CHAPTER–V
DISCUSSION

DISCUSSION

Physico-Chemical Properties of Effluent

The carpet industry used large amount of caustic soda (NaOH) and bleaching powder ($CaOCl_2$) for making the wool unshrinkable and for sharpening the brightness of the carpet. Chemical used in dyeing include acidic dye, potassium dichromate ($K_2Cr_2O_7$) glauber salt (Na_2SO_4), ammonium sulphate ($(NH4)_2\ SO_4$), acetic acid (CH_3COOH) and other salts while those used for washing include soap and washing soda (Na_2CO_3). All these chemicals after being used come out in the form of effluent and giving intermixed colour, i.e. brown during rainy season and dark brown during winter and summer seasons. The recurring inception of effluent in soil may alter the colour of soil surface. The soapanified waste with various salts may block the soil pores of the field. An organic odour of chlorinated moist wool and ammoniated organic odour of effluent was smelled.

Temperature, a catalyst, a depressant, an activator, a restrictor, a stimulator and a controller is one of the most important and influential water quality characteristics to aquatic organisms.

Most of the chemical, biochemical and biological activities are influenced by temperature. During present investigation higher temperature value recorded for effluent in comparission to tube well water (Table – 1; Figure – 1). The steaming action in dyeing and heat of the chemical reactions is responsible for higher temperature of effluent. It may be also due to higher concentration of degradable organic substances through which energy could have been released on account of decomposition leading to the increase of temperature. Similar results were reported by Vashishta and Sra (1979); Grover *et al.*, (1988); Mishra (1988); Ghimire and Bajracharya (1996); Dulari (1996) and Akaninwor *et al.*, (2007).

Although most of the chemical and bio-chemical reaction are influenced by hydrogen ion concentration, the pH of water used for irrigation purpose is normally not a critical parameter. The pH of irrigation water should not exceed a range of 5.5 to 9.0 ISI (1974). The present investigation showed that the pH of effluent was higher than tube well water (Table – 1; Figure – 2). It is due to the presence of excess of caustic soda, bleaching powder and washing soda. The alkaline nature of effluent has been reported by Mishra (1988); Dulari (1996) and Akaninwor *et al.*, (2007).

Electrical conductivity depends on the nature of the various dissolved ionized substances, their actual and relative concentration and the temperature. Most of the inorganic acids, bases and salts contribute to the electrical conductance. Higher electrical conductivity was determined in effluent than tube well water.

Disolved Oxygen (DO) is of much significant value for all the living aquatic organism and considered to be an important factor to reveal the nature of the whole aquatic system at a glance. Most of the physical, chemical and biological activities are directly related to the DO content in natural and waste water. High pollution load decrease the DO value to a considerable level which may be due to decomposition of organic compounds by microorganisms requiring oxygen. The present investigation showed no DO content in effluent (Table – 2; Figure – 5) which could be due to higher organic content. The above observation is supported by the findings of Tripathi *et al.*, (1991); Singh (1992) and Akaninwor *et al.*, (2007).

During the processing of woolen carpets and durries NaOH, $CaOCl_2$, detergent and soap turning are used with continuous water showers till the removal of the chemical. The wool particles also come out with effluent from the woolen carpets and durries. In addition to dissolve chemicals, suspended substances, dye, dust and

wool particles are responsible for very high content of total solids in the effluent, which may be detrimental to the organisms.

Biological Oxygen Demand (BOD) of water determine the amount of oxygen required by the microorganisms, to stablize decomposable organic matter, in a waste water under aerobic condition. It is a measure of the presence of organic materials in aquatic body which supports the growth of microorganisms Ciaccio (1971). In general, BOD is an approximate measure of the amount of biochemically degradable organic matter present in the water and it is used mainly to; (i) determine the degree of pollution in water bodies and their self purification capacity, (ii) pollution stress of waste water and (iii) efficiency of waste treatment. High BOD values indicate higher pollution load and more consumption of dissolve oxygen. A higher BOD of effluent was recorded under present investigation (Table – 2; Figure – 6) which might be due to the higher organic matter content. Similar finding were reported by Somashekar (1985), Agrawal *et al.*, (1986) and Singh (1992).

