REVIEW OF LITERATURE

A. On General Edaphic Factors

The earliest work on soil fauna was done by Diem (1903) on the soil fauna of Alps. McCatee (1907) estimated 1.2 million invertebrates per acre of forest floor and 13.7 million from a grassy meadow at Washington. Cameron (1913) first carried out the survey of soil insects, at Manchester, in which 163 different species were recorded. In 1917 Cameron first pointed out that environmental condition may cause a difference in the faunal makeup even in two types of grass lands. While Morris (1920) pointed out that food, moisture and aeration influenced vertical distribution of the soil dwelling forms. He estimated a population of 3.6 million per acre. Buckle (1921) opined that growth of vegetation increases the growth of the fauna. He also observed that the distribution and density of soil fauna were more stable on grass land than on arable land. Morris (1922) observed that the invertebrate population increases with the application of farm manure on arable land. Thomson (1924) while working on a piece of grass land, partly cultivated, tried to correlate the qualitative and quantitative seasonal variations of arthropod population with the general environmental condition. It was observed by him that Collembola and Acarina were by far the dominant groups with maximum population in winter months.

According to Edwards (1929) the faunal components varied from one soil type to the other. He also made an attempt to correlate the population fluctuation with difference in environmental factors. Ford (1935) studied the faunal composition of vegetation and soil of the ridges traversing a meadow and obtained a density of 263.8 million per acre in the soil and 8.8 million in the vegetation. He also found that the population increased in winter and decreased in summer.
Frenzell (1936) made a comparative study of the soil fauna of different habitats at different elevations in Germany and found that the soil moisture had a direct role on the fluctuation of the population. He recorded a maximum population of soil organisms in early winter and early spring while the minimum in mid-winter and mid-summer. Agrell (1941) while studying collembola population observed that they could withstand a lower temperature of -4°C to -10°C and upper temperature upto 36°C to 38°C. He also studied the effect of humidity and soil moisture. Gisin (1943) showed that the occurrence of some of the species which were lowly sensitive to different soil conditions might be used as a reliable index for determining the nature of the soil.

Hammer (1944 and 1953) while working with microfauna in Greenland and Canada, observed that the soil fauna were to some extent negatively correlated with the soil moisture.

Weis-Fogh (1948) observed in acarina and collembola, the population maxima in autumn and minima in summer.

According to Strenzke (1949) in wet habitat maximum population of soil animals was in autumn. He attributed such an increase to moisture and organic matter.

Macfadyen (1952) found the population to be maximum in winter and that too in the upper layer of the soil. A similar observation was also found by Murphy (1953), who observed a greater concentration of collembola in the upper layer of an woodland soil.

Bellinger (1954) studied the preference of soil animals and their habitat preference. In his opinion moisture, amount and nature of organic matter probably contributed in determining the habitat preference.
Harlov (1955) worked on the vertical distribution of mites and collembola in relation to soil structure and found that vertical distribution of collembolans was probably related to the size and shape of the soil cavities, relative humidity and presence or absence of food. Sheals (1957) made a detailed study of the microarthropods of Danish soil in different communities and reported the dependence of microarthropods on vegetation, temperature and other soil factors such as organic carbon content and soil pH.

Christiansen et al. (1961) while studying the ecology of collembola of a Cave, observed positive correlation of population with organic matter and moisture content of the soil. Poole (1961) while working on the ecology of the collembolan population in a coniferous forest soil came across the maximum population during summer. That soil factors such as pH, organic carbon, soil moisture could exert a triggering effect on the soil animals, had been observed by Davis and Murphy (1961). Hollerland (1962) observed that decomposing manure played a positive role in increasing the soil animal population.

Davis (1963) while studying the interrelationship between the microarthropods and the edaphic factors in Iron stones quarrying district found that organic matter content of the soil was the most important soil factors in such a habitat.

Choudhuri (1961, '62 and '63) estimated the role of different ecological factors, influencing the reproduction and development of different species of collembola. In his opinion the various soil factors played significant part in conditioning the make-up of collembolan population both quantitatively and qualitatively. He further observed that the capacity of collembolans to withstand the condition of dessication during summer varied from species to species leading to population fluctuation. Rapport and Najt (1966) made ecological investigation of microarthropods of two places in Argentina and observed two different population peaks in two different months. In
both the places acarina was found to be the most dominant group. According to Ghilarov (1973) "soil tillage and agricultural utilization affect soil animals in various ways and are, to a different degree, dangerous to various taxa and ecological groups of soil invertebrates accompanied by the change of predominating species". He also observed the elimination of many ecological groups/taxa following tillage and other procedures of soil utilization.

