OCCASIONAL PAPER NO. 186

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**A. CHATTOPADHYAY**
**&**
**A. K. HAZRA**
*Zoological Survey of India, M-Block, New Alipore, Calcutta - 700053*

*Edited by the Director, Zoological Survey of India*

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## CONTENTS

# INTRODUCTION

The word soil which is derived from the latin word "Solum" meaning floor, is a natural product of weathered rock acted upon by climate and living organisms, and a mixture of minerals and organic matter that supports life. Thus it can be said that the soil is a decomposition product, the solid phase of which has two main constituents, one is the mineral material and the other is the organic material. The vegetation growing in the soil provides the organic material that remains closely associated with the mineral part of soil. The decomposition of organic matter (litter) which is mainly influenced by the soil organisms (Wallwork, 1970), takes place in two phases. In the first phase the litter is fragmented and chemically altered by various organisms into a complex substance called "humus", which in the second phase is slowly broken down into various components (Handley, 1954; Burges, 1965, 1967). Different workers have reported that the decomposition of vegetable material originates with the infestation of micro-organisms like fungi and bacteria, by their action a radical change in the texture and chemical composition of the organic material takes place, which becomes more acceptable as food to soil animals like earthworms, insect larvae, millipeds, collembolans, mites etc. (wallwork, 1970). The action of these soil animals not only accelerates the physical disintegration of the organic material, but also appears to be necessary for the continued activity of the micro-organisms (Burges, 1965). The various biotic forms living in the soil are mutually interdependent.

To understand in detail the intrinsic nature of the role of soil animals on the formation and maintenance of the soil, it is necessary to identify the animals inhabiting the soil, study their life-histories and to assess their impact on the soil and vice-versa.

Heavy metals reach the soil in several ways. Repeated application of sewage on to the soil is one of the ways. Some industrial wastes containing such high concentrations of heavy metals lead and other heavy metals used in fuels and lubricants find their way into the atmosphere and drift across the areas of heavily congested traffic. (Thompson and Troeh, 1979). Mac Lean and Langille (1973) reported substantial increase in the lead, copper and molybdenum contents in soil and plants growing along road side.

Urbanization is invariably associated with the production of sewage which contains toxic elements as potential soil pollutants in various forms. (Thompson and Troeh, 1979). Soil normally contains small amounts of heavy metals like lead, zinc, copper and mercury and some other essential elements. But excessive amounts of these and other heavy metals are detrimental to life and can sterilize the soil. Heavy metal pollution is serious because it can persist for many decades (Thompson and Troeh, 1979).

The soil invertebrate fauna that exert profound influence in the litter breakdown, formation and maintenance of a healthy soil, started gaining appreciation since the latter half of the eighteenth century. Since then studies on the soil fauna showed an upward trend, as a result the recognition of general soil fauna and their identity went on increasing progressively. The study of soil ecosystem with special reference to soil dwelling animals, was made first in the thirties of the nineteenth century. In the meantime, rapid urbanization and industrialisation created a lot of problems of which pollution posed to be the most important and it increased along with the increase of human population which followed an exponential pattern.

The average garbage production per day from Indian cities is estimated at 41,000 tonnes, and such a production per year is of the order of 15 million tonnes. A total of 142 Class-I cities produce around 9000 million litres of sewage per day and only one-third of this waste receives some treatments. That the primary treatment of sewage can remove 60% of solids and perhaps one third of BOD, is well established (Foster, 1959). The great metropolitan city of Calcutta which has a high population density and unfortunately a good number of industries does not possess waste treatment plants (Sharma, 1984).

The problem of the effect of heavy metals on the soil organisms received due attention of the scientists in some countries recently. In India, however, no such attempts has yet been made, to assess the impact of heavy metals on soil arthropods.

The present investigation has been undertaken to achieve the following objectives -

(1) To estimate both qualitatively and quantitatively the arthropod population in sewage polluted embankment. For this purpose three open sewage canals namely Bagjola canal also known as Dumdum canal (North Calcutta), Beliaghata canal (East Calcutta) and Tollygunge Nulah (South Calcutta) were selected and a nonpolluted area at Shibpur Botanical Garden, Howrah (Western side of Calcutta).

(2) To study the seasonal changes in the population structure of the arthropods in both polluted and non-polluted sites.

(3) To undertake chemical studies so that the data can be used to monitor and assess current environmental status with a view to forecasting future consequences of pollution.

(4) To evalute the role of edaphic factors like, temperature, moisture, pH, organic carbon and heavy metals like copper, chromium and lead on the soil arthropods and their concentrations in both polluted and non-polluted areas.

(5) To findout a pollution tolerant arthropod group if any to help in monitoring.

## REVIEW OF LITERATURE

### A. On general Edaphic Factors

The earliest work on soil fauna was done by Diem (1903). Cameron (1913) first carried out the survey of soil insects, 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 dewlling forms. Buckle (1921) opined that growth of vegetation increases the growth of the fauna. Thomson (1924) while working on a piece of grassland observed 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 and also fluctuate with difference in environmental factors. Ford (1935) studied the faunal composition of vegetation and soil of the ridges traversing a meadow and found that the population increased in winter and decreased in summer.

Frenzell (1936) made a comperative 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. 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 that in acarina and collembola, the population maxima in autumn and minima in summer.

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 perference. In his opinion moisture, amount and nature of organic matter probably contributed in determining the habitat preference.

Haarlov (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 accross 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 factor in such a habitat.

According to Choudhuri (1961, '62 and '63) the various soil factors played significant part in conditioning the make-up of collembolan popolation both quantitatively and qualitatively. Rapoport 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.

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) 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 with a 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 my 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 human 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, whereas 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 at.* (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. 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.

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 deletarious 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 the species diversity.

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

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 deletarious 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 at. (1975), Harrington (1978) observed and discussed the problems of cattle & beef feedlot pollution in the soil, consequences of disposal of Cannery & other wastes on land and also the role of plants on the retention of heavy metals in the soil. Tayler (1972) studied the effect of heavy metals on productivity and found that Cadmium was strongly absorbed in humus. Bradford, *et at.* (1975) found toxic levels of Boron and excess of several heavy metals in some plants irrigated with sewage meterial. 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 Ammomium 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.

Vanrhee (1975) found that contamination of soils from irrigation practices on application of Copper-containing pig slurries on pastures was a serious threat to the structure and functioning of the soil biota. Vaņek (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 populaton of ants like *Formica polyctena.*

Council for agricultural Science & Technology in their Report No. 64 (1976) ascertained that heavy metals interfered with the sewage sludge decomposition and stabilization by their deletarious 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.

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. Getz, *et al.*

(1977) found highly increased lead level in startling (rural song bird) kidney & 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 deletarious effect on the organisms. Mitchell, *et al.* (1978), observed relatively small number of mites and collembola in sewage sludge ammended 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.

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. Anderson, (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 supressed reproduction in certain species of earthworms and 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 comperative 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 & 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.

Bhattacharya, et al. (1980) observed that herbicides administered for the elemination of unwanted plants in the agroecosystem have unintentionally upset the balance of ecosystem by affecting the sensitive nontarget soil animals like cryptostigmatid mites. Edwards, (1980) while studying earthworms in a plot where sewage sludge, sewage cake, animal slurries and wastes from breweries had been used as organic fertililisers, 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 meterials which might prove to be deletarious in the long run.

Huhuta, et al. (1977 and 1980) while observing the biological succession in sludge, observed that collembola propagated faster in the sewage ammended 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 ammendment because of their toxic effects to both plants and animals, including man.

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 indicates that the high acidity of the soil was not preferred by the Insects. On the otherhand, acarina flourished in manure and nearly doubled giving an impression that, that 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 Jhonson (1982) found that in a grassland ecosystem the degree of transfer of copper in the food chain was less than 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 form the bank of an open drain at Calcutta, they recorded acarina as the dominant group, they also reported the maximum concentration of arthropods at the surface soil 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 coper, 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.

## STUDY SITES

### I. Bagjola Canal (Dum Dum)

(a) *Location and characteristics of the sampling site :* The sewage canal, the "Bagjola Canal"of Dum Dum is on the northern part of Calcutta (Map-1). The canal was constructed during the year 1882. This open canal carried a substantial amount of city (Calcutta) sewage effluents, pumped into it by the Cossipore Pumping Station. The total length of the canal is about 15 km. having an average width of about 12 meters. The surrounding of the canal is thickly populated. Several small and medium industries, producing chemicals and paints, mosaic tiles, hosiery materials and some other ancilary industries like mirror factory etc. discharge their effluents directly into this canal. Thus the canal receives effluents through different sources.

Several cattle sheds are also there around the canal discharging the feed lots into it. The cattle excretory products are also scattered all over the embankments of the canal. The foul smell of obnoxious gases, supports the eutrophic and anaerobic condition of the canal. The canal carried very dark coloured thick sewage, suggesting the presence of a lot of sludge at the bottom of the canal. The site selected for sampling is near Jessore Road, thus the soil receives a considerable amount of automobile exhaust also. The soil of the embankment of the canal is alluvium in nature and blackish grey in colour.

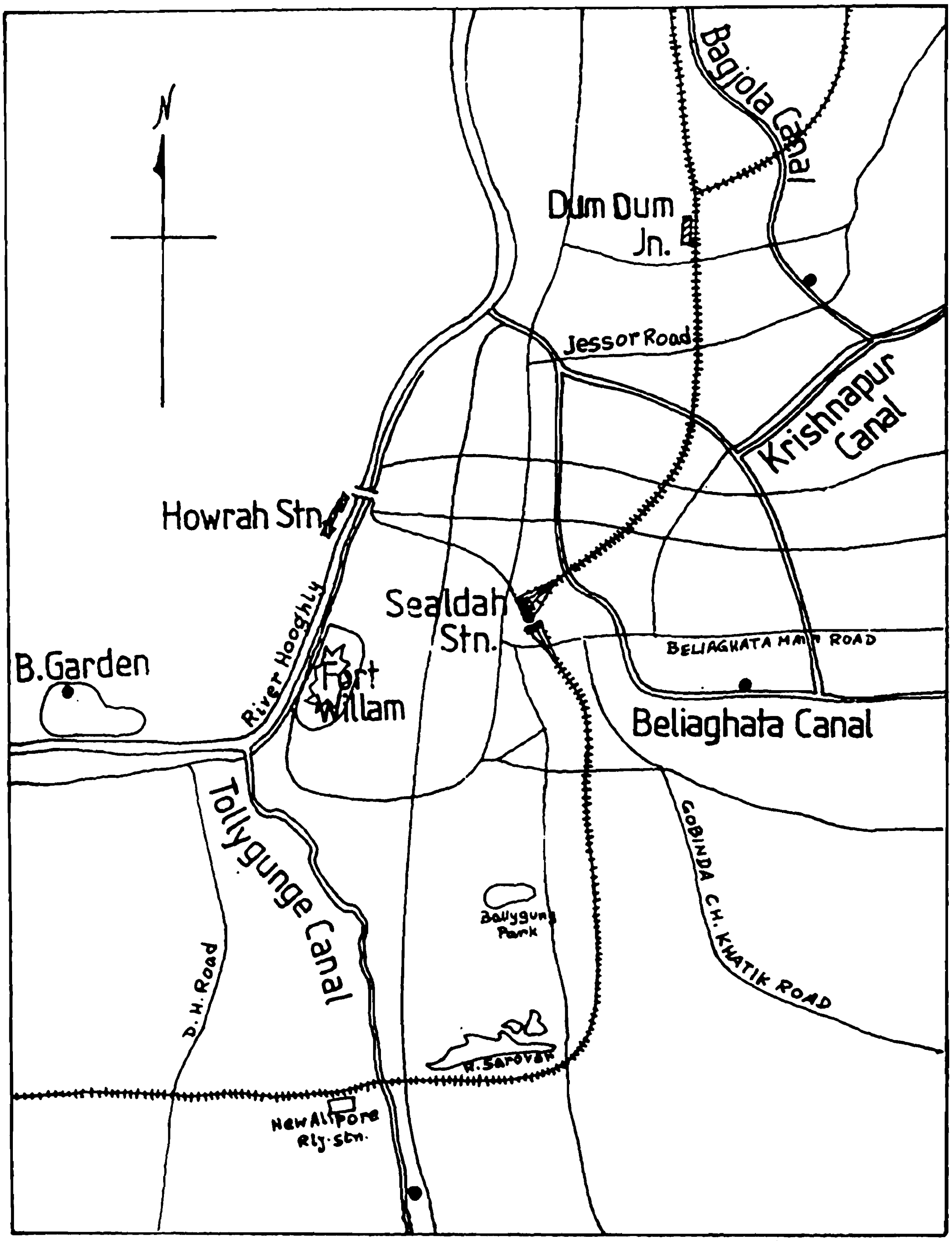
(b) *Vegetation* : The embankment of the canal at the site is almost barren, excepting the presence of a few species of herbs. The species that were encountered as *Ipomoea* sp. (Convolvulaceae) *Crozophora plicate* (Euphorbiaceae), *Lippia nodiflora* (Verbenaceae), *Jatropha gossipifolia* (Euphorbiaceae), *Croton sperciflora* (Euphorbiaceae), representatives of the families Amaranthaceae and Polygonaceae. The embankments also contained debris of water hyacinth (*Eichornia crassipes*). Water hyacinth was also recorded occasionally floating on the surface of the sewage. The plot contained grasses all along though not of much flourishing nature.

## II. **Beliaghata Canal**

(a) *Location and characteristics of the sampling site* The Beliaghata Canal is situated on the eastern part of Calcutta, being constructed during the period 1875-1882. It extends from the river Hooghly on the western side to Bhangar Kata Khal on the East, and meets the river Bidyadhari (Map-1).

This canal receives sewage from its adjoining areas like Ultadanga, Maniktala, Narkeldanga, Kankurgachi, Beliaghata, Sealdah etc. Host of industries have developed in these areas in the past decades, which include paper and pulp, pharmaceutical, chemical, cotton, plastic, mosaic tiles, electroplating, ceramics, mirror industries etc. A large share of the effluents of these industries is carried by this canal, thus it receives sewage as well as industrial effluents from diffused sources.

The sampling site on the embankment of this canal is near Beliaghata Main Road, nearly 3 kms. east of Sealdah Rly. Station. The canal at this point is about 15 meters. in width,




**Map No. 1**. Showing different sampling sites (●) in and around Calcutta having cattle shades on its both sides. A large area of the embankment is also used for dumping the solid refuses of the city. The sewage is dark in colour with thick consistency, suggesting anaerobic condition of the canal. The water surface of the canal contains water hyacinth in patches. The entire environment emits foul smell suggesting liberation of obnoxious gases.

The soil on the embankment contains very course sand, alluvium in nature, dark grey in colour, and admixed with particles of solid wastes such as glass, plastic, polythene, clothes, cotton, wood, bone and various other things.

(b) *vegetation* : The plot contains a few species of herbs, scanty grasses. The embankment is mostly barren at the sampling site. The floral species are identified as *Cyperus tagetum* (Cyperaceae), *Croton sperciflora* (Euphorbiaceae), *Ipomoea* sp. (Convolvulaceae) and some members of the families Labiateae and Amaranthaceae.