Chemical Oxygen Demand (COD) indicate the pollution stress and it determines the amount of oxygen required for chemical oxidation of organic matter using a strong oxidant under reflux

conditions. The COD values during the present investigation, were found to be higher in case of effluent (Table – 2; Figure – 7) which might be due to presence of chemically oxidisable substances in effluent. The observation is in accordance with that of Sharma (1986); Venkataswarulu *et al.*, (1987) and Singh (1992).

Alkalinity is an important factor for the water quality. The effect of alkalinity in water used for irrigation, may be important in some instances because it may indirectly increase the relative proportion of sodium in soil water. Higher alkalinity is due to various chemical compounds present in the effluent (Table – 2; Figure – 8).

The used chemicals Na_2CO_3, detergent, soap, dust, dirt and other impurities come out with wool particles as such in effluent. The higher concentrations of Na, K, Mg, Ca, hexavalent Cr, carbonates, chloride, phosphate, sulphate, nitrate, ammonium nitrogen and dye come out with effluent (Tables – 3 and 4; Figure – 9 – 20).

The higher concentrations and increased activity of these chemicals are due to the total escape of these chemicals in the effluent. Similar finding were observed by Mishra (1988); Tripathi *et al.*, (1989), Ghimire and Bajracharya (1996) and Akaninwor *et al.*, (2007).

Physico-Chemical Analysis of Control Soil and Treated Soil

The result presented in present investigation indicated a deleterious effect of effluent on physico-chemical properties of the treated soil. The size and shape of the soil particles and aggregates have a profound effect on the moisture content. Moisture content was found to be more in treated soil as compare to control soil. The electrical conductivity of the soil solution gives an idea of the total soluble salts of the soil.

The soil has the ability to assimilate certain amount of waste product but the regular practice of irrigation with effluent in large quantity in field pollute the soil. When the physico-chemical properties of soil are altered by the pollution, then changes occurs in qualitative and quantitative nature of the microflora. The microorganisms suited to the changed condition survive and multiply where as, the susceptible ones disappear or become restricted. Land application of effluent can cause beneficial as well as harmful effects. Microorganisms are present in all soil. Infact even in the presence of high amount of toxic substances complete distruction of the microflora is rarely possible Singh (1992). The physical characteristics of the soil are equally important as biological and

chemical characteristic for pollutant alteration (Korte *et al.*, 1976; Fuller, 1977; Fuller *et al.*, 1981; Cohe *et al.*, 1983; Tripathi *et al.*,1990; Singh, 1992; Ghimire and Bajracharya, 1996). The factor that influence soil permeability play an important role in pollutant attenution by soil.

The arrangement of soil particle into larger units, is termed as soil structure. Thus structure of soil can control the rate of fluid through soil, water holding capacity and solute retention. Effluent consists of organic carbon (organic matters), nitrogen, phosphorus and heavy metal like Cr (VI). The higher concentration of these chemicals in effluent cause adverse effect on normal physical, chemical and biological properties of soil i.e. porosity, pH, total nitrogen, exchangeable cation like sodium, potassium, calcium magnesium and anion chloride, sulphate, carbonate and nitrate (Tables – 5, 6, 7 and 8). High filtration rates of the soil changes the soil physical properties resulting from organic matter decomposition (Mc Call, 1942; Johnson, 1957 and Singh, 1992). Treated soil showed high potassium, nitrate and phosphorus content as compare to control soil. The porosity was found to be higher in control soil than treated soil. Porosity decreases as the sodium content of soil increases. The salt of sodium and potassium in soap and detergent, excess of sodium in

washing soda in effluent are responsible for the excesses accumulation of sodium in treated soil. Kelly (1963), Black (1968) and Triathi *et al.* (1989) have reported that high sodium content adversely affects the physical properties of soil decreasing permeability by fill in up the pore space of the soil with particles. Bulk density decreases as the porosity increases. The organic matter was higher in treated soil than the control soil.