Edward and Lofty (1973) while working on the influence of cultivation on soil arthropod population observed that the effects of ploughing more or less simulated the conditions that normally prevailed in an arable land. Marshall (1974) studied the effects of Urea at two different concentrations on the collembolan population and found that in the control plot collembola showed a summer increase with the August - maxima being statistically different from the April and January - minima. Further, he observed that both the concentration of urea tended to delay the summer peak to September.

Edwards and Lofty (1974) while studying the impact of organic manure and other factors on the invertebrate fauna of grasslands, observed that the total collembolan population remained little affected by the level of nitrogen. In their opinion collembola as a whole, was influenced by soil pH more than mites. According to Choudhuri and Banerjee (1975) the population of both acari and collembola chiefly depended on the concentration of organic matter in the soil. Singh (1975) was able to find out a strong positive correlation between the collembolan population and the moisture content of the soil.

According to Singh and Pillai (1975) the Oribatid mites were predominant in the soil of higher content of organic matter while the prostigmatid mites predominated the soil deficient in organic matter. A preliminary study on the soil microarthropods of a Himalayan grassland was made by Singh and Singh (1975) in which they observed
a higher population of the microarthropods in the upper stratum than below it. Singh (1976) while studying the effects of human impacts on the population density of the soil mesofauna observed indirect effects of man in causing the mesofaunal population to decrease.

Bhattacharya and Joy (1977) observed that the density of the microarthropods taken together and that of the acari considered alone declined significantly in the manure treated plot following the application of a herbicide, while as in the untreated plot no such significant decrease was evident. The study of the soil mesofauna in a grassland ecosystem by Pillai and Singh (1977) revealed the occurrence of two peak periods of mesofauna, one in the rainy season and the other in the winter season. According to them the contents of moisture and organic matter in the soil played significant role on the population fluctuation.

According to Roy and Ghatak (1977) the microarthropods showed an irregular trend of population-fluctuation being maximum in July - August and minimum in April - May. According to Choudhuri et al. (1978) the total oribatid population fluctuated irregularly, being maximum in July - August and minimum in April - May. In this study the population showed strong positive correlation with the contents of organic matter, moisture and nitrate and no correlation with microflora. The same author, Banerjee and Roy (1979) and Choudhuri and Pande (1979) observed a greater population density of acarines in the uppermost layer.

According to Ghatak and Roy (1979) vegetation played a very important role in the manifestation of acarine population. They observed more prominent acarine population peak in August when jute crop was standing and a less conspicuous peak in March when potato crop was present in the field. According to Mitchel (1979) temperature not only exerted direct effects on the microbial and faunal metabolism, but also affected the population growth and interspecific interactions between the fauna and their microbial food resources.
Abrams and Mitchel (1980) also observed that temperature affected the faunal metabolism as well as the faunal growth and interspecific interactions.

Joy and Bhattacharya (1981) and Hazra and Choudhuri (1981) observed in uncultivated unpolluted plots that the microarthropods like collembola and acarina population attained their maxima in July - August and minima in April - May.

B. On Soil Pollution

As early as 1939, Hafez, first studied the insect fauna of dung in Egypt. Hafez (1947), also studied the dipterous fauna of dung. Karg (1962) while studying with acarina, observed that the Oribatids are slow colonizers, in sub-optimal abiotic condition, which is reflected by their low abundance at waste disposal sites.

Davey (1963) observed the deleterious effects of pesticides on earthworms. Edwards (1969) first carried out an intensive work on the effect of pollutants on the animals and observed that the more the abundance of the pollutants less was species diversity, indicating tolerance and specificity of different species of soil organisms at different polluted zones.

Edwards and Lofty (1969) observed that more drastic population fluctuation of soil microarthropods could be expected from the effects of cultivation and the addition of organic manure.

Banle and Fricher (1970), Bengston (1971) and Weetman (1971) reviewed forest fertilization and the role of soil organisms in the decomposition of organic matter. Edwards, et al. (1970); Harding and Stuttard (1974) also studied the
importance of microarthropods in the decomposition process of organic matter. Gilbert (1970) tried to utilize organisms like Lichens & Bryophytes as the indicators of Sulphur dioxide pollution. In 1971, Gilbert, again assessed the effects of air pollution on the invertebrates living under bark of trees. That the heavy metals, depending on their concentration might interfere with the decomposition and stabilization of sewage sludge by causing deleterious impact on the biota, was first established by Imhoff, et al. (1971). In the opinion of Jenkins, (1972) soil microfauna presented a large reservoir of species presenting the properties of very good bio-indicators.