III. **Tollygunge nulah (Canal)**

(a) *Location and characteristics of the sampling site* Tollygunge nulah (canal) is situtated at the southern extrimity of the city. It originates from the river Hooghly near Hastings and extends towards Garia (Map-1). It was excavated during the year 1775-77 A.D. by Major Tolly it initially served the purpose of navigation, but rapid silting in subsequent years greatly hampered navigation (Banerjee and Roy 1967). This nulah (canal) also receives a considerable amount of sewage daily from the adjoining ever increasing human settlements. In the last decade areas surrounding Tollygunge has become thickly populated. Mushroom like growth of small industries has also created additional problems. Thus this canal receives daily city sewage from diffused sources as well as effluents from different industries and feed lot runoff. Characteristically the canal experiences daily low and ebb tides of the river Hooghly.

The sampling site, located on the embankment is situated at Naktola nearly 2 kms. north of Garia Rly. Station. Here the canal is approximately 6-7 metres in width. The embankment is not that slanting as was found in case of the other two canals. During ebb tide the lower part of the embankment remains completely immersed, and in monsoon period frequent overflooding of the canal is observed.

(b) *Vegetaion* : The slanting embankment of this site had vegetation richer than that of other two canals. The grasses were quite developed particularly *Cynodon dactylon* (Graminae), some herbs and shrubs were also found. The dominating floral species were *Lippia nodiflora* (Verbenaceae), *Ipomoea* sp. (Convolvulaceae), *Arum indica* (Araceae), *Croton* *sperciflora* (Euphorbiaceae), *Ricinus communis* (Euphorbiaceae), *Eichornia crassipes*, (Pontedariaceae), *Cyoerus tagetum* (Cyperaceae), *Zizyphus zuzube* (Rhamnaceae), *Polygonum orientale* and *P. barbatum* (Polygonaceae), *Haleotropum indicum* (Boraginaceae) and some members of the family Chenopodiaceae.

IV. **Botanical Garden**

(a) *Location and characteristic of the sampling site* The Shibpur Botanical Garden is situated on the western part of the River Hooghly, nearly six km. west of Howrah Rly. Station. A perenneal water body has been selected here for comparison. The water body is about 1 sq. km. in area occupying almost central part of the garden. The degree of inclination of the embankment of the water body is low. It is not connected to any sewage carrying canal, it does not also receive any sewage or industrial effluents from any source. Human interferene in this water body is also minmum and negligible. Thus it was found to be ideal situation for a comparative study. The soil at this site was found to be alluvium in nature, faint brownish in colour and clay-loam in texture.

(b) *Vegetation* : The embankment of this water body is thickly vegetated. The grasses are plenty and flourishing. The herbs, shrub and trees were all over the embankment. The embankment receive sunlight as well as shade from the trees. The floral species were identified as *Cynodon dactylon* (Graminae), *Cyperus tagetum* (Cyperaceae), *Croton sperciflora* (Euphorbiaceae), *Paspalam* sp. (Graminae), *Ipomoea* sp. (Convolvulaceae) etc. The plot also contained the fallen leaves and twigs from trees like *Mangifera indica* (Anacardiaceae), *Ficus religiosa* (Urticacae) etc. Water hyacinth was occassionally found near the embankment at this site.

## MATERIALS AND METHODS

### Methods of Sampling

The soil sampler used in the present study was deviced by Dhillon, 1964, modified by Roy, 1967, contained two pieces, one was the stainless steel corer which had a length of 5 cm, an internal diameter of 3.5 cm and an external diameter of 4.6 cm with a sharp cutting edge, sloping from outside to inside. The other end of the corer had a circular groove on the outer surface. This corer was fitted into a holder, which was a galvanised iron cylinder, of 30 cm long and 4.7 cm internal diameter so that the cutting edge of the corer remained at the distal end. The holder had two small holes at the bottom line of it, on the opposite sides. The corer was fitted with the holder by pressing steel clips, through the holes of the holder, that ended into the groove of the corer. The other end of the holder was fitted with two handles to drive the corer into the soil. The soil was collected by pushing the stainless steel corer duly into the soil. Then by pulling the holder, the steel corer was removed by manipulating the clips, thus the corer contained soil from 0-5 cm layer, then another corer of the same measurement was again pushed into the soil at the particular hole from where the first soil sample was collected. This corer, when removed, contained soil sample from 5-10 cm layer. Thus with the help of this instrument soils were collected from two layers of soil i.e., 0-5 cm and 5-10 cm. from all the sampling sites to study the vertical distribution of soil fauna.

The width of the embankments of all the canals and water pool were measured to be within 3-4 meters. The embankments of the canals and the waterbody were devided into three parallel horizontal rows, each of which measured about 10 meter x 1.5 meters. Four soil samples from each layer of each zone were collected at monthly interval, thus involving a total of 24 soil samples from each of the sampling sites per month. The sampling was conducted for two annual cycles (Dec. '80–Nov. '82). A total of 576 soil samples were collected from each of the sampling sites during the entire period of study.

**Extraction of samples**

In the present study the extraction-apparatus used was as designed by Macfadyen (1953) with slight modification for the extraction of soil arthropods. The apparatus was a cylindrical drum of about 20 cm in height and about 52 cm in diameter, with a metal cover on it. On the inner side of the cover a 40 watt lamp was mounted at the centre of it, the cover was detachable. At the floor of the drum were 24 small round apertures through which 24 galvanised iron funnels were fitted in such a manner so that the stems of the funnels remained hanging from the outside bottom of drum. The drum was kept mounted on a tripod stand, small collecting tubes of about 5 cm long were kept tightly associated with the stem of the funnels by rubber bung. These tubes contained 70% ethyl alcohol which preserved the soil arthropods so collected. Inside the drum, on each funnel the stainless steel corer containing the soil samples was placed in an upright position. The drum thus loaded with sample was kept under illumination for 72 hours for extraction. The extracted soil arthropods were then sorted out into different groups, under stereoscopic binocular microscopes, counted and preserved in separate glass vials in 70% alcohol for further study.

**Analysis of edaphic factors**

For the analysis of edaphic factors, soils were collected from each site and each layer separately throughout the period of sampling for population estimation. Several soil factors such as temperature, moisture, pH, organic carbon and heavy metals like copper, chromium lead were analysed by means of standard methods.

### Temperature

Temperature of the soil was measured directly by inserting a soil thermometer, caliberated from 0°C to 100°C having a least count of 0.1 °C, into the soil of each site and each layer.

### Moisture

The soil moisture was determined by Infrared Moisture Balance (Model A).

### Hydrogen ion concentration

The pH of the soil sample was determined by using a digital (Beckman) pH meter.

### Organic Carbon

The Organic caron content of soil was determined following the method of Walkley and Black, (1934).

### Estimation of heavy metals

Estimation of heavy metals like copper, chromium and lead was done by following spectographic method, using Automatic spectograph E 742. ( Manual of Chemical Analysis 1982. Published by G. S. I., Calcutta ).

## RESULTS

### (A) Edaphic factors

*Site-I - Bagjola Canal ( Dum Dum )* : Soil pH ranged from 6. 78 to 7. 28. In the month of August, the concentration of copper, chromium and lead were maximum and the respective values were 98.33±4.59 ppm, 37.50±1.71 ppm, and 36.67±1.67 ppm during the first year, but their respective values in the second year for this month were 99.17±2.39 ppm ; and 35.83±2.39 ppm, while the concentration of lead was maximum in September (39.17±2.39 ppm). Other soil factors such as temperature, moisture and organic carbon in the month of August are shown in Table-1. In April the values of copper, chromium and lead were found minimum; the respective values were 25.00±1.83 ppm. 19.17±1.54 ppm and 23.33±1.05 ppm in the first year and 23.33±1.05 ppm, 20.00±1.83 ppm and 19.17±3.96 ppm in the second year. The values of temperature, moisture and organic carbon in this month are shown in Table-1.

*Site-II - Beliaghata Canal* Soil pH varied from 7.03 to 6.62. In the month of May the concentrations of copper, chromium and lead were maximum, respectively being 178.30±7.49 ppm, 261.67±30.81 ppm and 251.67±29.93 ppm in the first year; and 195.83±6.76 ppm, 270.00±32.14 ppm, and 337.50±29.28 ppm respectively in the second year. Other soil factors such as temperature, moisture and organic carbon in the month of May are shown in Table-2.

Low concentrations of heavy metals were observed in the months of February and October, the concentrations (ppm) being 126.67±6.15, 71.67±9.19 and 125.00±2.24 of copper, chromium and lead respectively in February, and 95.83±13.69, 107.50±9.81 and 117.50±20.60 respectively in October of the first year, while these values were 120.00±3.41, 78.33±3.80 and 115.00±6.58 respectively in the month of February, and 10.3.33±8.72, 103.30±6.54 and 80.83±22.52 respectively in October of the second year. The corresponding values of temperature, moisture and organic carbon are shown in Table-2.

*Site - III - Tollygunge Nulah* Soil pH ranged from 6.88 to 7.75. The concentrations of copper, chromium and lead were found to be minimum in the month of February. The values were 20.83±2.39, 19.17±2.39 and 16.67±1.07 ppm respectively in the first year, while in the second year these values were 22.50±3.35, 30.00±1.83 and 20.83±1.54 ppm respectively for copper, chromium and lead. The other soil factors such as temperature, moisture and organic carbon in this month are shown in Table-3. In the month of September, of the second year the concentrations of copper, chromium and lead were found to be minimum, the values being 33.33±1.67, 90.83±4.17 and 29.17±1.54 respectively; while in the first year no such observation could be made due to complete inudation of the sampling site by rain water. Temperature, moisture and organic carbon in September were 28.17±0.28°C, 35.07±2.60% and 0.98±0.02% respectively (Table-3).

*Site-IV - Botanical Gardens* Soil pH varied from 6.199 to 7.37. The concentrations of copper, chromium and lead were found to be minimum in the month of August. The values in ppm were 8.50±0.72, 7.67±1.17 and 7.33±0.49 respectively in the first year and 8.67±0.67, 8.67±0.84 and 9.33±0.42 respectively in the second year. But temperature, moisture and organic carbon of soil in this month were quite high, the values for these are shown in Table-4.

**Table 1**

Showing mean values per sample along with their S.E. of the different soil factors and arthropod population, per month, at Bagjola canal, Dumdum.

| Month | Arthropod Population Mean ± S.E. | Soil factors (Mean ± S.E.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Temperature (°C) | Moisture (%) | pH | Organic Carbon (%) | Copper (ppm) | Chromium (ppm) | Lead (ppm) |
| Dec. | 13.17±6.45 | 13.17±0.49 | 32.70±4.73 | 6.83±0.28 | 2.63±0.18 | 30.83±2.39 | 21.67±2.47 | 21.67±2.07 |
| Jan. | 7.17±3.82 | 18.58±0.37 | 30.75±4.74 | 6.86±0.13 | 2.68±0.13 | 77.50±2.14 | 21.67±2.11 | 26.67±2.11 |
| Feb. | 8.17±4.09 | 14.33±0.40 | 30.50±3.37 | 6.83±0.31 | 2.73±0.15 | 86.67±1.05 | 26.67±1.67 | 30.00±1.29 |
| Mar. | 13.50±8.21 | 23.83±0.17 | 24.17±1.98 | 6.87±0.23 | 2.76±0.15 | 35.00±1.29 | 30.00±2.89 | 31.67±1.67 |
| Apr. | 28.00±6.96 | 25.50±0.50 | 20.15±1.28 | 6.94±0.27 | 2.78±0.14 | 25.00±1.83 | 19.17±1.54 | 23.33±1.05 |
| May. | 15.00±5.29 | 25.42±0.20 | 18.77±1.24 | 7.06±0.23 | 2.88±0.14 | 30.00±1.29 | 19.17±1.54 | 20.83±2.39 |
| Jun. | 5.17±1.25 | 26.92±0.33 | 18.62±1.24 | 6.99±0.24 | 2.84±0.14 | 88.33±2.11 | 31.67±1.05 | 36.67±2.47 |
| Jul. | 9.33±1.82 | 27.67±0.33 | 24.82±3.05 | 6.78±0.22 | 2.77±0.13 | 79.17±1.54 | 31.67±3.33 | 27.50±2.14 |
| Aug. | 5.17±1.19 | 28.83±0.42 | 33.67±4.83 | 6.89±0.21 | 2.67±0.12 | 98.33±4.59 | 37.50±1.71 | 36.67±1.67 |
| Sep. | 16.50±9.53 | 29.33±0.54 | 40.00±2.93 | 6.90±0.24 | 2.60±0.13 | 87.50±2.14 | 35.83±2.01 | 34.17±2.39 |
| Oct. | 11.83±5.32 | 28.58±0.52 | 33.75±2.92 | 6.92±0.20 | 2.59±0.14 | 64.17±2.39 | 33.33±3.33 | 32.83±2.60 |
| Nov. | 13.33±3.07 | 22.83±0.56 | 29.00±2.17 | 6.78±0.25 | 2.41±0.13 | 50.83±2.39 | 25.00±2.89 | 22.50±3.10 |
| Dec. | 13.83±2.09 | 13.67±0.60 | 28.07±3.50 | 6.78±0.24 | 2.52±0.12 | 33.33±2.47 | 23.33±2.11 | 24.17±2.71 |

*Table 1 (continued)*

| Month | Arthropod Population Mean ± S.E. | Soil factors (Mean ± S.E.) Temperature (°C) | Moisture (%) | pH | Organic Carbon (%) | Copper (ppm) | Chromium (ppm) | Lead (ppm) |
|---|---|---|---|---|---|---|---|---|
| Jan. | 10.00±2.18 | 19.00±0.29 | 28.02±3.80 | 7.03±0.17 | 2.52±0.10 | 75.83±2.39 | 28.33±1.67 | 25.83±2.01 |
| Feb. | 8.50±1.23 | 14.83±0.48 | 30.67±3.29 | 7.00±0.12 | 2.72±0.12 | 82.50±1.71 | 22.50±4.79 | 28.33±1.67 |
| Mar. | 13.50±3.22 | 23.50±0.26 | 24.46±1.57 | 6.98±0.22 | 2.45±0.33 | 33.33±1.67 | 25.00±2.24 | 29.33±2.11 |
| Apr. | 19.67±4.10 | 26.92±0.33 | 21.43±1.06 | 6.99±0.28 | 2.88±0.17 | 23.33±1.05 | 20.00±1.83 | 19.17±3.96 |
| May. | 13.67±3.14 | 26.00±0.18 | 19.70±1.51 | 7.28±0.06 | 2.76±0.08 | 30.00±1.29 | 20.00±1.29 | 25.00±2.58 |
| Jun. | 5.83±1.60 | 27.28±0.38 | 19.28±1.25 | 7.18±0.14 | 2.94±0.12 | 85.83±1.54 | 33.33±2.47 | 37.50±2.81 |
| Jul. | 9.00±2.99 | 28.25±0.34 | 23.79±4.79 | 7.13±0.11 | 2.80±0.12 | 80.00±1.29 | 33.33±2.47 | 29.17±3.96 |
| Aug. | 4.83±0.31 | 30.25±0.21 | 31.05±1.20 | 7.04±0.16 | 2.75±0.10 | 99.17±2.39 | 35.83±2.39 | 33.33±3.33 |
| Sep. | 8.67±1.02 | 29.67±0.17 | 37.07±2.93 | 7.04±0.15 | 2.53±0.09 | 88.33±2.47 | 34.17±1.54 | 34.17±2.39 |
| Oct. | 12.17±2.53 | 28.58±0.30 | 34.63±2.94 | 7.07±0.14 | 2.53±0.10 | 64.17±2.71 | 34.17±2.39 | 31.67±1.67 |
| Nov. | 12.83±1.56 | 22.08±0.37 | 30.57±2.06 | 6.95±0.18 | 2.57±0.04 | 47.50±2.81 | 23.33±2.11 | 26.67±2.79 |