Soil Microflora of the Control and Treated Field

The most prominent groups of microorganisms isolated from control and treated soils were fungi, bacteria and actinomycetes. The higher fungal population recorded from control soil as compared to the treated one could be either due to presence of some toxic substances therein or due to higher bacterial population which might have suppressed the growth of fungi and their population. Microbial population is considerably influenced by the environmental factors. The reason for decrease in number of general soil microbial population in summer may be due to increase in temperature and subsequently reduction in moisture content of the soil. Increases in general soil microbial population after rainfall could occur due to high soil moisture and moderate temperature. The fungal population in soil

varied with different moisture regions and thus it appear that the moisture has a profound influence on the population. Similar result was reported by Prakash and Khan (1971) and Singh (1992). Variation in fungal population in soil occurs due to the seasonal fluctuation of edaphic factors such as moisture, pH, temperature, aeration, organic matter and available nutrients (Alexander, 1977). The rare occurrence of some fungal species in both the soil samples seems to be due to their inability to withstand competition with other microorganisms Singh (1992). Healthy and diseased plant roots have been shown to support different fungal species which leads to the difference in the mycofloral population and its composition during decay of roots Rai and Upadhyay (1977) and Bashar (1990). Vast quantities of organic residues from crops decompose year after year with release of carbon, nitrogen, hydrogen, plant nutrients and small amount of heavy metals. Such cycling of nutrient is essential for living microorganisms present in soil. Even in the presence of high amount of toxic substances complete destruction of microflora is rarely possible. The most important means of altering the population of microorganisms is to alter the energy or food sources. Growth of microbial biomass on residues enhances turn over of soil organic matter through concurrent immobilization, mineralization and stabilization reaction Voroney *et al.*, (1989).

Fusarium oxysporum f. sp. *lini* and *F. oxysporum* f. sp. *lycopersici* were recorded in high frequency in both the soils. The wide spread occurrence of these species in both the samples can be attributed to their suitability to varying physico-chemical characteristics of the soil. Griffin (1972) has also observed that fungi have wide range of tolerance to individual physico-chemical parameter. Pollutants induce biochemical and physiological changes in the host plant and alteration of physico-chemical environment of the host surface may favour infestation by the pathogen.

Bacteria g^{-1} dry soil was higher in treated soil as compared to the control soil (Table – 11; Figure – 21). The increase in bacterial population in treated soil may be due to presence of more organic matter and humus of different types. Bacteriological characteristics of soil and water as affected by some industrial waste has been reported by Fayes *et al.*, (1988). The other possible reason for lesser number of bacterial population in control soil may be due to presence of large number of actinomycetes which might have suppressed the growth and population of bacteria. Similar finding were reported by Chandra (1990) and Singh (1992).

Per Cent Incidence of Wilting of Tomato in Treated and Control Soil

A higher per cent incidence of wilting of tomato was recorded in control field as compared to treated field irrigated with effluent (Table – 12; Figure – 22). The decrease in per cent incidence of wilting in field may be partly due to presence of some antagonistic microorganisms therein which could have suppressed the growth and population of the pathogen and/or partly due to effect of some toxic substances in the treated field through effluent irrigation which might have suppressed the growth of the pathogen resulting decrease of the wil disease. Garret (1963) and Burgess and Griffin (1967) reported that these factors are chiefly governed by the physico-chemical nature of soil environments. The lower incidence of wilt may be due to the action of presence of microbial population strongly antagonistic to *F. oxysporum* f. sp. *lycopersici* spores (Arjuna Rao 1971; Smith and Snyder, 1972) or some residual inhibitory substances present therein. Bacteriological characteristics of soil and water as affected by some industrial wastes has been reported by Fayes *et al.*, (1988). The bacterial population were high in treated soil in comparison to control soil (Table – 11) it could have reduced the overall fungal population and have inhibited the growth of pathogen also. In presence of

antagonists, the germtube may got lysed and destroyed. This can be one of the reasons, for low incidence of disease in treated soil (Chandra, 1990 and Singh 1992).

The continuous increase of wilting of tomato year after year, might be due to long term survival of the pathogen in the soil, increasing its inoculums potential. Houston and Knowles (1949) have reported that *F. oxysporum* f. sp. *lini* could survive for 50 years. *F. oxysporum* f. sp. *ciceri* can survive in dead plant debris in the soil for more than five years

