4. RESULTS AND DISCUSSION

Microbes mediate important biochemical transformations associated with nutrient cycling in soils. Since these soil biochemical transformations are indicators of soil quality (Verchot and Borelli, 2005), biochemical properties related to biocycles of elements (C, N and P) are used to diagnose soil quality. These properties include general biochemical parameters—nitrogen mineralisation and specific biochemical parameters—the activities of hydrolytic enzymes such as cellulase, amylase, protease, urease, phosphatase, and dehydrogenase. In view of rapid formation of 2-hydroxyquinoxaline from a widely used organophosphorus insecticide, quinalphos, soil quality was monitored using nitrogen mineralisation and soil enzymes of C, N and P biocycles in two soils under the influence of 2-hydroxyquinoxaline.

4.1. Effect of 2-hydroxyquinoxaline on nitrogen mineralisation in soils

The nitrogen mineralisation capacity refers to capability of soils to transform organic nitrogen compounds into ammonium/nitrate under optimum moisture and temperature conditions over a period of time. This determination has been used to assess the influence of 2-hydroxyquinoxaline on soil quality.

4.1.1. Ammonification

Microbial processes, in particular, associated with nitrogen cycle, are often chosen as test systems owing to the ecological significance of nitrogen transformation in the biosphere. Hence, ammonification, a first step in the nitrogen mineralization was studied under the influence of 2-hydroxyquinoxaline in the laboratory as described under section 3.4.
The sum of different forms ($\text{NH}_4^+$ - N + NO$_2^-$ - N + NO$_3^-$ - N) of inorganic nitrogen formed from organic nitrogen in soils indicate total ammonifying activity because NO$_2^-$ - N and NO$_3^-$ - N can occur after the formation of NH$_4^+$ - N from organic nitrogen in soils. Ammonifying activity reached peak on 5th or 10th day of incubation in both soils amended with/without 2-hydroxyquinoxaline (Fig. 2 & 3). More than 50% of added organic nitrogen was recovered as NH$_4^+$ - N in both soils with/without amendment of 2-hydroxyquinoxaline with in 5 days of incubation. Black soil exhibited more ammonifying activity than red soil. 2-Hydroxyquinoxaline was innocuous to ammonification in red soil except on 15th day of incubation. 2-Hydroxyquinoxaline was initially innocuous to ammonification in black soil as reflected by recovery of ammonia to the same extent from black soils with and without 2-hydroxyquinoxaline (Fig. 2 & 3). 2-Hydroxyquinoxaline was inhibitory to ammonifying activity in black soil at both concentrations of 2 and 10 ppm on 10th day. Soil made recovery from the inhibition later 15th day onwards. Quinalphos the parent compound of 2-hydroxyquinoxaline was shown to be stimulatory to ammonification along with other insecticides, monocrotophos and cypermethrin even at higher concentration of 25 ppm (Vijaya Ananda Kumar Babu, 2000). Similarly, monocrotophos and quinalphos enhanced ammonification in soils up to 2.5 kg ha$^{-1}$ but higher concentration of these insecticides were toxic to mineralization process in two agricultural soils (Rangaswamy and Venkateswarlu, 1990, 1993). Similar observations on ammonification in soils were made with other organophosphates chlorpyrifos, methyl parathion, dichlorvos, phorate (Jaya Madhuri, 2004). Organophosphates such as diazinon and zinophos at level of 100 ppm were reported to stimulate ammonification after 1 week of incubation in a sandy loam.
Fig. 2. Effect of 2-hydroxyquinoxaline on ammonification in black soil

Values plotted in the figure are means of triplicates
Fig. 3. Effect of 2-hydroxyquinoxaline on ammonification in red soil

Values plotted in the figure are means of triplicates.
soil (Tu, 1970). Ammonification was enhanced by diazinon, chlorpyrifos and thionazin all at 1 or 10 kg ha\(^{-1}\) in a sandy loam soil (Tu, 1969). Chlorpyrifos, diazinon, ethoprophos, fensulfothion stimulated ammonification from added peptone (Tu, 1970, 1972). In contrast, the formation of ammonical nitrogen was less in soils treated with disyston and Thimet at 100 ppm (Singh and Gulati, 1972), pirimiphos-ethyl and fonofos at 11 kg ha\(^{-1}\) (Gawaad et al., 1973a) and disulfoton at 1 kg ha\(^{-1}\) (Rajukannu et al., 1976). According to the study of Idris (1973), higher concentrations of both monocrotophos and methidathion were toxic to ammonification. In a similar way, the application of fensulfothion at field rates was innocuous or toxic to ammonification (Ross, 1974). Tu (1989) reported that ammonium production was not appreciately altered by the treatments of DOWCO 429 X, DPX 43898, tefluthrin and trichloronate in a sandy loam and an organic soil.