**Table 2**

Showing mean values per sample along with their S.E. of the different soil factors and arthropod population, per month, at Beliaghata canal.

| Month | Arthropod population mean ± S.E. | Soil factors (Mean ± S.E.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Temperature (°C) | Moisture (%) | pH | Organic carbon (%) | Copper (ppm) | Chromium (ppm) | Lead (ppm) |
| Dec. | 6.50±1.06 | 15.58±0.55 | 29.28±3.57 | 7.62±0.10 | 2.65±0.06 | 105.00±3.41 | 58.33±7.15 | 105.00±2.24 |
| Jan. | 3.17±1.25 | 20.07±0.45 | 27.43±3.56 | 7.53±0.10 | 2.53±0.30 | 120.00±5.16 | 59.17±2.71 | 110.00±3.65 |
| Feb. | 9.67±3.80 | 24.00±0.47 | 30.52±6.25 | 7.41±0.09 | 2.57±0.04 | 126.67±6.15 | 71.67±9.19 | 125.00±2.24 |
| Mar. | 9.17±3.79 | 22.42±0.27 | 30.70±5.91 | 7.33±0.11 | 2.59±0.03 | 127.50±2.50 | 75.83±8.21 | 125.83±2.01 |
| Apr. | 5.00±1.61 | 26.42±0.37 | 22.30±0.75 | 7.25±0.12 | 2.59±0.04 | 158.33±8.33 | 208.33±51.07 | 235.83±50.15 |
| May. | 5.67±1.91 | 29.33±0.54 | 20.78±0.76 | 7.29±0.13 | 2.66±0.05 | 178.30±7.49 | 261.67±30.81 | 251.67±29.93 |
| Jun. | 3.00±0.63 | 30.00±0.32 | 20.15±0.64 | 7.19±0.17 | 2.62±0.05 | 170.00±6.19 | 236.67±19.77 | 216.77±14.03 |
| Jul. | 5.67±0.95 | 29.50±0.56 | 30.20±1.69 | 7.19±0.16 | 2.56±0.06 | 153.33±3.33 | 161.67±35.06 | 170.00±10.00 |
| Aug. | 9.50±1.50 | 29.58±0.45 | 35.00±4.75 | 7.23±0.13 | 2.51±0.06 | 145.00±4.28 | 181.67±17.20 | 143.33±17.44 |
| Sep. | 5.17±0.48 | 29.58±0.27 | 39.47±3.26 | 7.15±0.15 | 2.46±0.06 | 135.00±2.24 | 170.00±10.33 | 167.67±6.54 |
| Oct. | 9.33±1.93 | 29.08±0.33 | 34.42±3.40 | 7.20±0.21 | 2.51±0.04 | 95.83±13.69 | 107.50±9.81] | 117.50±20.60 |
| Nov. | 8.83±1.01 | 24.00±0.42 | 34.67±3.77 | 7.03±0.19 | 2.45±0.07 | 105.00±9.57 | 112.50±11.31 | 114.17±9.34 |
| Dec. | 5.67±0.80 | 16.17±0.51 | 34.02±3.83 | 7.54±0.12 | 2.48±0.10 | 113.33±7.15 | 65.00±6.95 | 106.67±4.71 |

*Table 2 (continued)*

| Month | Arthropod population mean ± S.E. | Soil factors (Mean ± S.E.) Temperature (°C) | Moisture (%) | pH | Organic carbon (%) | Copper (ppm) | Chromium (ppm) | Lead (ppm) |
|---|---|---|---|---|---|---|---|---|
| Jan. | 3.83±0.31 | 20.42±0.58 | 30.59±2.45 | 7.51±0.08 | 2.59±0.06 | 120.00±5.95 | 73.33±5.11 | 109.17±3.27 |
| Feb. | 6.00±1.06 | 23.25±0.28 | 28.67±4.14 | 7.56±0.08 | 2.65±0.02 | 120.00±3.41 | 78.33±3.80 | 115.00±6.58 |
| Mar. | 6.33±1.80 | 22.58±0.45 | 30.07±5.04 | 7.30±0.09 | 2.59±0.05 | 113.33±30.07 | 83.33±2.47 | 114.17±3.27 |
| Apr. | 3.33±1.17 | 26.83±0.38 | 23.88±0.77 | 7.23±0.13 | 2.64±0.06 | 170.00±4.83 | 227.50±11.21 | 248.33±24.31 |
| May. | 3.17±0.48 | 29.92±0.47 | 21.72±1.10 | 7.38±0.10 | 2.70±0.04 | 195.83±6.76 | 270.00±32.14 | 337.50±29.28 |
| Jun. | 4.33±1.77 | 30.58±0.20 | 20.78±1.13 | 7.37±0.07 | 2.59±0.06 | 169.17±5.83 | 239.17±11.13 | 255.10±23.59 |
| Jul. | 5.17±1.08 | 30.25±0.34 | 28.28±3.00 | 7.31±0.10 | 2.61±0.04 | 139.17±2.01 | 199.17±5.83 | 178.33±5.58 |
| Aug. | 5.33±1.02 | 30.08±0.15 | 32.22±1.19 | 7.23±0.12 | 2.58±0.05 | 139.17±3.96 | 180.00±14.20 | 155.83±5.97 |
| Sep. | 4.83±0.65 | 29.08±0.27 | 38.67±2.05 | 7.22±0.12 | 2.53±0.06 | 129.17±6.88 | 165.83±7.68 | 170.83±10.90 |
| Oct. | 6.00±0.87 | 28.42±0.33 | 35.15±3.08 | 7.19±0.21 | 2.47±0.07 | 103.30±8.28 | 203.30±6.54 | 80.83±22.52 |
| Nov. | 4.67±0.33 | 22.53±0.45 | 32.52±2.16 | 7.13±0.17 | 2.46±0.10 | 98.33±6.54 | 99.17±9.52 | 107.50±7.72 |

**Table 3**

Showing mean values per sample along with their S.E. of the different soil factors and arthropod population, per month, at Tollygunge Nulah.

| Month | Arthropod population mean ± S.E. | Soil factors (Mean ± S.E.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Temperature (°C) | Moisture (%) | pH | Organic carbon (%) | Copper (ppm) | Chromium (ppm) | Lead (ppm) |
| Dec. | 6.33±2.43 | 9.08±0.99 | 28.50±2.77 | 7.75±0.02 | 0.84±0.05 | 28.33±2.11 | 38.33±3.33 | 20.00±1.29 |
| Jan. | 17.67±7.76 | 7.17±0.65 | 27.50±1.86 | 7.75±0.05 | 0.90±0.09 | 21.67±2.11 | 28.33±1.67 | 18.33±1.67 |
| Feb. | 26.83±13.66 | 19.67±0.56 | 27.03±1.34 | 7.73±0.02 | 0.94±0.10 | 20.83±2.39 | 19.17±2.39 | 16.67±1.07 |
| Mar. | 8.67±2.51 | 27.00±0.10 | 24.55±1.22 | 7.55±0.03 | 1.00±0.10 | 32.50±1.12 | 38.33±2.79 | 20.83±2.01 |
| Apr. | 4.00±0.77 | 28.25±0.31 | 23.87±1.04 | 7.45±0.04 | 1.02±0.10 | 26.67±2.11 | 46.67±4.41 | 20.83±1.54 |
| May. | 9.33±1.12 | 28.69±0.44 | 21.62±1.24 | 7.31±0.16 | 1.10±0.08 | 25.83±2.71 | 30.83±2.71 | 20.00±1.83 |
| Jun. | 5.83±0.87 | 30.08±0.27 | 21.28±1.22 | 7.21±0.18 | 1.08±0.08 | 30.00±1.29 | 38.33±2.11 | 20.00±1.83 |
| *Jul. | | | | | | | | |
| *Aug. | | | | | | | | |
| *Sep. | | | | | | | | |
| Oct. | 6.00±1.51 | 27.50±0.18 | 31.02±1.42 | 7.07±0.16 | 0.94±0.02 | 28.33±2.79 | 38.33±2.79 | 19.17±1.54 |
| Nov. | 6.33±1.84 | 22.42±0.27 | 28.55±1.92 | 6.91±0.22 | 1.01±0.03 | 34.17±3.96 | 34.17±3.96 | 21.67±1.67 |
| Dec. | 5.67±1.41 | 9.75±0.48 | 24.80±2.96 | 7.57±0.07 | 0.92±0.07 | 37.50±3.10 | 37.50±3.10 | 20.83± |

* Data could not be taken due to inundation of the embankments

*Table 3 (continued)*

| Month | Arthropod population mean ± S.E. | Soil factors (Mean ± S.E.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Temperature (°C) | Moisture (%) | pH | Organic carbon (%) | Copper (ppm) | Chromium (ppm) | Lead (ppm) |
| Jan. | 13.00±1.03 | 9.50±0.52 | 27.70±1.70 | 7.32±0.22 | 0.94±0.04 | 21.67±2.11 | 27.50±2.14 | 17.50±1.71 |
| Feb. | 14.50±2.55 | 20.50±0.56 | 27.03±1.57 | 7.71±0.05 | 1.00±0.10 | 22.50±3.35 | 30.00±1.83 | 20.83±1.54 |
| Mar. | 9.67±1.86 | 26.67±0.81 | 25.62±1.41 | 7.51±0.05 | 1.08±0.04 | 30.00±1.29 | 39.17±2.17 | 17.50±1.71 |
| Apr. | 5.67±0.67 | 28.17±0.17 | 24.90±1.02 | 7.40±0.04 | 1.11±0.05 | 27.50±1.71 | 30.83±2.39 | 19.17±1.54 |
| May. | 8.17±1.28 | 29.50±0.34 | 21.88±1.26 | 7.38±0.03 | 1.14±0.05 | 32.50±1.12 | 37.50±4.23 | 20.83±2.01 |
| Jun. | 6.83±0.83 | 29.75±0.17 | 21.92±1.67 | 7.34±0.05 | 1.15±0.06 | 29.17±1.54 | 35.00±1.29 | 21.67±2.11 |
| Jul. | 7.67±1.54 | 28.25±0.31 | 28.37±3.35 | 7.29±0.04 | 0.98±0.03 | 30.00±2.58 | 31.67±3.07 | 22.50±3.10 |
| Aug. | 3.83±1.35 | 28.33±0.40 | 32.00±1.37 | 7.23±0.05 | 0.90±0.04 | 35.00±2.58 | 87.50±5.12 | 27.50±1.71 |
| Sep. | 3.50±1.06 | 28.17±0.28 | 35.06±2.60 | 7.10±0.11 | 0.98±0.02 | 33.33±1.67 | 70.83±4.17 | 29.17±1.54 |
| Oct. | 8.00±1.34 | 28.58±0.35 | 34.75±3.24 | 7.20±0.08 | 1.01±0.01 | 29.17±1.54 | 31.67±3.33 | 20.00±1.29 |
| Nov. | 7.83±1.66 | 22.17±0.60 | 31.80±3.50 | 6.88±0.15 | 1.01±0.03 | 28.33±2.11 | 31.67±2.79 | 19.17±1.54 |

**Table 4**

Showing mean values per sample along with their S.E. of the different soil factors and arthropod population, per month, at Botanical garden site.

| Month | Arthropod population mean ± S.E. | Soil factors (Mean ± S.E.) Temperature (°C) | Moisture (%) | pH | Organic carbon (%) | Copper (ppm) | Chromium (ppm) | Lead (ppm) |
|---|---|---|---|---|---|---|---|---|
| Dec. | 22.50±7.45 | 18.25±0.83 | 24.05±2.35 | 7.12±0.05 | 2.18±0.15 | 7.33±0.95 | 9.33±1.36 | 7.17±0.75 |
| Jan. | 13.83±3.25 | 21.08±0.96 | 22.22±2.33 | 6.99±0.09 | 2.03±0.09 | 8.31±0.61 | 9.00±0.45 | 8.50±0.81 |
| Feb. | 12.83±3.70 | 23.08±0.93 | 20.13±1.93 | 7.11±0.06 | 2.09±0.05 | 9.33±0.67 | 7.83±0.83 | 9.00±1.37 |
| Mar. | 11.83±3.96 | 26.83±0.31 | 18.25±1.69 | 7.03±0.08 | 2.32±0.07 | 10.50±0.96 | 10.00±0.52 | 11.17±0.83 |
| Apr. | 9.00±1.73 | 32.25±0.51 | 16.15±1.45 | 7.21±0.04 | 2.05±0.05 | 11.67±1.05 | 11.50±0.81 | 11.17±0.83 |
| May. | 7.50±1.95 | 34.50±0.43 | 16.02±1.59 | 7.19±0.04 | 1.93±0.05 | 19.1±1.54 | 8.67±1.45 | 18.33±2.11 |
| Jun. | 8.67±2.26 | 33.92±0.45 | 16.43±1.82 | 7.30±0.03 | 2.43±0.03 | 10.50±0.96 | 9.67±0.33 | 10.50±0.96 |
| Jul. | 29.83±6.73 | 32.08±0.42 | 26.42±1.72 | 7.03±0.07 | 2.71±0.04 | 20.00±1.29 | 19.17±1.54 | 19.17±1.54 |
| Aug. | 32.67±6.49 | 33.50±0.41 | 32.02±1.55 | 7.02±0.06 | 2.75±0.06 | 8.50±0.72 | 7.67±1.17 | 7.33±0.49 |
| Sep. | 27.00±2.45 | 32.08±0.33 | 35.78±2.36 | 7.09±0.08 | 3.02±0.07 | 9.50±1.26 | 10.17±1.05 | 9.33±0.42 |
| Oct. | 22.50±6.45 | 30.42±0.37 | 30.95±1.16 | 7.37±0.64 | 2.88±0.06 | 10.67±1.91 | 9.17±1.38 | 9.50±1.26 |
| Nov. | 23.00±4.66 | 25.42±0.40 | 25.02±0.89 | 7.01±0.07 | 2.93±0.05 | 9.33±0.84 | 16.67±2.11 | 8.00±0.52 |
| Dec. | 18.17±5.05 | 19.42±0.49 | 22.95±1.45 | 7.08±0.05 | 2.27±0.14 | 8.17±0.19 | 9.83±1.22 | 8.17±0.91 |