Population Dynamics of the Pathogen in the Selected Fields

In present study the higher frequency and total count of *Fusarium oxysporum* f. sp. *lycopersici* was recorded in rhizosphere and on rhizoplane of wilted tomato plants than the healthy plants. The population (per cent occurrence) of pathogen was also higher in rhizosphere of wilted and healthy plants than the non-rhizosphere. Several workers observed that rhizosphere mycoflora differed quantitatively as well as qualitatively from the non-rhizosphere one (Timonin, 1940; Starkey, 1958; Atique *et al.*, 1982; Dubey and Dwivedi, 1988; Bashar, 1990; Singh, 1992; Marcus *et al.*, 1995; Singh, 1996 and Singh, 2007). During the present studies of microbial

antagonism Aspergilli, Penicillia and few other microorganisms exhibited high antagonistic activity against *F. oxysporum* f. sp. *lycopersici* (Table – 14). The reason for the low population of pathogen on the rhizoplane of healthy plants may be due to increased population of aspergilla, penicellia and other microorganisms in the root-region. The root exudates of healthy plants might have favoured the growth and reproduction of antagonistic form in the root-region which could have suppressed the growth of the pathogen. On the other hand the highest population of pathogen in the rhizosphere and rhizoplane of wilted plants (Table – 13) may be due to smaller number of antagonistic forms in the root-region and release of altered root exudates which could have favoured the growth of pathogen but have suppressed the growth and germination of antagonistic microorganisms. Bowen (1978), Newman (1978), Cattelan (1994), Marcus *et al.* (1995), Rangeswaran and Prasad (2000) and Gupta *et al.* (2001) suggested that rhizosphere microflora can control the growth of pathogen by antibiosis.

Due to the effect of rhizosphere there was a gradual increase in the per cent occurrence and percent frequency of the pathogen from November to March in the selected fields. The reason could be ascribed to increase in the quantity of root exudation up to

December (flowering stage) due to increase in the vegetative growth and thereafter decrease in exudation up to the March (senescent stage).

The per cent occurrence and per cent frequency of *F. oxysporum* f. sp. *lycopersici* in non-rhizosphere rhizosphere and rhizoplane were high in control field as compared to the treated field irrigated with effluent. The greater number of fungi in control field as compared to the treated one could be due to presence of toxic substances and/or increased bacterial population in such soil inhibiting the fungal population.

Colony Interaction Between the Test Pathogen and Some Dominant Microflora

All the microorganisms inhibited the growth of *Fusarium oxysporum* f. sp. *lycopersici* in varied degrees in dual culture experiments on agar plates (Table – 14; Figure – 23; Plate – 4). Mutual intermingling growth of *Fusarium oxysporum* f. sp. *lycopersici* was found with *Cladosporium cladosporoides* which may be due to the equal growth rate of interacting fungi. Inhibition zone was recorded between *F. oxysporum* f. sp. *lycopersici* and *Aspergillus luchuensis*, *A. niger*, *Penicillium frequentans*, colourless bacteria, *Streptomyces rimosus* and *S. rochi* (SR_I).

The occurrence of inhibition zone between antagonists and pathogen on agar medium is commonly considered as a result of production of antibiotics by microorganisms, changes in pH and competition for nutrients. Mechanical obstruction to the growth and hyphal interference are other main phenomenon of antagonisms. The overgrowth is achieved when one microorganism exhibits higher growth rate, tolerance against antibiotics produce by the other microorganisms and very high capacity of antibiotics production.

The possible explanation for the cause of microbial antagonisms has been described previously by Upadhyay and Rai (1987). Antagonisms against any organism by an antagonist occur due to several factors like production of secondary metabolites, change in pH, growth rate of the interacting microbes, competition for nutrient and space and mechanical obstruction (Ikediugwu and Webster, 1970a; Fokkema, 1976; Skidmore and Dickinson 1976; Rai *et al.*, 1977; Arrora and Upadhyay, 1978; Singh, 1996 and Singh, 2002). Several physical and chemical factors which may influence the biochemical activity of interacting fungi are manly responsible for the phenomenon of hyphal interaction. This was reported by Berry (1959) and Ikediugwu and Webster (1970a, b). Mechanical obstruction and hyphal interaction are the main cause of antagonism. This was