Viets (1971), Gambrell and Peele (1973), Hinriches et al. (1974), Larson, et al. (1975), Harrington (1978) observed and discussed the problems of cattle and beef feed lot pollution in the soil, consequences of disposal of Cannery and other wastes on land and also the role of plants on the retention of heavy metals in the soil. Tyler (1972) studied the effect of heavy metals on productivity and found that Cadmium was strongly absorbed in humus.

Edwards and Thompson (1973) reviewed the literature on the effects of pesticide in earthworms and observed that depending on concentration and the nature of the pesticide the earthworm population exhibited either a long term or a short term reaction. That the soil invertebrates had tremendous role in the processing of the organic wastes, was shown by Applehof (1974, 1980). She demonstrated that two pounds of earthworms could process, a pound of garbage per day. Edwards (1974) also found the microarthropods to be very active in the decomposition process of organic matter. Edwards and Jeffs (1974) found that some pesticides were degraded within the tissues of the earthworms; for instance, even the most stable pesticide, DDT become degraded to DDE in earthworms.
Miller (1974) while studying the anaerobical digestion of sewage sludge found that with increasing sludge stabilization there was a parallel decrease in total viable bacteria. Bradford, et al. (1975) found toxic levels of Boron and excess of several heavy metals in some plants irrigated with sewage material. Curds and Hawkes (1975) observed that sewage sludge decomposition and stabilization was a biologically mediated process, in which various soil organisms would take part. He also studied the importance of such organisms in aerobic and anaerobic digesters. Dindal, et al. (1975) found that waste water irrigation of soil caused a shift in the soil fauna biomass towards earthworms and a general decrease in species diversity.

Edwards and Lofty (1975), while investigating the soil fauna at a grass plot manured by organic wastes, found that addition of dung, fishmeal, etc., in excess in the soil increased the acidity of the soil, even large doses of Ammonium nitrogen also decreased the soil pH, that in turn decreased the earthworms numerically in the soil community. Ireland (1975) studied soil Oligochaetes in a highly polluted calcium deficient base metal mining area. He obtained a negative correlation between the lead and calcium content of Oligochaetes.

Love, et al. (1975) and Loehr (1977) found that sewage sludge contain heavy metals and human pathogens that could endanger public health. Vanrhee (1975) found that contamination of soils from irrigation practices from application of Copper-containing pig slurries on pastures was a serious threat to the structure and functioning of the soil biota. Vanek (1967), Gorny (1975), Petal, et al. (1975), Petal (1978) and Bhattacharya et al. (1980) suggested that air pollutants released by industries caused a reduction in the population size of soil invertebrates. According to Gorny (1976) the industrial effluents rich in nitrogen increased population of ants like *Formica polyctena*. 
Council for Agricultural Sciences & Technology in their Report No. 64 (1976) ascertained that heavy metals interfered with the sewage sludge decomposition and stabilization by their deleterious impact on the biota, whether the metal would be toxic to biota would depend on absorptivity, chelation and ionic form of the metal as well as the species concerned, but would most likely be below toxic levels. Varanka, et al. (1976) and Mitchell (1978) have established a definite role of soil organisms on the decomposition of sewage sludges and sludge amended soils.

Dindal, et al. (1977) found that the contamination of soil by municipal waste water irrigation might disturb the structure and functioning of the soil organisms. Edwards and Lofty (1977, 1979) reported that earthworms improved mineral availability and general soil fertility. Getz, et al. (1977) found highly increased lead level in startling (rural song bird) kidney and liver from urban environments. According to them this have caused because the earthworms ingested by the startlings contained high amount of lead from an increasing polluted soil.

Hayes and Theis (1978) while studying the anaerobic digestion of the sewage sludge observed that heavy metals interfered with the decomposition and stabilization of sewage sludge by their deleterious effect on the organisms. Mitchell, et al. (1978), observed relatively small number of mites and collembola in sewage sludge amended soils. They also found collembola 10 times more numerous than acarina. Tadros and Saad (1978) studied the distribution of microfauna on the bank of a drainage system. Williams, et al. (1978) and Prento (1979) studied the accumulation of different heavy metals in meadow voles as well as in earthworms and also studied their physiological significance.
Petal *et al.* (1975) and Petal (1978) observed that industrial pollution decreased the species richness and species diversity, considerably in the ant community of the soil. Andersen (1979) while studying the heavy metal content in earthworms, found that in winter the accumulation of Lead was lower as was the activity, while in summer the activity and the lead content in earthworms were high. The same worker (1980) studied the concentration of heavy metals in earthworms in sewage sludge ammended soil on the road side. He found that sludge suppressed reproduction in certain species of earthworms. He also found that in all the species the concentration of metals in individuals to be higher in the soils containing high level of metals. Further he also found that in certain species from soil, polluted by automobile exhaust, metal content was highest, close to the street. The low pH value closest to the street was ascribed to acid pollution from the motor traffic.