*Table 4 (continued)*

| Month | Arthropod population mean ± S.E. | Soil factors (Mean ± S.E.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Temperature (°C) | Moisture (%) | pH | Organic carbon (%) | Copper (ppm) | Chromium (ppm) | Lead (ppm) |
| Jan. | 13.00±2.57 | 21.75±0.79 | 21.55±1.72 | 7.00±0.08 | 1.97±0.07 | 8.00±0.73 | 9.00±0.86 | 9.00±0.68 |
| Feb. | 14.50±1.75 | 22.58±0.71 | 19.89±1.76 | 7.16±0.04 | 2.05±0.06 | 9.00±0.68 | 10.17±1.05 | 9.17±1.38 |
| Mar. | 12.50±3.19 | 25.25±0.17 | 17.78±1.42 | 7.08±0.05 | 2.32±0.12 | 9.50±1.26 | 9.33±0.67 | 10.50±0.96 |
| Apr. | 10.33±1.74 | 30.75±0.38 | 14.97±1.08 | 7.17±0.04 | 2.02±0.08 | 11.33±1.23 | 11.50±0.81 | 12.00±1.00 |
| May. | 8.83±1.85 | 33.17±0.31 | 15.95±1.41 | 7.19±0.03 | 1.98±0.08 | 16.67±1.67 | 11.00±1.32 | 18.33±1.67 |
| Jun. | 11.83±2.57 | 33.92±0.49 | 17.82±1.34 | 7.32±0.03 | 2.31±0.05 | 10.17±1.05 | 11.00±1.32 | 10.50±0.96 |
| Jul. | 29.17±6.40 | 32.25±0.31 | 24.27±1.97 | 7.08±0.06 | 2.65±0.06 | 19.94±1.98 | 17.50±1.12 | 19.17±2.01 |
| Aug. | 36.00±5.77 | 33.42±0.42 | 31.23±1.25 | 7.14±0.05 | 2.81±0.08 | 8.67±0.67 | 8.67±0.84 | 9.33±0.42 |
| Sep. | 27.67±4.08 | 32.25±0.40 | 35.92±2.00 | 7.00±0.08 | 2.92±0.06 | 10.17±1.05 | 12.17±1.30 | 10.83±0.98 |
| Oct. | 24.00±4.06 | 29.92±0.45 | 32.47±1.79 | 7.41±0.06 | 2.90±0.07 | 11.83±1.94 | 9.67±1.33 | 12.17±1.83 |
| Nov. | 19.83±3.74 | 25.33±0.44 | 26.55±1.06 | 7.01±0.07 | 2.91±0.05 | 8.67±0.99 | 18.33±1.05 | 13.00±2.29 |

Moderate concentration of copper, chromium and lead were found in the month of May. The values in ppm were 19.17±1.54, 8.67±1.45 and 18.33±2.11 respectively and 16.67±1.67, 111.00±1.32 and 18.33±1.67 respectively in two consequtive years. In the month of May soil temperature was highest, 34.50±0.43°C in the first year and 33.17±0.31°C in the second year. In this month the concentrations of moisture and organic carbon were very low (Table-4).

### (B) Faunal makeup

*Site-I - Bagjola Canal (Dum Dum)* It is evident from the Table-1 that the total arthropods collected per soil sample on average showed a tendency to attain a maximum population (peak) during the month of April, having a mean value and S. E. of 28.00±6.96. The population dropped down to minimum during August, the mean value and S. E. being 4.83±0.31, after which it gradually increased except in September of the first year when it suddenly spurted up to 16.50±9.53. (Fig. 1).

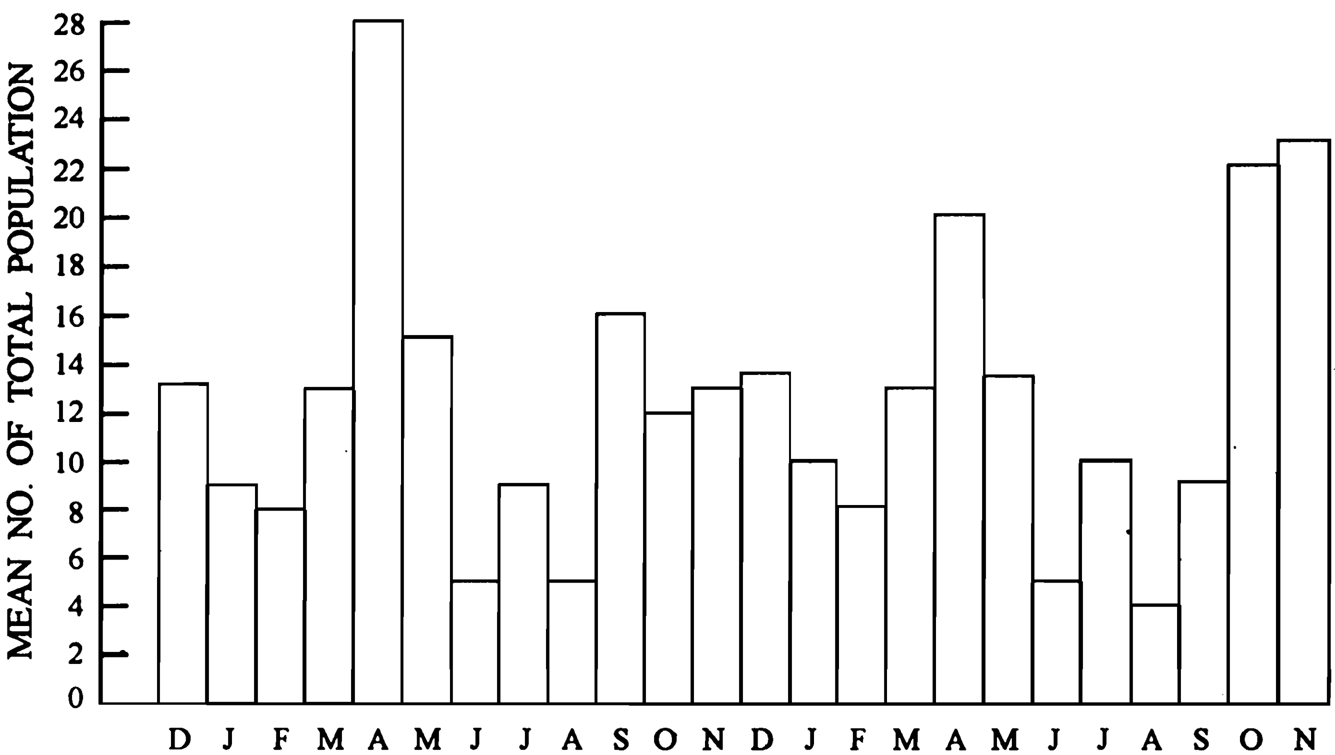



**Fig. 1.** Showing histogram of total population of arthropods at Bagjola canal site, Dum Dum

Faunal analysis indicate the presence of ten groups of arthropods, diperea and their maggot, hymenoptera, coleoptera, psocoptera, hemiptera with their nymphs, thysanoptera, araneida, crustacea etc. In this plot acarina had prodominated by attaining 32.98% of the total population (Table-5). Collembola came second having a population of 16.74%. Diptera and their maggots (13.50%), Hymenoptera (8.56%), and Coleoptera (5.40), occupied 3rd, 4th and 5th position respectively in order of dominance.

All other groups were numerically low and irregular in distribution. Some other non-arthropod organisms were also present which remained unidentified (categorised as "others") and constituted 11.00% of the total population (Table-5).

*Site-II - Beliaghata Canal* The total soil arthropods collected from this plot showed maximum population in February, of the first year having a mean value per sample (9.67±3.80), and minimum population with a mean value per sample (3.00±0.63) in June (Table-2). The yearwise breakup revealed maximum population in June and May of the two years. The total population exhibited (Fig. 2) two annual peaks one during the months of February-March while the other in the month of October (91.33±1.93 and 6.00±0.87), the lean periods were found during the months of May-June as stated above and again in the month of January (3.17±1.25 and 3.83±0.31).

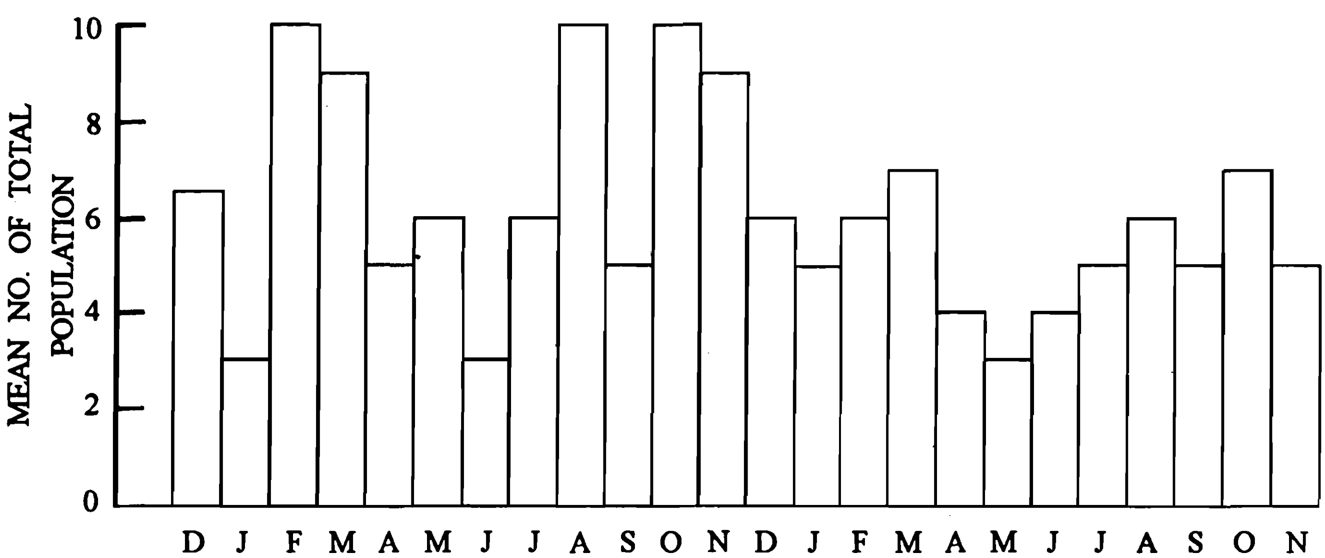



**Fig. 2.** Showing histogram of total population of arthropods at Beliaghata canal site

Faunal analysis indicated acarina as the most dominant group having 30.60% of the total population, followed by collembola (23.53%). Diptera (adults and maggots) jointly shared the third position having a concentration of 13.30% of the total population Hymenoptera (9.84%) and coleoptera (6.12%) were found to occupy respectively the fourth and the fifth

**Table 5**

Showing individual groups of arthropods and their monthly population in percentage at Bagjola Canal, Dumdum.

| Months | Diptera | Maggot | Collembola | Coleoptera | Hymenoptera | Acarina | Thysanoptera | Hemiptera | Hemiptera Nymph | Pseudoscorpion | Psocoptera | Crustacea | Araneida | Diplura | Protura | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec. | 0.48 | 2.94 | 0.18 | 0.24 | 0.06 | 0.66 | 0.12 | – | – | – | 0.18 | 0.06 | – | – | – | 0.06 |
| Jan. | 0.18 | – | 0.54 | 0.12 | 0.18 | 2.04 | 0.06 | – | – | – | 0.12 | – | – | – | – | 0.06 |
| Feb. | 0.18 | – | 0.30 | – | 0.24 | 1.38 | 0.06 | – | – | – | – | – | – | – | – | 0.78 |
| Mar. | 0.24 | – | 0.24 | – | 0.30 | 3.30 | – | – | – | – | – | – | – | – | – | 0.78 |
| Apr. | 0.54 | – | 0.54 | 0.36 | 2.04 | 2.10 | – | – | – | – | – | – | – | – | – | 5.40 |
| May. | 0.24 | – | 0.54 | 0.12 | 0.24 | 1.02 | 0.12 | – | – | – | 0.36 | – | – | – | – | 2.76 |
| Jun. | 0.12 | – | 0.42 | 0.06 | 0.24 | 0.72 | – | – | – | – | 0.12 | – | – | – | – | 0.18 |
| Jul. | 0.72 | – | 0.54 | 0.30 | 0.30 | 1.14 | – | – | – | – | 0.18 | – | 0.12 | – | – | – |
| Aug. | 0.30 | – | 0.30 | 0.18 | 0.24 | 0.72 | – | 0.06 | – | – | – | – | 0.06 | – | – | – |
| Sep. | 0.30 | 0.48 | 0.24 | 0.12 | 0.54 | 3.96 | – | – | – | – | 0.30 | – | – | – | – | – |
| Oct. | 0.78 | – | 0.42 | 0.30 | 0.06 | 0.30 | – | 0.06 | 1.92 | – | – | – | – | – | – | 0.30 |
| Nov. | 0.18 | 0.30 | 0.12 | 0.60 | 0.36 | 0.42 | 1.20 | – | 0.08 | – | – | 0.06 | – | – | – | 0.06 |
| Dec. | 0.06 | 0.48 | 0.18 | 0.60 | 0.06 | 0.30 | 1.08 | – | – | – | – | 0.18 | – | 0.06 | – | 0.24 |

*Table 5 (continued)*

| Months | Diptera | Maggot | Collembola | Coleoptera | Hymenoptera | Acarina | Thysanoptera | Hemiptera | Hemiptera Nymph | Pseudoscorpion | Psocoptera | Crustacea | Araneida | Diplura | Protura | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 0.42 | – | 0.96 | 0.24 | 0.36 | 1.86 | – | 0.12 | – | – | – | – | – | – | – | 0.48 |
| Feb. | 0.42 | – | 1.14 | 0.12 | 0.24 | 1.50 | 0.06 | – | – | – | 0.06 | – | – | – | – | 0.18 |
| Mar. | 0.36 | 0.12 | 1.44 | – | 0.18 | 1.38 | 0.12 | 0.12 | 0.18 | – | 0.06 | – | – | – | – | 0.06 |
| Apr. | 0.72 | – | 2.22 | 0.18 | 0.30 | 1.92 | – | 0.06 | 0.06 | – | 0.06 | – | – | – | – | 0.36 |
| May. | 0.42 | 0.12 | 0.90 | 0.12 | 0.48 | 1.68 | 0.12 | – | 0.12 | – | 0.06 | – | 0.06 | – | – | 0.18 |
| Jun. | 0.54 | 0.12 | 0.54 | 0.54 | 0.48 | 0.72 | 0.06 | – | – | – | 0.06 | – | – | – | – | – |
| Jul. | 0.36 | – | 1.14 | 0.30 | 0.36 | 1.56 | – | – | – | – | 0.12 | – | – | – | – | 0.06 |
| Aug. | 0.12 | – | 0.84 | 0.54 | 0.24 | 0.78 | – | 0.12 | 0.06 | – | 0.06 | – | – | – | – | – |
| Sep. | 0.54 | 0.06 | 0.78 | 0.30 | 0.18 | 1.02 | – | – | – | – | 0.18 | – | – | – | – | – |
| Oct. | 0.18 | – | 0.66 | 0.18 | 0.06 | 0.30 | 0.06 | 0.06 | – | – | – | – | – | – | – | 0.06 |
| Nov. | 0.54 | – | 0.66 | 0.36 | 0.42 | 0.66 | – | – | – | – | 0.12 | – | – | – | – | – |
| Total | 9.36 | 4.14 | 16.74 | 5.40 | 8.56 | 32.98 | 0.78 | 0.78 | 2.34 | – | 2.28 | 0.06 | 0.30 | – | – | 11.00 |

position (Table-6). Other groups of arthropods were found to be low in concentration and highly irregular in distribution.