reported by Bernett and Binder (1973), Upadhyay and Rai (1983), Singh (1996) and Singh (2002). Papavizas (1985) has reviewed the biology of *Trichoderma*, which is a fast growing and antagonistic fungus against many pathogenic and non pathogenic fungi. Recently Verma *et al.*, (2007) reviewed the antagonistic role of *Trichoderma* sp. as a biological control agent. Due to capacity of fast growing nature, rapid sporulation and producing toxic metabolites the antagonistic activity of *Trichoderma* spp. has been potentiated (Garret, 1981; Singh, 2002 and Hassan and Waffa, 2006). Hence high antagonistic activity of *Trichoderma* spp. observed against *F. oxysporum* f. p. *lycopersici* may be due to the above reasons. Inhibition in growth of *F. oxysporum* f. sp. *lycopersici* by *Aspergillus* spp. is also in conformity with the similar report by Mukhopadhyay (1977), Srivastava *et al.*, (1981), Saxena (1986), Bashar (1990), Chandra (1990) and Singh (1992) in case of other pathogenic fungi. In the past several reports of biological control of plant pathogen using bacteria has been published (Howell and Stipanovic, 1988; Keel *et al.*, 1989; Bashar, 1990; Sullivan and O'Gara, 1992; Cook, 1993; Dowling and O'Gara, 1994; Nautial, 1997; Singh, 2002; Kloepper *et al.*, 2004; Koumoutsi *et al.*, 2004; Islam *et al.*, 2005; Laclere *et al.*, 2005 and Pal and Gardenar, 2006).

Streptomyces rimosus and *S. roch* (SR_I) inhibited the growth of the test pathogen. Several investigators have also observed the inhibition of growth of different pathogenic fungi by *Streptomyces* spp. Mukhopadhyay (1977), O'Brien *et al.*, (1984), Rai and Bashar (1989), Chandra (1990), Singh (1992) and Singh (1996). Inhibitory effects of some antagonists on plant pathogen are thought to be due to some toxic substances produced by the antagonists. Recently Whipps (2001) has reviewed the use of different biocontrol antagonists including bacteria in plant disease control and the mechanisms involved in them.

Effect of Volatile Metabolites of Some Dominant Microflora on Mean Radial Growth of the Test Pathogen

It is clear from the Table – 15 that the volatile substances emanating from the cultures of the test microorganisms inhibited radial growth of the pathogen *Fusarium oxysporum* f. sp. *lycopersici* to varied degree. The growth inhibition of the test pathogen may be attributed to the presence of growth inhibitory substances in the volatiles (Bilai, 1956; Dennis and Webster, 1971b; Tamimi and Hutchinson, 1975 and Singh, 1990). Growth inhibition of fungi by gases emanating from bacterial and actinomycetous cultures have also

been reported by French (1962), Dennis and Webster (1971b) and Gupta and Tandon (1977), Chandra (1990), Bashar (1990) and Singh (1992). Vilanova *et al.*, (2007) reported production of volatile and non volatile compounds by *Saccharomyas cerevisae*. Hutchinson (1971, 1973) and Fries (1973) proposed that inhibitory or stimulatory effects depend upon the concentration of the metabolites and specified sensitivity of the responding fungus. Upadhyay and Rai (1987) observed the inhibitory effect of volatile metabolites of some saprophytic microflora against *Fusarium udum*. The gross effect may also depend on the interaction between the volatile factors of two fungi as some part of chemical reaction may occur there which may include the nullification of the metabolism by each other. Fries (1973) discussed the mode of action of volatile substances.

The result suggest that there was difference in volatile substances produced by various microorganisms as they showed different degree of growth inhibition of *F. oxysporum* f. sp. *lycopersici*. The decrease in inhibition of radial growth of the pathogen with prolongation of incubation period may be due to decrease in the production of the volatile substances or due to development of resistance in the test pathogen against the volatile substances.

Effect of Non-Volatile Metabolites of Some Dominant Microflora on Hyphal Dry Weight and Mean Radial Growth of the Test Pathogen

The effect of culture filtrates of the test microorganisms to inhibit mycelial growth of the test pathogen was more pronounced as compare to the volatile one (Tables : 16 – 17; Figure : 24 – 25; Plates : 5 – 6). Inhibition of hyphal dry weight and mean radial growth of the test pathogen due to non volatile metabolites of the test microorganisms might be due to the production of the antibiotics in the culture filtrates (Gottlieb and Shaw, 1970; Dennis and Webster, 1971a; Skidmore, 1976; Rai *et al.*, 1981; Furgal and Halena, 1988; Kumar *et al.*, 1988 and Szekeres *et al.*, 2005) and alteration in pH of the medium due to staling growth substances (Newhook, 1957; Bhatt and Vaughn, 1962 and Bier, 1966). In the present study *Streptomyces* spp. have been found to produce some substances which ultimately change the pH of the medium towards alkaline side. Inhibition of mycelial growth of *Fusarium oxysporum* f. sp. *lycopersici* by the metabolites of *Streptomyces* spp. is in accordance with the results obtained by several workers in case of other fungal species (Fries, 1973; Rai and Bashar, 1989 and Singh, 1992). Rai *et al.*, (1981)