4.1.2. Nitrification

Nitrification is probably the most commonly used soil microbial process for assessing effects of pesticides. Autotrophic nitrification occurs in two steps. The first step corresponds to oxidation of NH\(_4^+\) to NO\(_2^-\) whereas the latter step pertains to oxidation of NO\(_2^-\) to NO\(_3^-\). Thus, nitrification transforms less mobile soil nitrogen into a mobile form. Therefore, nitrification in two soils under the impact of 2-hydroxyquinoxaline under aerobic conditions in laboratory was studied as described earlier under section 3.4.

The sum of NO\(_2^-\) - N and NO\(_3^-\) - N formed from organic nitrogen through NH\(_4^+\) - N in soil represents total nitrifying activity. In both soils the formation of oxidized nitrogen (inclusive of NO\(_2^-\) - N and NO\(_3^-\) - N) from organic nitrogen occurred in lower amounts at earlier interval (5\(^{th}\) day interval) and did not exceed
even 1 μg of nitrogen per gram of soil. Its quantity was increased in both soils with/ without the chemical at latter intervals between 10-30 days of incubation period due to oxidation of higher amounts of $\text{NH}_4^+$ - N and reached peak on 10th and 15th day of incubation. Like ammonification, higher rate of nitrification occurred in black soil than in red soil.

2-Hydroxyquinoxaline was innocuous to nitrification in red soil at both concentrations in this study as indicated by recovery of oxidized nitrogen ($\text{NO}_2^-\text{-} N + \text{NO}_3^-\text{-} N$) from soil with and without 2-hydroxyquinoxaline to the same extent (Fig. 4 & 5). However, 2-hydroxyquinoxaline enhanced nitrification at both concentrations in the black soil (Fig. 4). Higher amounts of oxidized nitrogen was recovered from peptone in 2-hydroxyquinoxaline amended soil in comparison to control.

Monocrotophos, quinalphos, cypermethrin up to 2.5 ppm level caused stimulation in nitrification (Rangaswamy and Venkateswarlu, 1990, 1993; Vijaya Ananda Kumar Babu, 2000). Similarly, other organophosphates such as chlorpyrifos, methyl parathion, dichlorvos, phorate induced stimulation in nitrification at lower concentrations up to 50 ppm in soils (Jaya Madhuri, 2004). Pyrethroids such as permethrin at 0.5 and 5 ppm level had no influence on oxidation of ammonia from native organic matter during the second week incubation but the same insecticide at 5 ppm stimulated nitrification after 4 weeks in a sandy loam soil (Tu, 1980 b). Fonofos and pirimiphos at 1.1 kg ha$^{-1}$ (Gawaad et al., 1973 b) decreased nitrification initially which was latter recovered to normal in a sandy clay soil and clay soil.

In contrast, nitrification was depressed by tefluthrin (Tu, 1989). The pesticide, Baythroid within a range of 0.4-6.4 ppm significantly inhibited
Fig. 4. Effect of 2-hydroxyquinoxaline on nitrification in black soil

Values plotted in the figure are means of triplicates.
Fig. 5. Effect of 2-hydroxyquinoxaline on nitrification in red soil

Values plotted in the figure are means of triplicates
nitrification especially at higher doses in a silty clay soil during 25 days of incubation (Lodhi et al., 1994). Pell et al., (1998) observed that large number of pesticides at 100 ppm were inhibitory to potential ammonium oxidation activity in soil. Similarly, Telone C at 90 L ha\(^{-1}\) decreased nitrification of native organic nitrogen and of fortified (NH\(_4\))\(_2\) SO\(_4\) - nitrogen in loamy sand soil samples for two weeks (Tu et al., 1996). Zinophos at 10 and 100 ppm depressed nitrification of soil organic matter for two weeks and to a lesser extent after 3 weeks in a sandy loam soil (Tu, 1970).