*Site-III - Tollygunge Nulah* The total microarthropods collected from this site showed maximum concentration in the month of February, the mean value along the S. E. being 26.83±13.66; while the minimum concentration (3.50±1.06) was found in the month of September, (Table-3). The total arthropods showed a lower concentration during the second year (Fig. 3).

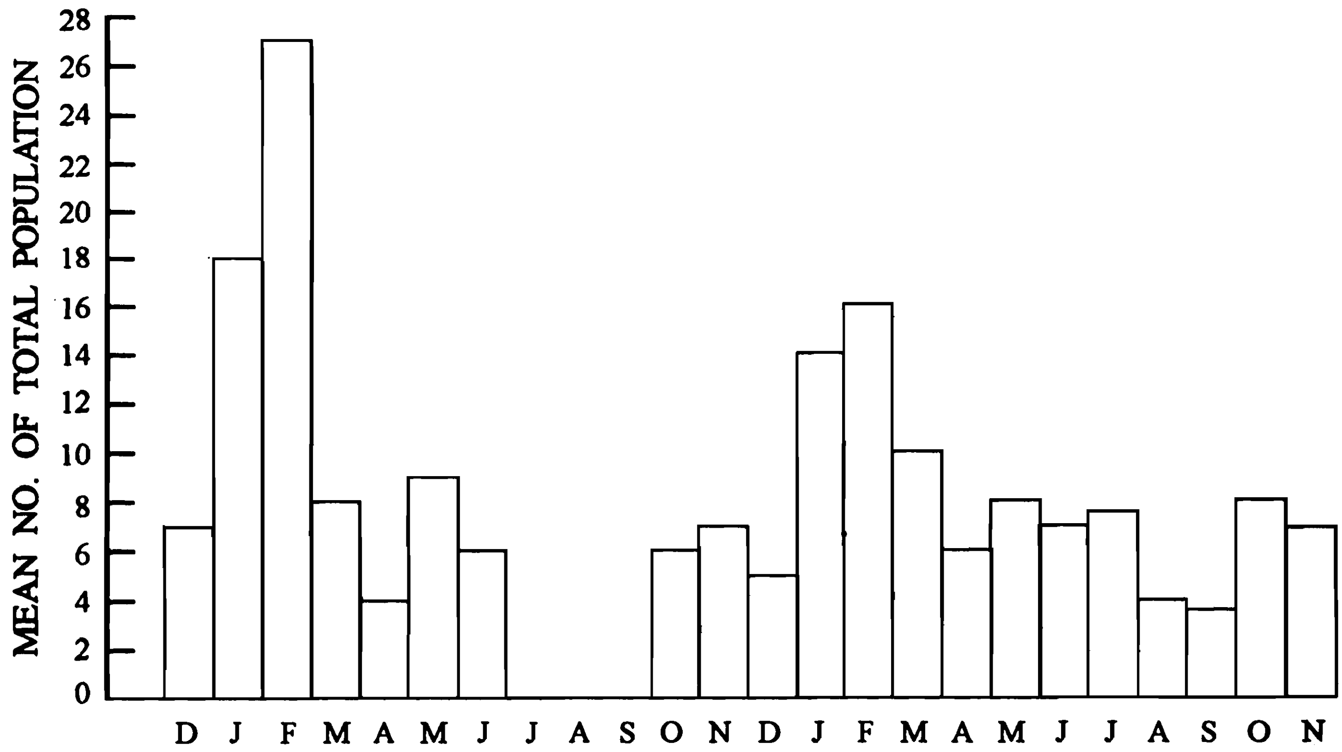



Fig. 3. Showing histogram of total population of arthropods at Tollygunge canal site

The concentration of Collembola being 32.40% of the total population was maximum (Table-7). Acarina came next having a concentration of 26.91% of the total population. Diptera and their maggots having a concentration of 15.13% occupied the third position followed by Hymenoptera (9.54%) and Coleoptera (9.33%). Other groups of Arthropods were found to be relatively low in concentration and highly irregular in distribution. some other non-arthropod soil organisms together constituted 0.54% only of the total population.

Site-IV - *Botanical Gardens* : The total arthopod population (Table-4) was found to be maximum in the month of August while the minimum population in the month of May.

**Table 6**

**Showing individual groups of arthropods and their monthly population in percentage at Beliaghata canal.**

| Months | Diptera | Maggot | Collembola | Coleoptera | Hymenoptera | Acarina | Thysanoptera | Hemiptera | Hemiptera Nymph | Pseudoscoraion | Psocoptera | Crustacea | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec | 0.60 | 0.12 | 1.32 | 0.24 | 0.84 | 0.84 | — | — | — | 0.12 | 0.12 | 0.48 | — |
| Jan. | — | 0.36 | 0.60 | 0.12 | 0.12 | 1.08 | — | — | — | — | — | — | 0.24 |
| Feb. | 1.08 | 0.12 | 2.16 | 0.12 | 0.12 | 0.60 | 1.80 | 0.12 | — | — | — | — | 0.48 |
| Mar. | 1.20 | — | 1.32 | 0.36 | — | 4.68 | 0.24 | — | — | — | — | — | — |
| Apr. | 0.24 | — | 0.24 | 0.24 | 0.60 | 1.56 | — | — | — | — | 0.60 | — | 0.12 |
| May. | — | — | 0.84 | 0.36 | — | 1.32 | — | — | — | — | 1.56 | — | — |
| Jun. | 0.24 | — | 0.60 | — | 0.24 | 0.86 | — | — | — | 0.12 | — | — | 0.12 |
| Jul. | 0.60 | — | 1.20 | 0.12 | — | 2.04 | — | — | — | — | 0.12 | — | — |
| Aug. | 1.20 | — | 1.20 | — | 1.32 | 2.04 | 0.72 | — | — | — | 0.24 | — | 0.12 |
| Sep. | 0.60 | — | 0.48 | 0.36 | — | 2.16 | — | — | — | — | 0.12 | — | — |
| Oct. | 0.96 | — | 0.60 | 0.84 | 2.28 | 1.68 | 0.12 | 0.12 | — | — | — | — | 0.12 |
| Nov. | 0.48 | — | 1.56 | 0.24 | 1.20 | 2.16 | — | — | — | — | 0.36 | — | — |
| Dec. | 0.30 | — | 1.20 | 0.12 | — | 1.92 | — | 0.12 | — | — | 0.12 | — | 0.24 |

*Table 6 (continued)*

| **Months** | **Diptera** | **Maggot** | **Collem-bola** | **Coleop-tera** | **Hymen-optera** | **Acarina** | **Thysa-noptera** | **Hemip-tera** | **Hemip-tera Nymph** | **Pseu-dos-cora-ion** | **Psoco-ptera** | **Crus-tacea** | **Other** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 0.60 | — | 0.60 | 0.24 | 0.24 | 0.96 | — | — | — | — | 0.12 | — | — |
| Feb. | 0.36 | 0.12 | 1.32 | 0.48 | 0.12 | 1.68 | — | — | — | — | — | — | 0.24 |
| Mar. | 0.60 | — | 1.32 | 0.24 | 0.12 | 1.92 | 0.24 | — | — | — | — | — | 0.12 |
| Apr. | 0.48 | — | 0.48 | — | 0.72 | 0.72 | — | — | — | — | — | — | — |
| May. | 0.36 | — | 0.60 | 0.48 | 0.12 | 0.60 | 0.12 | — | — | — | — | — | — |
| Jun. | 0.36 | — | 0.36 | 0.24 | 0.12 | 1.44 | 0.12 | 0.12 | — | — | — | — | 0.36 |
| Jul. | 0.48 | — | 1.32 | 0.36 | 0.12 | 1.44 | — | — | — | — | — | — | — |
| Aug. | 0.36 | — | 1.20 | 0.12 | — | 2.04 | — | — | — | — | — | — | — |
| Sep. | 0.36 | — | 0.84 | 0.36 | — | 1.92 | — | — | — | — | — | — | — |
| Oct. | 0.48 | — | 1.20 | 0.12 | 0.72 | 1.56 | — | 0.12 | 0.12 | — | — | — | — |
| Nov. | 0.48 | — | 0.96 | 0.36 | 0.36 | 1.20 | — | — | — | — | — | — | — |
| Total | 12.48 | 0.72 | 23.52 | 6.12 | 9.84 | 39.60 | 1.68 | 0.48 | 0.12 | 0.24 | 3.36 | 0.48 | 2.16 |

## Table 7

Showing individual groups of arthropods and their monthly population in percentage at Tollygunge Nulah.

| Months | Diptera | Maggot | Collembola | Coleoptera | Hymenoptera | Acarina | Thysanoptera | Hemiptera | Hemiptera Nymph | Pseudoscoraion | Psocoptera | Crustacea | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec | 0.72 | 0.09 | 1.71 | 0.18 | — | 0.27 | — | 0.18 | — | — | 0.18 | — | 0.90 |
| Jan. | 0.54 | 0.18 | 2.34 | 0.36 | — | 2.52 | — | — | — | — | 0.90 | — | 3.24 |
| Feb. | 0.90 | — | 9.00 | 1.80 | 0.72 | 1.35 | — | 0.09 | — | — | 0.18 | — | 0.36 |
| Mar | 0.36 | 0.18 | 1.26 | — | 0.18 | 2.43 | 0.90 | — | — | — | — | — | — |
| Apr. | 0.54 | 0.36 | 0.18 | — | — | 0.45 | — | 0.09 | — | 0.09 | — | — | 0.45 |
| May. | 0.72 | 0.18 | 0.99 | — | 0.54 | 1.53 | — | — | — | — | 0.72 | — | 0.36 |
| Jun. | 0.72 | — | 0.54 | — | 0.54 | 0.90 | — | — | — | 0.09 | — | — | 0.36 |
| Jul. | Canal Flooded with Rain Water | | | | | | | | | | | | |
| Aug. | -do- | | | | | | | | | | | | |
| Sep. | -do- | | | | | | | | | | | | |
| Oct. | 0.54 | — | 0.63 | 0.35 | 0.09 | 0.99 | — | — | — | — | 0.09 | — | 0.54 |
| Nov. | 0.45 | 0.09 | 0.36 | 0.68 | 0.63 | 0.68 | 0.18 | 0.18 | 0.27 | — | — | — | — |
| Dec. | 0.18 | — | 0.90 | 0.54 | 0.45 | 0.90 | — | 0.18 | — | — | — | — | — |

*Table 7 (continued)*

| Months | Diptera | Maggot | Collembola | Coleoptera | Hymenoptera | Acarina | Thysanoptera | Hemiptera | Hemiptera Nymph | Pseudoscoraion | Psocoptera | Crustacea | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 0.72 | 0.18 | 1.80 | 0.90 | 0.81 | 1.62 | — | — | — | — | — | — | 0.63 |
| Feb. | 1.08 | 0.27 | 1.89 | 1.17 | 0.27 | 2.43 | 0.18 | 0.27 | — | — | 0.09 | — | 0.18 |
| Mar. | 0.63 | — | 1.98 | 0.09 | — | 1.98 | — | — | — | — | — | — | 0.54 |
| Apr. | 0.27 | 0.27 | 0.54 | — | 0.36 | 1.35 | — | 0.09 | 0.09 | — | — | — | 0.09 |
| May | 0.45 | 0.18 | 1.17 | 0.18 | 0.45 | 1.17 | — | 0.09 | 0.36 | — | 0.09 | — | 0.27 |
| Jun. | 0.45 | — | 0.81 | 0.36 | 0.81 | 0.54 | — | 0.09 | 0.18 | — | 0.27 | — | 0.18 |
| Jul. | 0.45 | — | 1.44 | 0.63 | 0.09 | 1.44 | 0.09 | — | 0.09 | — | 0.09 | — | 0.09 |
| Aug. | 0.81 | — | 1.62 | 0.36 | 0.72 | 1.53 | 0.09 | — | — | — | 0.09 | — | 0.09 |
| Sep. | 0.27 | 0.18 | 1.35 | 0.45 | 1.26 | 0.99 | 0.90 | — | — | — | 0.18 | — | 0.09 |
| Oct. | 0.72 | — | 0.99 | 0.72 | 0.72 | 0.99 | — | — | — | — | 0.09 | — | 0.09 |
| Nov. | 0.45 | — | 0.90 | 0.72 | 0.90 | 0.90 | 0.09 | — | — | — | 0.18 | 0.09 | — |
| Total | 12.79 | 2.16 | 32.40 | 9.33 | 9.54 | 26.91 | 0.90 | 1.17 | 1.44 | 0.18 | 2.34 | 0.09 | 7.56 |

The histogram of the total population showed a single annual peak in August and minimum in May (Fig. 4).