reported that *Streptomyces* spp. were more active antagonists than other to inhibit the growth of some litter decomposing fungi. Thus the growth of fungus in culture filtrate depend upon the level and balance of metabolites and nutrient status of the culture filtrate (Robinson, 1969). Different antibiotics, toxins and emzymes such as fusaric acid, geodin, terricin, terric acid, aspergillic acid, hadacidine, gliotoxin, viridian, penicillin, trichodermin, alamethicine, dermadin, suzukacillin, proteolytic enzyme and chitinase etc. are known to produce by the species of *Fusarium, Aspergillus*, *Penicillium* and *Trichoderma* (Brain and Hemming, 1945; Meyer, 1966; Ooka *et al.*, 1966 and Szekeres *et al.*, 2005). Hsi (1968) showed that organic acids produced by *Aspergillus niger* made the media too acidic for the growth of *Macrophomina phaseolina* and no antibiotic activity was detected either in the culture filtrate or in mycelil cake. Several fungi are known to be capable of producing antibiotics (Turner, 1971 and Szekeres *et al.*, 2001) which might have suppressed the growth of the test pathogen. The difference in response to a particular concentration of the culture filtrate by the test pathogen might be due to differences in nature, quality and quantity of the inhibitory substances produced by the individual microorganism.

Effect of Pesticides on Per Cent Growth Inhibition of Test Pathogen

Laboratory evaluation of pesticides revealed that all the pesticides caused partial or complete inhibition of *Fusarium oxysporum* f. sp. *lycopersici* at their used concentrations (Table – 18 and 19; Figure – 26 and 27). Similar observations have also been reported for other fungicides by Verma and Vyas (1977), Kotasthane and Agrawal (1978), Goyal and Mehrotra (1981), Vishwakarma and Basu Chaudhury (1982a), Bashar (1990), Singh *et al.*, (1994), Iqbal *et al.*, (1994), Mantecom and Pereyra (1997) and Singh (2002).

Efficacy of various fungicides against *Fusarium oxysporum* f. sp. *lycopersici* indicate that MEMC bavistin and benlate showed promising results as compare to others (Table – 18), Similar trends to control root diseases of Chickpea and Soyabeen with benlate, bavistin and thiram against the pathogens have been reported earlier by Haware *et al.*, (1978), Shukla *et al.*, (1981), Zimenez – Diaz and Trapero – Casas (1985), Bashar (1990) and Singh (2002). Many fungicides effective against several pathogens *in vivo* and *in vitro* have been reported by various investigators (Sen and Kapoor, 1975; Dharamveer, 1976; Raut and Bhombe, 1983; Singh and Agarwal, 1986; Kotasthane *et al.*, 1987; Ray and Das, 1987; Delgado *et al.*,

1990; Huang, 1992; Mantecon and Pereyra, 1997; Shivpuri and Gupta, 2001 and Singh, 2002).

Nene and Thapliyal (1979) reported that organomercurials are more toxic than the inorganic ones because of lipoid solubility of organomercuriales which facilitates diffusion. This may probably explain the high toxicity of MEMC observed in the present investigation also. Jhooty and Bains (1972) observed that brassicol completely checked the mycelia growth of *Rhizoctonia solani* at 5 ppm. Inhibitory effect of brassicol may be due to disruption of semi-permiability of the cell membrane ultimately affecting the metabolic activities of the pathogen (Kataria and Grover, 1975). In the present study brassicol was found to be less effective as compare to other fungicides. This variation might be due to selection of a different test pathogen. Singh and Singh (1970) observed that reaction of *Fusarium* to fungicides varies from species to species and some time even from isolate to isolate of the same species.

It is clear from the result (Table – 18) that blue copper brassicol, dithane M-45 folfat. mancozeb and thiram exhibited less effect against *Fusarium oxysporum* f. sp. *lycopersici* at lower concentration as compared to bavistin, benlate and MEMC.

A considerable effect of the insecticides was observed at higher concentrations, unlike the fungicides none of them arrested the growth of the test pathogen completely. During the present investigation the maximum inhibition of the test pathogen was recorded with BHC (Table – 19). Similarly, growth inhibition of some fungi by insecticides has also been reported by Leach and Frank (1982) and Bashar (1990).