4.2. Effect of 2-hydroxyquinoxaline on soil enzymes

Soil enzymes play an essential role in catalyzing reactions necessary for the decomposition of organic matter and nutrient cycling in ecosystems (Taylor et al., 1989; Dilly and Irmler, 1998; Johansson et al., 2000) involving a range of plants, microorganisms, animals and their debris (Granass et al., 1999). Therefore, changes in enzymes could alter the availability of nutrients for plant uptake and these changes are potentially sensitive indicators of soil quality (Ajwa et al., 1999; Albiach et al., 2000, Aon et al., 2001; Aon and Colaneri, 2001). Soil enzymes activities are used as indices of microbial activity and soil fertility (Deng and Tabatabai, 1997; Bandick and Dick, 1999; Kang and Freeman 1999; Criquiet et al., 2000; Alvarez and Guerrero, 2000). The impact of 2-hydroxyquinoxaline on activities of soil enzymes involved in biocycles of C, N and P elements was examined.

4.2.1. Cellulase activity

With regard to the enzymes involved in the carbon cycle, cellulase has been the most widely used in the evaluation of soil quality in soils (Bandick and Dick, 1999; Saviozzi et al., 2001). Cellulase plays an important role as a group of
enzymes in global recycling of abundant polymer, cellulose in the nature. Therefore, influence of 2-hydroxyquinoxaline on cellulase activity in two soils was determined in the manner as described under section 3.5.1.

2-Hydroxyquinoxaline was toxic to cellulase activity in black soil at both concentrations on only 10 days of incubation as reflected by low cellulase activity in 2-hydroxyquinoxaline - amended soil in comparison to control (Fig. 6). Inhibition of cellulase activity by 2-hydroxyquinoxaline in the black soil was more pronounced at higher concentration 10 ppm. About 19% decrease in cellulase activity in black soil at 2 ppm of 2-hydroxyquinoxaline was recorded as against 37% in the same soil by the same metabolite at 10 ppm concentration at 10th day interval. Cellulase activity in black soil was recovered from this inhibition at later intervals of incubation. 2-Hydroxyquinoxaline amended black soil exhibited higher cellulase activity on 20th day and 30th day incubation over control. 2-Hydroxyquinoxaline appeared to be less toxic to cellulase activity in other soil, red soil used in this study (Fig. 7). Inhibition of cellulase activity in red soil by 2-hydroxyquinoxaline at only 2 ppm on 10th day of incubation was found and even did not exceed about 11% of cellulase activity in control. 2-Hydroxyquinoxaline was stimulatory to cellulase activity in red soil at later incubation intervals at both concentrations.

Quinalphos, the parental compound of 2-hydroxyquinoxaline was stimulatory to cellulase activity in soils even at highest concentration (25 ppm) throughout incubation period of 30 days (Vijaya Ananda Kumar Babu, 2000). Similarly, organophosphates - chlorpyrifos, methyl parathion, dichlorvos, phorate stimulated cellulase activity in soils at concentration up to 50 ppm level (Jaya Madhuri, 2004). But the same insecticides at higher concentrations were
Fig. 6. Effect of 2-hydroxyquinoxaline on cellulase activity in black soil

Values plotted in the figure are means of triplicates. Bars marked with the same letter are not significantly different (P<0.05) from each other according to DMR test.
Fig. 7. Effect of 2-hydroxyquinoxaline on cellulase activity in red soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
toxic to cellulase activity. Similarly, cellulase activity increased up to 50% by the nematicide, fenamiphos at 18.6 kg ha\(^{-1}\) in a fine silty montomylonilontite under green clover pasture (Ross, et al., 1984). However, the same pesticide at higher level, 39 and 930 mg kg\(^{-1}\) had deleterious effect on cellulase with reduction in activity by 24 and 48% respectively even 62 days after treatment under laboratory conditions (Ross and Speir, 1985). The same compound reduced the activity by 10% over control even under field condition. 2-Hydroxyquinoxaline, a metabolite of quinalphos was shown to be stimulatory to cellulase activity in soil except initial stage of incubation.

4.2.2. Amylase activity

Amylases catalyse the hydrolytic depolymerisation of the polysaccharide, starch in soil. The activity of amylase under the impact of 2-hydroxyquinoxaline in two soils under the laboratory conditions was studied as mentioned in the section 3.5.2.