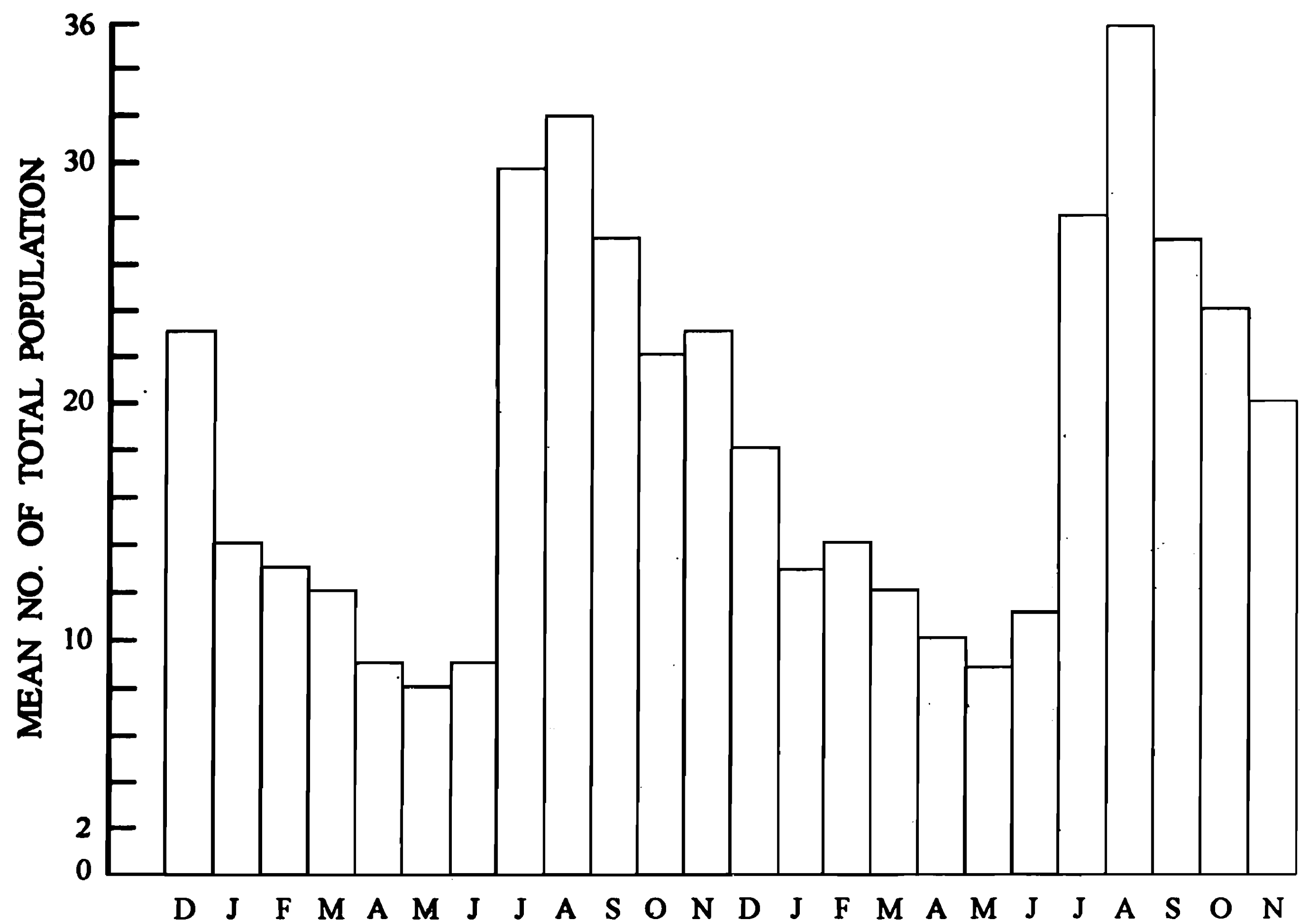



**Fig. 4.** Showing histogram of total population of arthropods at Botanical Garden site

On faunal analyses several groups of arthropods were found (Table-8). Acarina by constituting 48.08% of the total population was the most dominant group. Collembola having a concentration of 35.38% was the second dominant group. Hymenoptera having 7.72% of the total population was the third major group, while diptera along with their maggots occupied the fourth position by virtue of comprising 4.60% of the total population. In this respect coleoptera was found to be fifth having a concentration of 3.48%. Some other groups of arthropods and nematodes were also recorded, but either they were very low in concentration or were highly irregular in distribution. Some other unidentified non-arthropod soil inmates termed as "others" were recorded and they together constituted 1.36% of the total population.

**Table 8**

Showing individual groups of arthropods and their monthly population in percentage at Botanical Gardens, Howrah.

| Months | Diptera | Maggot | Collembola | Coleoptera | Hymenoptera | Acarina | Thysanoptera | Hemiptera | Hemiptera Nymph | Pseudoscorpion | Psocoptera | Crustacea | Araneida | Diplura | Protura | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec. | 0.28 | 0.16 | 1.44 | 0.28 | 0.44 | 2.44 | — | 0.12 | — | 0.04 | — | — | 0.02 | — | 0.12 | — |
| Jan. | 0.16 | — | 1.04 | 0.16 | 0.36 | 1.24 | 0.04 | 0.04 | — | — | 0.12 | 0.04 | — | — | — | — |
| Feb. | 0.16 | — | 0.80 | 0.28 | 0.16 | 1.44 | — | 0.04 | 0.04 | — | — | 0.04 | 0.08 | — | — | — |
| Mar. | 0.20 | 0.12 | 0.92 | 0.20 | 1.08 | 0.04 | 0.04 | — | — | — | — | 0.04 | — | — | — | — |
| Apr. | 0.04 | 0.04 | 0.52 | 0.16 | 0.40 | 0.72 | 0.04 | 0.04 | — | — | — | — | 0.12 | — | 0.04 | — |
| May | 0.08 | 0.08 | 0.40 | 0.04 | 0.16 | 0.56 | 0.04 | 0.16 | — | 0.04 | — | — | 0.04 | — | 0.12 | — |
| Jun. | 0.12 | 0.08 | 0.68 | 0.12 | 0.24 | 0.56 | 0.04 | 0.04 | 0.04 | — | 0.04 | — | — | — | 0.04 | — |
| Jul. | 0.04 | 0.12 | 2.20 | 0.28 | 0.60 | 2.96 | 0.04 | 0.12 | 0.08 | 0.12 | 0.04 | 0.16 | 0.12 | — | — | — |
| Aug. | 0.08 | 0.16 | 3.08 | 0.12 | 0.20 | 4.04 | — | 0.08 | — | — | — | — | 0.04 | — | 0.80 | 0.12 |
| Sep. | 0.08 | 0.12 | 2.28 | 0.16 | 0.32 | 3.04 | 0.08 | — | 0.08 | — | — | 0.08 | 0.08 | — | 0.04 | 0.04 |
| Oct. | 0.20 | 0.08 | 1.72 | 0.12 | 0.44 | 2.44 | — | 0.08 | — | 0.08 | 0.04 | 0.04 | 0.04 | 0.04 | 0.08 | — |
| Nov. | 0.12 | 0.04 | 1.96 | 0.12 | 0.16 | 2.84 | 0.08 | — | — | — | — | — | — | — | 0.04 | 0.12 |
| Dec. | 0.08 | 0.08 | 1.28 | 0.24 | 0.44 | 1.92 | 0.04 | 0.08 | — | — | — | — | 0.08 | — | 0.08 | — |

*Table 8 (continued)*

| Months | Diptera | Maggot | Collembola | Coleoptera | Hymenoptera | Acarina | Thysanoptera | Hemiptera | Hemiptera Nymph | Pseudoscorpion | Psocoptera | Crustacea | Araneida | Diplura | Protura | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 0.04 | — | 0.88 | 0.12 | 0.20 | 1.52 | 0.04 | 0.04 | — | 0.04 | — | — | 0.04 | 0.04 | 0.04 | — |
| Feb. | 0.08 | 0.12 | 0.92 | 0.08 | 0.36 | 1.68 | — | — | 0.08 | — | — | — | — | 0.04 | — | 0.08 |
| Mar. | 0.08 | 0.04 | 0.72 | 0.12 | 0.08 | 1.48 | 0.04 | — | — | — | 0.20 | 0.08 | — | — | — | 0.08 |
| Apr. | 0.12 | 0.04 | 0.76 | 0.12 | 0.28 | 0.80 | 0.04 | 0.08 | — | — | — | — | — | — | — | 0.20 |
| May | 0.04 | 0.04 | 0.68 | 0.08 | 0.32 | 0.84 | 0.04 | — | — | — | — | — | — | — | — | 0.16 |
| Jun. | 0.04 | 0.08 | 0.88 | 0.08 | 0.20 | 1.24 | 0.04 | 0.04 | — | — | 0.04 | — | 0.04 | 0.04 | — | 0.08 |
| Jul. | 0.08 | 0.12 | 2.28 | 0.16 | 0.56 | 3.08 | 0.04 | — | — | — | 0.12 | — | — | 0.08 | — | 0.44 |
| Aug. | 0.08 | 0.04 | 3.24 | 0.04 | 0.44 | 4.56 | 0.04 | 0.04 | — | 0.04 | 0.08 | — | — | 0.04 | — | — |
| Sep. | 0.48 | 0.04 | 2.36 | 0.16 | 0.64 | 2.88 | — | — | — | — | — | — | 0.04 | — | — | — |
| Oct. | 0.12 | 0.08 | 2.20 | 0.16 | 0.40 | 2.80 | — | — | — | — | — | — | — | — | — | — |
| Nov. | 0.04 | 0.08 | 2.04 | 0.12 | 0.12 | 2.12 | 0.04 | 0.04 | — | — | — | — | 0.04 | — | — | 0.04 |
| Total | 2.84 | 1.76 | 35.28 | 3.48 | 7.72 | 48.08 | 0.76 | 1.08 | 0.32 | 0.44 | 1.08 | 0.32 | 0.56 | 1.04 | 0.08 | 1.36 |

**(C) Seasonal variation in the populations of dominant arthropods**

*Site-I - Bagjola Canal (Dum dum) :* Acarines exhibited two annual peaks, one in March and other in September in the first year, while in the second year the peaks were not so prominent, though higher mean values were obtained in January and April. In the remaining months the acarine population fluctuated irreguarly (Fig. 5).

In the second year the collembolans exhibited two annual peaks, but no such peak was found in the first year. In case of diptera, April and July of the first year exhibited two annual peaks, whereas in the second year the peaks were found in April and September. Hymenoptera showed a single annual peak during the months of April or May-June. Coleopera exhibited its annual peak in April and June.

*Site-II - Beliaghata Canal :* Here the acarines showed two annual peaks in both the years, one in the month of March (Post-winter) and the other August-September (late-monsoon) as will be evident from figure-6. The trend of fluctuation was, however, irregular, Two annual peaks were observed in collembola also, one during the months of February-March (Post-winter) and another during October-November (Pre-winter). In case of collembola also the trend of fluctuation was irregular. The dipterans showed two annual peaks, one in March and the other in July-August. Hymenoptera exhibited highly irregular trend of fluctuation in both the year, the peak was observed in October. In case of coleoptera a similar trend as that of Hymenoptera was observed.

*Site-III - Tollygunge Nulah :* The Acarine population in this plot was found to produce two annual peaks, one in the months of January/February while the other during the monsoon. In case of collembola two peaks were also observed, one during February-March (post-winter) and the other in August (Fig. 7). Diptera exhibited two annual peaks, one in the month of February while the other in August, but the population showed an irregular trend of fluctuation. Two peaks, one during January and the other in September were found in case of hymenoptera, while in coleoptera the February peak was very much prominent. Thus at this site all the five major groups exhibited the post-winter and the monsoon annual peaks of population growth.

*Site-IV - Botanical Garden :* Here both acarines and collembolans exhibited a similar trend of population fluctuation. The populations reached peak during August (monsoon) and a semi-peak population was seen during November-December i.e., in winter (Fig 8). In case of hymenoptera the trend of fluctuation was very much irregular, but the monsoon peaks were prominent. Coleoptera also exhibited two annual peaks, one in winter (December-January) while the other in monsoon.