Aoki and Kuriki (1980) made a comparative study of collembola and mites in two plots by the side of the road. They found that average density of Oribatids in the green areas was about three times as high as that in the suburban road sides. On the contrary, the densities of Acridids and Tarsonemids were highest in the urban road side and lowest in the green areas. Relative abundance of collembola was highest in the green areas in comparison to the road sides, where the pollution level was higher.

Bhattachary, *et al.* (1980) observed that herbicides administered for the elimination of unwanted plants in the agroecosystem might unintentionally upset the balance of ecosystem by affecting the sensitive nontarget soil animals like Cryptostigmatid mites. Broadbent and Tomlin (1980) observed that any agricultural practice, including the use of insecticides, which interfered with the composition of the decomposer community or shifted its component population equilibrium might result in reduced litter decomposition which could affect soil fertility.
Brockmann, et al. (1980) found that at refuse disposal sites Oribatid mites were slow colonizers and they noticed sub-optimal abiotic conditions which was reflected by their low abundance. Edwards (1980) while studying earthworms in a plot where sewage sludge, sewage cake, animal slurries and wastes from breweries had been used as organic fertilisers, found that the application of these might increase the population but unfortunately there could be uptake of heavy metals like Pb, Cd, etc. into earthworm tissues from the sewage materials which might prove to be deleterious in the long run.

Garay, et al. (1980) have found that even trampling might alter the species composition of the mite community, which depended on the porosity of the soil, the available soil organic matter and litter structure. Hoy (1980) while studying the effects of Lindane on all major groups, found that annual application of this would certainly cause a continuous depression in the numbers of most species and they would probably have cumulative effect.

Huhuta, et al. (1977 and 1980) while observing the biological succession in sludge, observed that Collembola propagated faster in the sewage amended soil in the oldest material tested, a compost mixture of digested sludge and bark in the third year after application, the animal community differed considerably from that of the adjacent arable soil. Mitchel and Horner (1980) in their observation found that both organic (Phenols) and inorganic (heavy metals) pollutants if present in the sewage sludge, might limit its utilization as a soil amendment because of their toxic effects to both plants and animals, including man. By minimising those components such as heavy metals and undesirable process such as the production of toxic compounds, the utilization of wastewater treatment and sludge management as a mechanism for soil reclamation and nutrient conservation might be fully realized.
Tadros (1980) while studying the soil fauna from open drain in Egypt, found that the percentage of both collembola and Insecta was low in the manure when compared with that from cast drain soil, this result indicated that the high acidity of the soil was not preferred by the Insects. On the other hand, acarina flourished in manure and nearly doubled giving an impression that the environment was preferable to them. Hartenstein, et al. (1981) reported of the negative effect of lead, present in the sewage sludge, on the growth of earthworms. Jaggy and Streit (1982) also observed a similar effect of Copper on Lumbricids.

Hunter and Johnson (1982) found that in a grassland ecosystem the degree of transfer of copper in the food chain was less than the cadmium. Streit and Jaggy (1983) observed that copper, present in excess amount in the soil became absorbed in the earthworms, but the toxicity of copper on earthworms was also dependent on the nature of the soil. Chattopadhyay and Hazra (1983) studied the soil arthropod population from the bank of an open drain at Calcutta, they recorded acarina as the dominant group consisting of 38.32%, they also reported the maximum concentration (64.96%) of arthropods at the surface soil (0-5 cm) layer.

Hazra and Chattopadhyay (1985) while studying the effect of copper on the population of the soil arthropods on the embankment of a sewage canal at Calcutta observed that the total soil arthropod population was represented by 23.76% at the polluted site, having a mean concentration of 134.6 ± 5.66 ppm of copper, whereas in the uncontaminated plot, where the mean copper concentration was 11.12 ± 0.77 ppm had 76.24% of the total population. They also observed a significant negative correlation between the mean concentration of copper and arthropod population, at the polluted site.