Amylase activity was high in both soils with/without 2-hydroxyquinoxaline at earlier intervals, 0 or 10 day interval and dropped to low levels at latter interval, 30-day incubation (Fig 8 & 9). Decrease in activity of amylase at latter intervals may be due to depletion of nutrients in soils. Though no consistent trend in amylase activity in soils was noticed, 2-hydroxyquinoxaline even at higher level appeared to be innocuous or stimulatory to amylase activity in both soils at all time intervals except 30 day incubation. However, amylase activity was enhanced by the parent compound, quinalphos at lower concentration up to 2.5 kg ha\(^{-1}\) but was inhibited by the same compound at concentration higher than 2.5 kg ha\(^{-1}\) in soils (Rangaswamy and Venkateswarlu, 1992a). Similarly, four organophosphates chlorpyrifos, methyl parathion, dichlorvos, phorate caused stimulation in
Fig. 8. Effect of 2-hydroxyquinoxaline on amylase activity in black soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
Fig. 9. Effect of 2-hydroxyquinoxaline on amylase activity in red soil

Values plotted in the figure are means of triplicates. Bars marked with the same letter are not significantly different (P<0.05) from each other according to DMR test.

Values plotted in the figure are means of triplicates. Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test.
Effect of 2-Hydroxyquinoxaline on Microbial Activities in soils

Results and Discussion

Amylase activity in soils at lower concentrations up to 5 kg ha\(^{-1}\) but the same insecticide inhibited amylase activity at higher concentration of 10 kg ha\(^{-1}\) in soils (Jaya Madhuri, 2004). Several pesticides including organophosphates at 5 and 10 mg kg\(^{-1}\) caused enhancement in amylase activity (Tu, 1982). On contrary, no effects were observed with tefluthrin, DOWCO 429X and DPX 43898 at 10 mg kg\(^{-1}\) in a sandy loam soil (Tu, 1990) and fenamiphos at 18.6 kg ha\(^{-1}\) (Ross and Speir, 1985).

4.2.3. Protease activity

Proteases promote break down of proteinaceous substances in soil to simpler nitrogenous compounds that are available for plant nutrition. Protease activity was measured in terms of tyrosine equivalents formed from casein in soil samples under the influence of 2 hydroxyquinoxaline as described under section 3.5.3.

Both soils with/without 2-hydroxyquinoxaline exhibited maximum activity in protease on 10\(^{th}\) day of incubation (Fig. 10 & 11). 2-Hydroxyquinoxaline was not toxic to protease activity even at higher concentration. About 12,000 pg of tyrosine equivalents was formed from casein in 2-hydroxyquinoxaline amended red soil as against 11,250 pg in control on 10\(^{th}\) day. Protease activity in 2-hydroxyquinoxaline amended red soil at 2 ppm level was comparable to that of control. But protease activity in 2-hydroxyquinoxaline amended red soil at higher concentration was slightly lower than that of control. 2-Hydroxyquinoxaline was stimulatory to protease activity in black soil at both concentrations used in this study on 10\(^{th}\) day of incubation. This stimulation in protease activity by 2-hydroxyquinoxaline did not exceed about 20% over control.
Fig. 10. Effect of 2-hydroxyquinoxaline on protease activity in black soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
**Fig. 11.** Effect of 2-hydroxyquinoxaline on protease activity in red soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
2-Hydroxyquinoxaline-amended black soil at both concentrations yielded protease activity lower than control by 15% on 30th day incubation.

Insecticides, including quinalphos caused stimulation in protease activity in soils at lower concentration up to 25 ppm level (Rangaswamy et al., 1994; Vijaya Ananda Kumar Babu, 2000). Similar observations on protease activity in soils amended with four organophosphates chlorpyrifos, methyl parathion, dichlorvos, phorate were recorded (Jaya Madhuri, 2004). In the present study, 2-hydroxyquinoxaline, a degradation product of quinalphos was stimulatory at earlier intervals to protease activity in soils. This stimulation was not noticed in later intervals of incubation.

4.2.4. Urease Activity

Urea is an organic chemical used as a nitrogenous fertilizer in agriculture. Conversion of organic nitrogen to inorganic nitrogen through hydrolysis of urea to ammonia and carbon dioxide is due to activity of urease enzyme secreted by certain microorganisms and plants. This enzyme is responsible for supply of nitrogen demand to growing crop. Since urease has also been used in the evaluation of changes in soil quality (Pascual et al., 1999; Chakrabarti et al., 2000), the effect of 2-hydroxyquinoxaline on urease activity in two soils under aerobic conditions in laboratory was assessed.