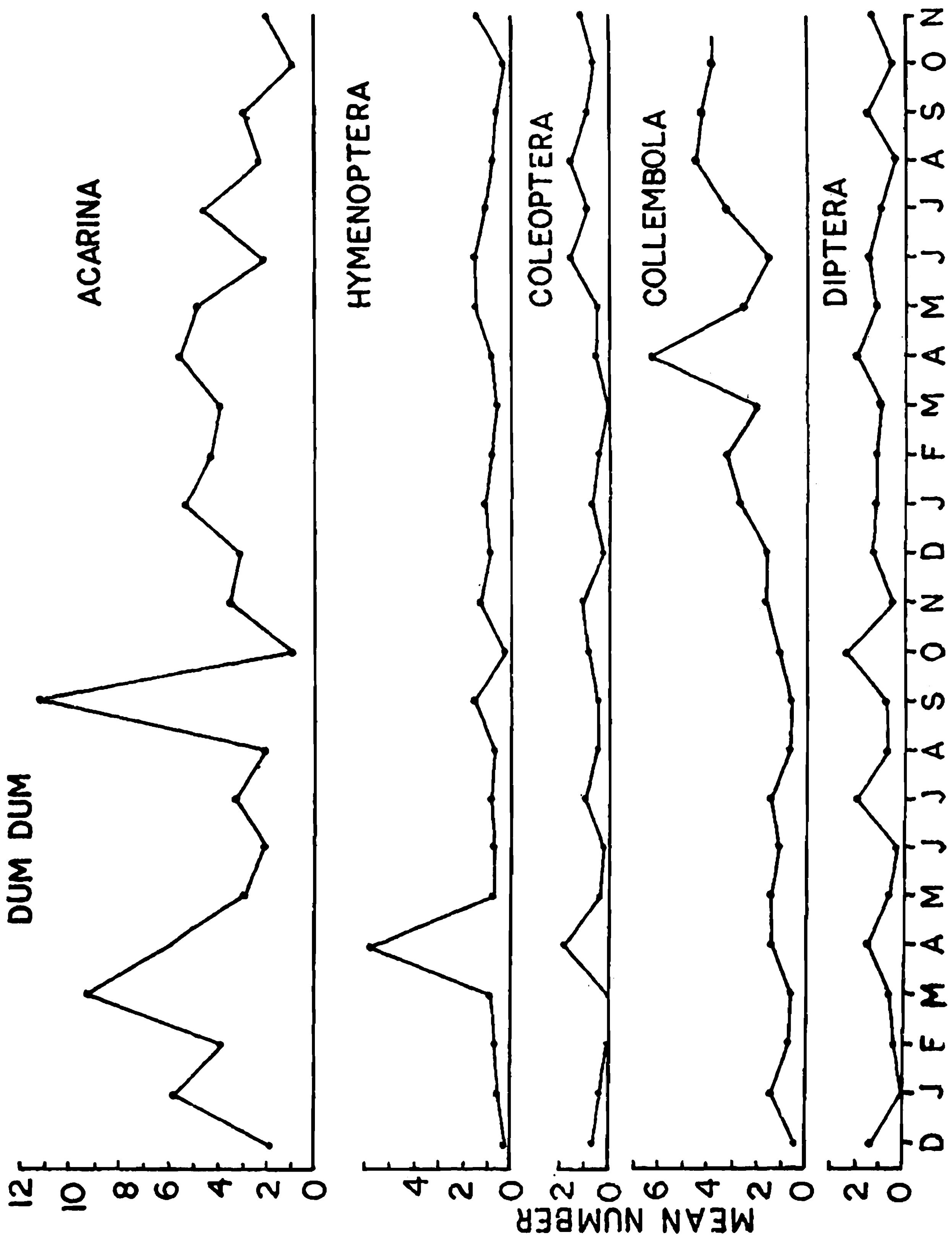



**Fig. 5 :** Showing seasonal fluctuation of dominant arthropods groups at Bagjola canal site, Dum Dum

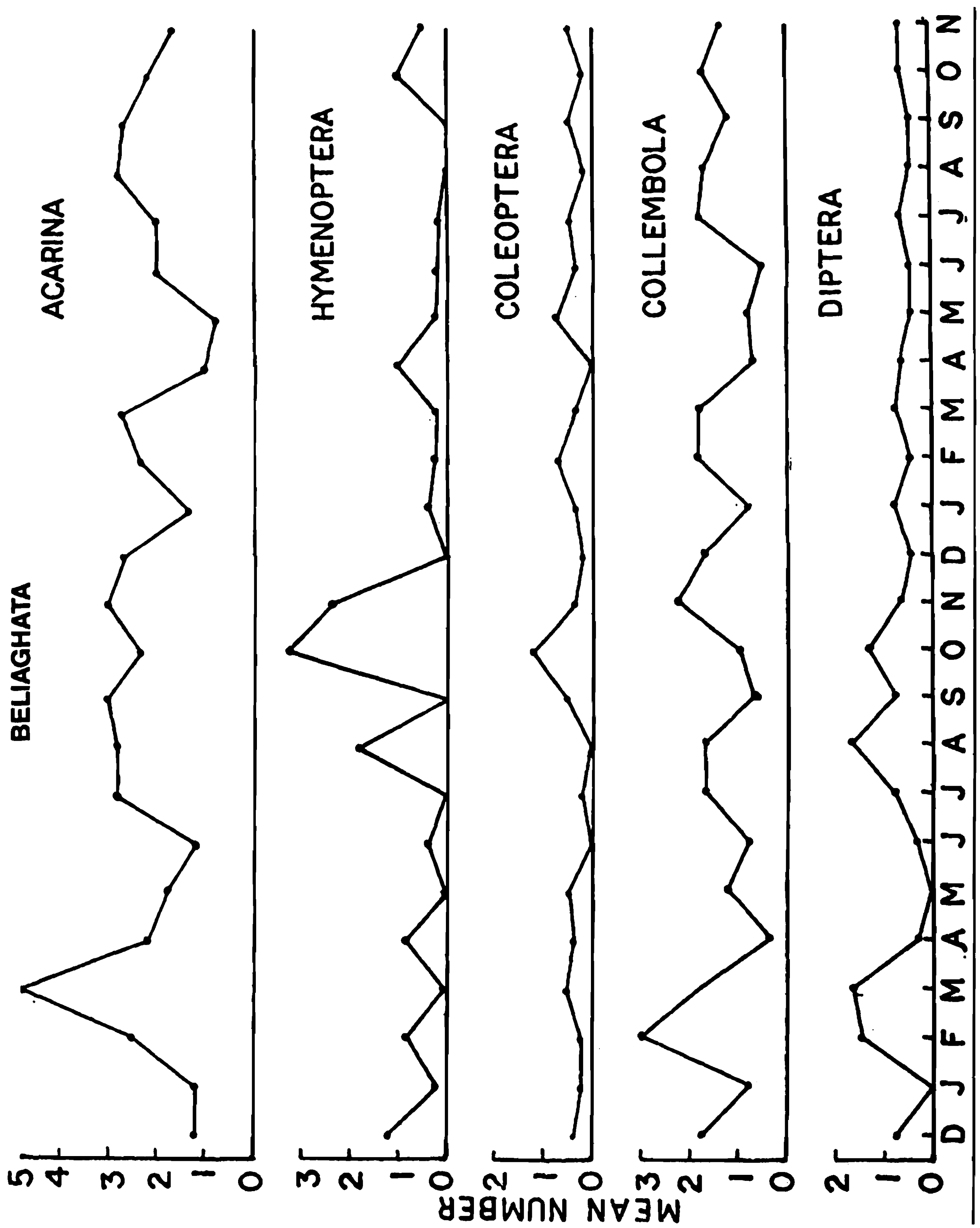



Fig. 6 :Showing seasonal fluctuation of dominant arthropods groups at Beliaghata canal site.

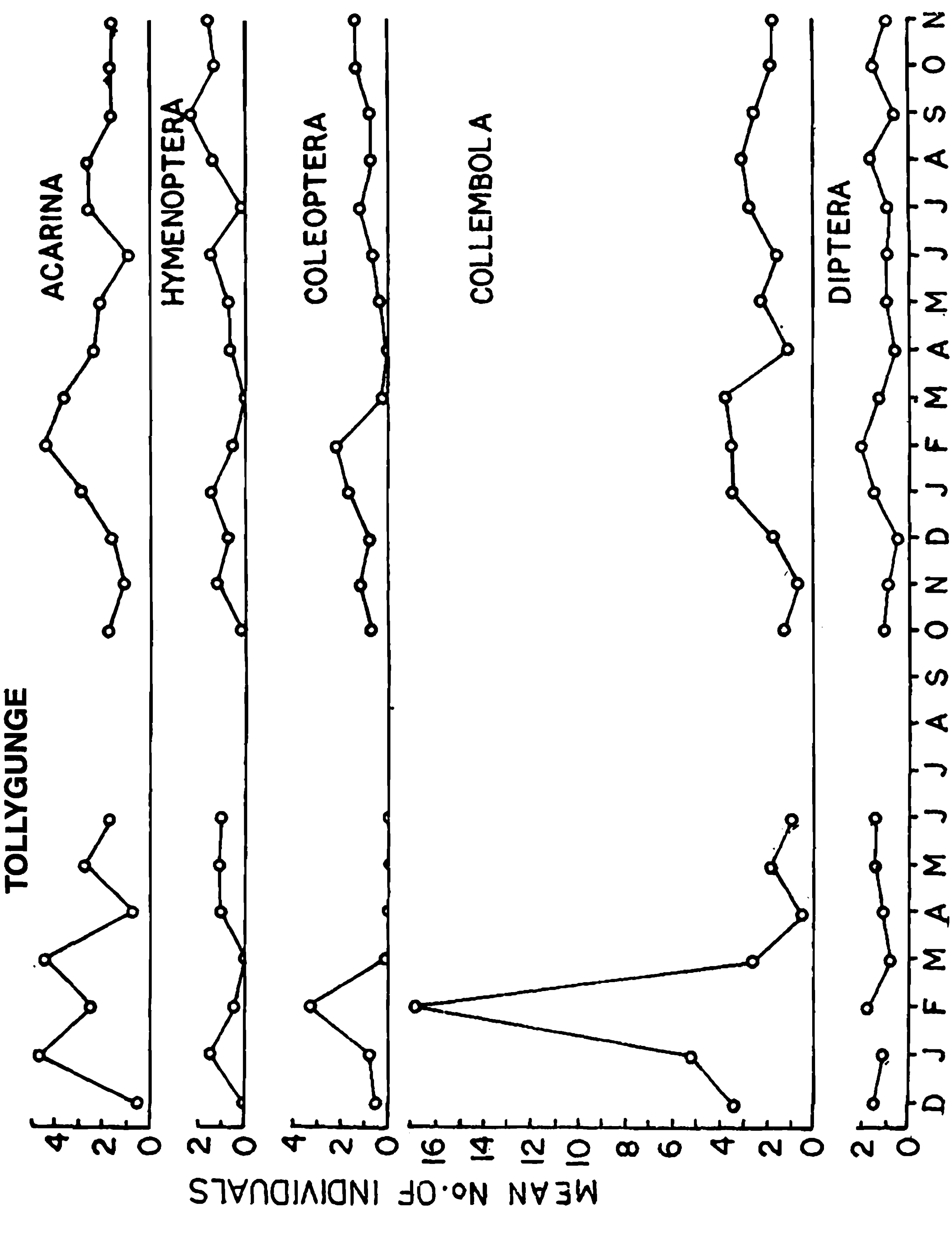



**Fig. 7 :** Showing seasonal fluctuation of dominant arthropods groups at Tollygunge canal site

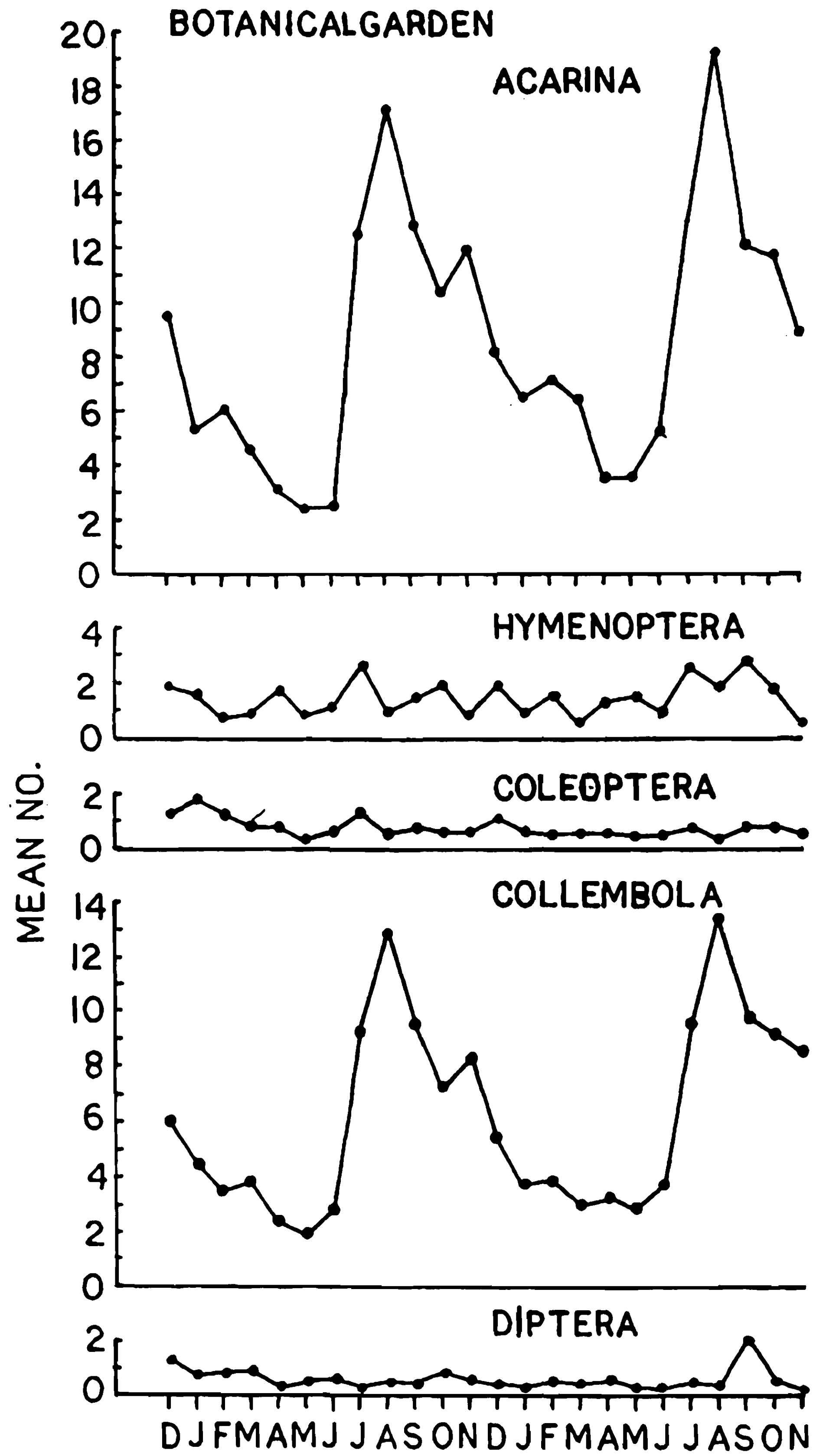



**Fig. 8** :Showing seasonal fluctuation of dominant arthropods groups at Botanical Garden site

## (D) Vertical Distribution

*Site-I - Bagjola Canal (Dum Dum)* : The depthwise monthly mean population per sample of five major groups of arthropods collected, namely, acarina, collembola, diptera, hymenoptera and coleoptera are given in Table-9. Beside the coleopterans (0.55 in 0-5 cm and 0.70 in 5-10 cm) all other arthropod groups showed maximum aggregation of population in the upper (0-5 cm) layer of the soil. The monthly distribution also revealed that, barring a few months in some groups, the concentration of population was higher in the upper layer throughout the year. In case of coleoptera a cluster of grubs were found in April of the initial year in a particular sample in 5-10 cm layer, which contributed largely to the increase in the population density in the lower layer. Similarly, in case of diptera, the maggots were found aggrregated in the samples representing the lower layer (5-10 cm) in months of April and July of the first year and April in the second year which might have caused the variation in respect of population density of diptera in both upper and lower layers.

*Site-II - Beliaghata Canal* : The depthwise monthly mean population per sample of five major groups of arthropods as mentioned earlier (Table-10) indicated that the upper layer of the soil (0-5 cm) contained majority of arthropods. In case of hymenoptera, in the months of August and September of the initial year aggregation of ants (Formicidae) was witnessed in the samples from 5-10 cm layer, which tilted the concentration of hymenoptera more towards 5-10 cm layer.

*Site-III - Tollygunge Nulah* : In Table-11 the depthwise mean monthly population per sample of five major groups of arthropods are given, from which it would be observed that in all five major groups the populations were more concentrated in 0-5 cm layer.

It would also be evident from the table that almost throughout the year the populations of different groups of arthropods showed tendencies to occupy the upper most (0-5 cm) layer, barring a few months in a few groups as exceptional cases.

*Site-IV - Botanical Garden* : The Table-12 indicated the monthly mean population per sample of five dominant (major) arthropod groups collected from the soil. In all the groups the populations were more concentrated in the upper layer (0-5 cm) than in the lower (5-10 cm) one. In most of the months of the year the arthropod population showed greater affinity towards the top soil than the lower depth of the soil.

