (Abdel Mallek et al., 1994). Parathion, methidathion and methoate at recommended field rates had no effect on urease activity during about 6 weeks (Bayer et al., 1982). Fenamiphos at 18.6kg/ha reduced the activity of urease under field conditions (Ross et al., 1984; Ross and Speir, 1985). Reduced urease activity was observed with fenamiphos but recovered after one month (Tu, et al., 1995).