2-Hydroxyquinoxaline appeared to be innocuous to urease activity in black soil (Fig. 12) throughout incubation period as urease activity in 2-hydroxyquinoxaline - amended soil was comparable to that of control. In red soil, 2-hydroxyquinoxaline inhibited urease activity by 40% over control at 0 - day interval (Fig. 13). This level of inhibition in urease activity in metabolite - amended soil was not noticed at latter intervals due to recovery. On contrary,
Fig. 12. Effect of 2-hydroxyquinoxaline on urease activity in black soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
Fig. 13. Effect of 2-hydroxyquinoxaline on urease activity in red soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
addition of insecticides including quinalphos, at 2.5 kg ha^{-1} significantly increased urease activity on 10^{th} day incubation in black and red soils (Rangaswamy and Venkateswarlu, 1992a; Vijaya Ananda Kumar Babu, 2000). Other organophosphates, chlorpyrifos, methyl parathion, dichlorvos, phorate were shown to be stimulatory to urease activity in soils at lower concentrations up to 50 ppm but were toxic to urease activity at higher concentration in soils (Jaya Madhuri, 2004). Tu (1995) reported initial inhibition of enzyme activity for one week followed by stimulation after two weeks in sandy soil treated with four experimental insecticides. Organophosphates, such as fenitrothion, malathion and phorate at elevated doses in a range of 50 and 1000 mg kg^{-1} strongly inhibited urease activity by 40 - 50\% throughout 60 days in a sandy clay soil and a silt loam soil (Lethbridge and Burns, 1976). Furthermore the rapid disappearance of the parent compound, malathion was observed in the study suggesting that the inhibition of the urease activity was mediated by one or several metabolites rather than by the parent compound. According to Gianfreda et al., (1994), glyphosate enhanced urease activity in native soils by 1.1 to 1.4 folds and in soils components by 2.59 to 6.73 folds at concentrations of 0.3 and 1.5 mM but had no influence on free or immobilized jack-bean meal urease. In another study, urease activity was not affected by the presence of glyphosate at 5.4 kg ha^{-1} in soil (Davies and Greaves, 1981). Pesticides including organophosphorus insecticides could disrupt urea hydrolysis in soils at higher dose in a range of 100 - 1000 ppm (Lethbridge et al., 1981). Fenamiphos at 18.6 kg ha^{-1} reduced the activity of urease under field conditions but after 5 months, activity was same as in control while no effect was observed under laboratory conditions (Ross et al., 1984; Ross and Speir, 1985).
4.2.5. Phosphatase activity

Phosphatases play a key role in phosphorus mineralisation and P cycling. They catalyze hydrolysis of organic phosphorus in soil releasing inorganic phosphorus for uptake of plants and microbes (Tabatabai, 1994; Alef and Nannipieri, 1995; Amador et al., 1997; Condron et al., 2005). Phosphatase enzymes are actively secreted into soil by many plants and microbes in response to demand for inorganic phosphorus or passively released from decaying cells (Quiquampoix and Mousain, 2005). Hence, phosphatase activity was measured under the influence of 2-hydroxyquinoxaline in two soils in the laboratory as described under section 3.5.5.

Hydrolysis of an exogenously added substrate, p-nitrophenyl disodium orthophosphate by phosphatases was greater in red soil, than in black soil (Fig. 14 & 15). The rate of hydrolysis of p-nitrophenyl phosphate was similar in both soils with/without 2-hydroxyquinoxaline. About 60 and 40 μg of p-nitrophenol per gram of soil were released on 10th and 30th day of incubation in black soil amended with/without 2-hydroxyquinoxaline. The similar trend was observed in respect of red soil. It was clear that 2-hydroxyquinoxaline had innocuous effect on phosphatase activity in both soils.