Less effectiveness of some of the pesticides may be attributed to the tolerant capacity of the pathogen. Development of tolerant to a chemical may be due to changes in the fungal cell that inhibit the pesticides to a greater or lesser extent from reaching the site of action. Such changes may result in a decrease in the permeability of the cell membrane and pesticidal detoxication even before the site action is reached (Dekkar, 1976). Conversion of a chemical in an inactive from by fungi may also be considered as a detoxication mechanism. PCNB is changed into penta chloroaniline and pentachlorothioanisol compounds by many fungi. These compounds are not so active and cause very less effect on population of the fungi in natural soil (Nakanishi and Oku, 1969 and Bashar, 1990).

Effect of Effluent on Per Cent Growth Inhibition of Some Dominant Microflora and Test Pathogen

It is clear from the Table – 20 that effluent inhibited radial growth of pathogen *Fusarium oxysporum* f. sp. *lycopersici* and other microorganisms to varied degree. None of the concentration used in experiment arrested the growth of microorganisms completely. Inhibition in radial growth of microorganisms may be due to toxic substances present in effluent. Downing (1971) observed effluent to inhibit microbial population in activated sludge treatment. Leach *et al.*, (1978) also noted suppressed microbial activity. Chandra (1990) reported inhibitory effect of sluge on radial growth of some microorganisms including *Fusarium oxysporum*. The inhibition of microorganism might be due to their inability to neutralize the toxic effect Chandra (1990). The bacteriological characteristics of soil and water as affected by some industrial waste was reported by Fayes *et al.*, (1988).

Effect of Heavy Metals on Radial Growth of Some Dominant Microflora and Test Pathogen

All the heavy metal inhibited, more or less, growth of pathogen (*Fusarium oxysporum* f. sp. *lycopersici*) as well as of some

other microorganisms (Tables : 21 – 25). Huising and Huising (1974) have mentioned that all the elements, essential or non-essential, are potentially toxic depending on their form, concentration and route of exposure. The extent of inhibition increased with increase in the concentration of the heavy metals.

None of the heavy metals caused complete inhibition of any microorganisms at any used concentration while Cd was the most effective heavy metal against the test pathogen. The toxicity may be due to permeability of fungal cells to metals (Ross and Old, 1973). Cadmium is potent component of a few fungicide to control various diseases of crops due to toxicity against several pathogenic fungi. Toxicity of Cd and effect of various factors on its toxicity against the microorganisms have been extensively studied by Babich and Stolzky (1978). They reported toxic effect of Cd on mycelial growth of *Amanita muscaria* and *Rhizipogon roseolus*. Cadmium act as growth inhibitor . for some bacteria like *Bacillus cireus*, *E. coli* and *Agrobacterium tumifaciens* and actinomycetes (*Nocardia paraffinae*). Insam *et al.* (1996) studied the effect of heavy metal stress on metabolic quotient of the soil microflora.

The toxic effect of Ni on *Aspergillus niger* has been reported earlier by Babick and Stotzky (1982, 1983a). Nickel was

found inhibitory to *Bacillus urevis*, *Pseudomonas* sp., actinomycetes and filamentous fungi. Nickel was found to be more toxic to growth of *T. viride*, *Rhizopus stolonifer* and *Penicillium vermiculatum*.

The toxic effect of Pb has been observed against the growth of *A. niger*, *Saprolegnia* sp. and *Achlya* sp. (Babick and Stotzky, 1983). The inhibitory effect of Cd, Pb, N, Cr and Zn on *Macrophomina phaseolina*, *F. oxysporum* f. sp. *ciceri* and some other microorganisms have been reported earlier by Dubey and Dwivedi (1988), Bashar (1990) and Singh (1992). Zinc and chromium caused considerable effect to check the growth of the test pathogen as well as some dominant microorganisms. Toxicity of high concentration of Zn might be due to interference with the metabolism of Mg causing Mg-deficiency to the pathogen (Adiga *et al.*, 1962). Zn has been reported as an essential element for the growth of fungi at low concentration (Mc Han and Johnson, 1970 and Ross, 1975). In a review Giller *et al.*, (1998) discussed the toxicity of heavy metals to microorganisms and microbial process.