Quinalphos, the parent compound of 2-hydroxyquinoxaline was shown to be stimulatory to phosphatase at all concentrations within a range of 1-5 kg ha⁻¹ but was inhibitory to phosphatase activity at concentrations higher than 5 kg ha⁻¹ (Rangaswamy and Venkateswarlu, 1996; Vijaya Ananda Kumar Babu, 2000). Similar observation on phosphatase activity in soils were made with other organophosphates-chlorpyrifos, methyl parathion, dichlorvos, phorate (Jaya Madhuri, 2004). Chlorpyrifos, tebufos and fonfos increased activities of acid
Fig. 14. Effect of 2-hydroxyquinoxaline on phosphatase activity in black soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
Fig. 15. Effect of 2-hydroxyquinoxaline on phosphatase activity in red soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
phosphatase in a loam soil sites in the field (Sikora et al., 1990). On the contrary, parathion, triazophos, permethrin and fonofos at 5 mg kg$^{-1}$ reduced the phosphatase activity by 2 fold (Tu, 1981 b). But malathion and parathion at the same concentration stimulated the activity in a clay soil (Tu, 1989). On the other hand, the phosphatase activity was not affected by the application of pesticides to some other soils. In a clay loam soil diazinon and chlorpyrifos, at 1 or 10 kg ha$^{-1}$ were innocuous to phosphate mobilization (Tu, 1980 a). In the field study, fenamiphos at 18.6 kg ha$^{-1}$ had no effect on phosphatase activity (Ross et al., 1984). In a similar study under laboratory conditions, fenamiphos at 37 and 930 mg kg$^{-1}$ had no deleterious effect on the activity of phosphatase (Ross and Speir, 1985).

4.2.6. Dehydrogenase activity

Dehydrogenase activity of the soil is considered to be an indicator of the microbial redox system and of the oxidative activities (Trevors, 1984). Since dehydrogenase conduct a broad range of oxidation activities responsible for the degradation of organic matter, dehydrogenase activity has been considered a good measure of microbial oxidative activity in soils (Margesin et al., 2000). Dehydrogenase activity was used to evaluate soil quality in two soils under aerobic conditions in the manner as specified in the section 3.5.6.

In the present study, 2-hydroxyquinoxaline at only higher concentration, 10 ppm inhibited dehydrogenase activity in black soil at all time intervals except 20-day interval (Fig. 16). But, 2-hydroxyquinoxaline at lower concentration was either innocuous or stimulatory to dehydrogenase activity in the same soil. On other hand, 2-hydroxyquinoxaline was more toxic to dehydrogenase activity in red soil even at low concentration of 2 ppm (Fig. 17). This was reflected by recovery
Fig. 16. Effect of 2-hydroxyquinoxaline on dehydrogenase activity in black soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
Fig. 17. Effect of 2-hydroxyquinoxaline on dehydrogenase activity in red soil

Values plotted in the figure are means of triplicates
Bars marked with the same letter are not significantly different (P≤0.05) from each other according to DMR test
of formazan to the lesser extent from the metabolite-amended soil in comparison to control at all time intervals.

Unlike 2-hydroxyquinoxaline, its parent compound, quinalphos caused enhancement in dehydrogenase activity in soils up to 25 ppm level but was toxic to dehydrogenase activity at concentrations greater than 25 ppm (Rangaswamy, et al., 1989; Rangaswamy, et al., 1994; Gundi et al., 2005). In the same studies other pesticides such as monocrotophos, cypermethrin, fenvalerate were also shown to be stimulatory to dehydrogenase activity in soils at lower concentration. The presence of four organophosphates chlorpyrifos, methyl parathion, dichlorvos and phorate caused enhancement in dehydrogenase activity at concentrations within a range of 1-5 kg ha\(^{-1}\) but depression in the enzyme activity at higher concentration of 10 kg ha\(^{-1}\) in soils (Jaya Madhuri, 2004). Methyl parathion at 15 kg ha\(^{-1}\) was reported to stimulate soil dehydrogenase activity. Likewise, tefluthrin, DOWCO 429 X and DPX 43898 at 10 mg kg\(^{-1}\) induced increase in dehydrogenase activity in a sandy loam soil during 2 weeks while dehydrogenase activity was initially reduced by tefluthrin and unaffected by other pesticides in an organic soil after two weeks (Tu, 1990). But dehydrogenase activity was unaffected by several pesticides (Chendrayan et al., 1980). The insecticide quinalphos completely disappeared in soils within two weeks (Babu, et al., 1998) but the presence of its metabolite, which is toxic to microbial activity, raises concern to environmental safety. This needs to be further examined.