**Table 9**

Showing vertical distribution of the dominant groups of arthropods at Bagjola canal, Dumdum *in mean number/sample.*

| | Collembola | | Acarina | | Diptera | | Coleoptera | | Hymenoptera | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (cm.)** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** |
| **Months** | | | | | | | | | | |
| D | — | 1.00 | 1.00 | 2.67 | 1.00 | 1.67 | 0.33 | 1.00 | — | 0.33 |
| J | 1.67 | 1.33 | 9.67 | 1.67 | 0.33 | 0.67 | 0.67 | — | 0.33 | 0.67 |
| F | 1.67 | — | 7.33 | 0.33 | 0.33 | 0.67 | — | — | 1.33 | — |
| M | 1.33 | — | 16.00 | 2.33 | 1.00 | 0.33 | — | — | — | 1.67 |
| A | 3.00 | — | 9.33 | 2.33 | — | 3.00 | — | 3.67 | 3.33 | 8.00 |
| M | 1.67 | 1.33 | 4.33 | 1.00 | 1.00 | 0.33 | 0.33 | 0.33 | 1.00 | 0.33 |
| J | 1.33 | 1.00 | 3.33 | 0.67 | 0.67 | — | — | 0.33 | 1.00 | 0.33 |
| J | 3.00 | 0.33 | 3.00 | 3.33 | 2.00 | 2.00 | 2.00 | — | 1.33 | 0.33 |
| A | 1.67 | — | 2.33 | 1.67 | 0.33 | 1.33 | 0.33 | 0.67 | 1.00 | 0.33 |
| S | 1.33 | — | 2.00 | 20.00 | 1.00 | 0.67 | 0.67 | — | 2.33 | 0.67 |
| O | 2.33 | — | 1.67 | — | 3.00 | 1.67 | 1.00 | 0.67 | 0.33 | — |
| N | 2.00 | 1.33 | 3.67 | 3.00 | 1.00 | 0.67 | 0.67 | 1.33 | 2.33 | — |
| D | 1.67 | 1.67 | 2.67 | 3.33 | 1.67 | 1.00 | 0.33 | — | 1.00 | 0.67 |

*Table 9 (continued)*

| | **Collembola** | | **Acarina** | | **Diptera** | | **Coleoptera** | | **Hymenoptera** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (cm.)** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** |
| **Months** | | | | | | | | | | |
| J | 2.33 | 3.00 | 3.67 | 5.33 | 0.67 | 1.67 | 1.00 | 0.33 | 0.67 | 1.33 |
| F | 3.67 | 2.67 | 6.00 | 2.33 | 1.33 | 1.00 | — | 0.67 | 1.33 | — |
| M | 3.33 | 0.67 | 5.33 | 2.33 | 1.00 | 1.67 | — | — | 1.00 | — |
| A | 4.00 | 8.33 | 6.33 | 4.33 | 1.67 | 2.33 | 0.67 | 0.33 | 1.67 | — |
| M | 2.67 | 2.33 | 7.00 | 2.33 | 1.67 | 1.33 | 0.33 | 0.33 | 2.00 | 0.67 |
| J | 1.67 | 1.33 | 2.00 | 2.00 | 2.67 | 1.00 | 2.00 | 1.00 | 1.67 | 1.00 |
| J | 3.00 | 3.33 | 5.00 | 3.67 | 1.67 | 0.33 | 1.00 | 0.67 | 1.67 | 0.33 |
| A | 1.67 | 3.00 | 2.67 | 1.67 | 0.67 | — | 1.00 | 2.00 | 1.00 | 0.33 |
| S | 2.33 | 2.00 | 2.33 | 3.33 | 1.00 | 1.33 | 0.67 | 1.00 | 0.67 | 0.33 |
| O | 1.33 | 2.33 | 1.00 | 0.67 | 0.67 | 0.33 | — | 1.00 | — | 0.33 |
| N | 1.67 | 2.00 | 2.33 | 1.33 | 1.33 | 1.67 | 0.33 | 1.67 | 2.00 | 0.33 |
| $\overline{X}$ | 2.19 | 1.62 | 4.62 | 2.99 | 1.19 | 1.11 | 0.55 | 0.70 | 1.09 | 0.62 |

**Table 10**

Showing vertical distribution of the dominant groups of arthropods at Beliaghata canal, *in mean number/sample*

| | Collembola | | Acarina | | Diptera | | Coleoptera | | Hymenoptera | |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth (cm.) | 0-5 | 5-10 | 0-5 | 5-10 | 0-5 | 5-10 | 0-5 | 5-10 | 0-5 | 5-10 |
| Months | | | | | | | | | | |
| D | 2.00 | 1.67 | 1.00 | 1.33 | 1.00 | 1.00 | 0.33 | 0.33 | 1.33 | 1.00 |
| J | 1.67 | — | 2.00 | 0.33 | 0.33 | 0.67 | 0.33 | — | 0.33 | — |
| F | 6.00 | — | 4.33 | 0.67 | 1.33 | 2.00 | — | 0.33 | 1.33 | 0.33 |
| M | 2.00 | 1.67 | 5.33 | 4.33 | 1.33 | 2.00 | 0.67 | 0.33 | — | — |
| A | 0.33 | 0.33 | 4.00 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | — | 1.67 |
| M | 1.33 | 1.00 | 3.67 | — | — | — | 0.67 | 0.33 | — | — |
| J | 1.00 | 0.67 | 1.33 | 1.00 | 0.33 | 0.33 | — | — | 0.33 | 0.33 |
| J | 1.33 | 2.00 | 4.00 | 1.67 | 1.33 | 0.33 | — | 0.33 | — | — |
| A | 2.67 | 0.67 | 3.67 | 2.00 | 1.67 | 1.67 | — | — | 0.67 | 3.00 |
| S | — | 1.33 | 3.33 | 2.67 | 1.00 | 0.67 | — | 0.33 | — | — |
| O | 1.67 | 0.33 | 2.67 | 2.00 | 1.33 | 1.33 | 2.33 | — | 1.00 | 5.33 |
| N | 3.00 | 1.33 | 3.67 | 2.33 | — | 1.33 | 0.67 | — | 2.00 | 2.67 |
| D | 1.00 | 2.33 | 2.67 | 2.67 | 0.67 | 0.33 | — | 0.33 | — | — |

*Table 10 (continued)*

| | Collembola | | Acarina | | Diptera | | Coleoptera | | Hymenoptera | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (cm.)** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** |
| **Months** | | | | | | | | | | |
| J | 1.00 | 0.67 | 1.00 | 1.67 | 1.00 | 0.67 | 0.67 | — | — | 0.67 |
| F | 2.67 | 1.00 | 2.67 | 2.00 | 0.67 | 0.33 | — | 1.33 | 0.33 | — |
| M | 2.67 | 1.00 | 2.33 | 3.33 | 0.67 | 1.00 | 0.33 | 0.33 | — | 0.33 |
| A | 1.00 | 0.33 | 2.00 | — | 1.33 | — | — | — | 1.00 | 1.00 |
| M | 0.33 | 1.33 | 1.33 | 0.33 | 0.67 | 0.33 | 1.00 | 0.33 | — | 0.33 |
| J | 0.33 | 0.67 | 3.00 | 1.00 | 0.33 | 0.67 | — | 0.67 | — | 0.67 |
| J | 2.67 | 1.00 | 2.67 | 1.33 | 1.33 | — | — | 1.00 | — | 0.33 |
| A | 1.33 | 2.00 | 3.67 | 2.00 | 1.00 | — | 0.33 | — | — | — |
| S | 2.33 | 0.67 | 2.33 | 3.00 | 0.67 | 0.33 | — | 1.00 | — | — |
| O | 1.33 | 2.00 | 2.00 | 2.33 | 0.33 | 1.00 | 0.33 | — | 1.33 | 0.67 |
| N | 1.67 | 1.00 | 0.67 | 2.67 | 1.00 | 0.33 | 0.33 | 0.67 | 0.67 | 0.33 |
| $\overline{X}$ | 1.72 | 1.03 | 2.72 | 1.70 | 0.82 | 0.69 | 0.34 | 0.33 | 0.43 | 0.77 |

**Table 11**

Showing vertical distribution of the dominant groups of arthropods at Tollygunge canal, *in mean number/sample*

| | Collembola | | Acarina | | Diptera | | Coleoptera | | Hymenoptera | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (cm.)** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** |
| **Months** | | | | | | | | | | |
| D | 4.33 | 2.00 | 0.33 | 0.67 | 1.33 | 1.33 | — | 0.67 | — | — |
| J | 7.33 | 2.33 | 9.00 | 0.33 | 2.33 | 0.33 | 0.67 | — | 0.33 | — |
| F | 29.67 | 3.67 | 5.00 | — | 2.67 | 0.67 | 3.67 | — | 0.33 | 2.33 |
| M | 3.00 | 1.67 | 6.67 | 3.00 | 1.67 | 0.33 | — | — | 0.67 | — |
| A | 0.67 | — | 1.00 | 0.67 | 2.33 | 1.00 | — | — | — | — |
| M | 2.00 | 1.67 | 4.00 | 1.67 | 1.00 | 2.33 | — | — | 1.00 | 1.00 |
| J | 1.33 | 0.67 | 2.33 | 1.00 | 1.67 | 1.00 | — | — | 1.00 | 1.00 |
| J | | | embankment inundated | | | | | | | |
| A | | | " " " | | | | | | | |
| S | | | " " " | | | | | | | |
| O | 2.00 | 0.33 | 2.00 | 1.67 | 2.00 | — | 0.33 | 1.00 | 0.33 | — |
| N | 1.33 | — | 1.67 | 0.67 | 1.00 | 0.67 | 1.00 | 1.33 | 2.00 | 0.33 |
| D | 2.33 | 1.00 | 2.33 | 1.00 | 0.33 | 0.33 | 1.00 | 0.67 | 1.33 | 0.33 |

*Table 11 (continued)*

| | Collembola | | Acarina | | Diptera | | Coleoptera | | Hymenoptera | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (cm.)** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** |
| **Months** | | | | | | | | | | |
| J | 3.67 | 3.00 | 3.67 | 2.33 | 1.00 | 1.67 | 2.00 | 1.33 | 1.67 | 1.33 |
| F | 4.67 | 2.33 | 6.00 | 3.00 | 2.00 | 2.00 | 1.33 | 3.00 | 0.67 | 0.33 |
| M | 6.00 | 1.33 | 4.33 | 3.00 | 1.00 | 1.33 | — | 0.33 | — | — |
| A | 0.67 | 1.33 | 3.67 | 1.33 | — | 1.00 | — | — | 0.67 | 0.67 |
| M | 2.67 | 1.67 | 1.67 | 2.67 | 1.00 | 0.67 | 0.67 | — | 1.00 | 0.67 |
| J | 1.33 | 1.67 | 0.67 | 1.33 | 1.00 | 0.67 | 0.33 | 1.00 | 0.67 | 2.33 |
| J | 4.00 | 1.33 | 3.00 | 2.33 | 1.00 | 0.67 | 1.33 | 1.00 | — | 0.33 |
| A | 3.67 | 2.33 | 3.33 | 2.33 | 2.00 | 1.00 | 0.67 | 0.67 | 2.33 | 0.33 |
| S | 4.00 | 1.00 | 2.33 | 1.33 | 0.67 | 0.33 | 1.00 | 0.67 | 3.33 | 1.33 |
| O | 1.67 | 2.00 | 2.00 | 1.67 | 1.00 | 1.67 | 0.67 | 2.00 | 0.67 | 2.00 |
| N | 1.33 | 2.00 | 1.67 | 1.67 | 0.67 | 1.00 | 2.00 | 0.67 | 2.67 | 0.67 |
| $\overline{X}$ | 3.98 | 1.51 | 3.04 | 1.53 | 1.25 | 0.95 | 0.76 | 0.65 | 0.92 | 0.68 |

**Table 12**

Showing vertical distribution of the dominant groups of arthropods at Botanical Garden, *in mean number/sample*

| | Collembola | | Acarina | | Diptera | | Coleoptera | | Hymenoptera | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (cm.)** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** |
| **Months** | | | | | | | | | | |
| D | 9.00 | 3.00 | 14.00 | 4.67 | 2.33 | 1.00 | 2.00 | 0.67 | 2.67 | 1.00 |
| J | 4.67 | 4.00 | 7.00 | 3.33 | 0.67 | 0.67 | 2.00 | 0.33 | 1.00 | 2.00 |
| F | 5.00 | 1.67 | 9.67 | 2.67 | 1.00 | 0.33 | 1.33 | 1.00 | 1.33 | — |
| M | 6.67 | 1.00 | 7.33 | 1.67 | 1.33 | 0.33 | 0.67 | 0.67 | 1.67 | — |
| A | 3.33 | 1.00 | 4.33 | 1.67 | 0.33 | 0.33 | 1.00 | 0.33 | — | 3.33 |
| M | 3.00 | 0.67 | 3.33 | 1.33 | 0.67 | 0.67 | — | 0.33 | 1.33 | — |
| J | 4.67 | 1.00 | 3.00 | 1.67 | 1.00 | 0.67 | 0.67 | 0.33 | 1.33 | 0.33 |
| J | 11.33 | 7.00 | 17.00 | 21.67 | 1.00 | 0.33 | 2.00 | 0.33 | 2.67 | 2.33 |
| A | 13.33 | 12.33 | 20.67 | 13.00 | 0.67 | 1.33 | — | 1.00 | 1.67 | — |
| S | 9.67 | 9.33 | 15.67 | 9.67 | 0.67 | 1.00 | 1.00 | 0.33 | 0.67 | 0.67 |
| O | 10.33 | 4.00 | 12.67 | 7.67 | 2.33 | — | 0.67 | 0.33 | 2.67 | 1.00 |
| N | 11.00 | 5.33 | 13.67 | 10.00 | 1.00 | 0.33 | 0.67 | 0.33 | 1.00 | 0.33 |
| D | 8.67 | 2.00 | 13.67 | 4.33 | 1.33 | — | — | 2.00 | 3.00 | 0.67 |

*Table 12 (continued)*

| | Collembola | | Acarina | | Diptera | | Coleoptera | | Hymenoptera | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (cm.)** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** | **0-5** | **5-10** |
| **Months** | | | | | | | | | | |
| J | 3.00 | 4.33 | 10.00 | 2.67 | 0.33 | — | 1.00 | — | — | 1.67 |
| F | 5.33 | 2.33 | 11.00 | 3.67 | 1.00 | 0.67 | 0.33 | — | 3.00 | — |
| M | 4.67 | 1.33 | 6.33 | 6.00 | 0.33 | 0.67 | — | 1.00 | 0.67 | — |
| A | 5.00 | 1.33 | 4.00 | 2.67 | 0.33 | 1.00 | 0.67 | 0.33 | 2.33 | — |
| M | 4.00 | 1.67 | 4.67 | 2.33 | 0.67 | — | 0.67 | — | 1.67 | 1.00 |
| J | 5.67 | 1.67 | 5.33 | 5.00 | 1.00 | — | 0.67 | — | 1.00 | 0.67 |
| J | 12.00 | 7.00 | 15.33 | 10.33 | 1.67 | — | 1.33 | — | 3.00 | 1.67 |
| A | 15.67 | 11.00 | 23.33 | 14.67 | 0.67 | 0.33 | 0.33 | — | 2.00 | 1.67 |
| S | 12.00 | 7.67 | 14.33 | 9.67 | 2.33 | 1.67 | 0.67 | 0.67 | 3.33 | 2.00 |
| O | 10.00 | 8.33 | 17.00 | 6.33 | 1.00 | 0.67 | — | 1.33 | 0.33 | 3.00 |
| N | 9.33 | 7.67 | 9.00 | 8.00 | 1.00 | — | 0.67 | 0.33 | — | 1.00 |
| $\overline{X}$ | 7.80 | 4.27 | 10.92 | 6.43 | 1.27 | 0.55 | 0.62 | 0.49 | 1.46 | 1.01 |

## STATISTICAL ANALYSIS

The data involving different edaphic factors, including heavy metals, and the mean number of total arthropod population as well as mean number of five major soil arthropods were subjected to statistical analysis separately for each site, in order to find out regression and correlation. The dependence of total population of soil arthropods and five major arthropod groups namely acarina, collembola, diptera, hymenoptera and coleoptera (Y), on each of the seven variables of the soil i.e., temperature, moisture, pH, organic carbon, copper, chromium and lead were studied.

The interrelationships of seven different soil factors were also subjected to statistical analysis, separately for each site to study the extent of stability of such relationships at different sites.

The correlation coefficient values between the total number of arthropods and the soil factors, the number of five major arthropod groups and soil factors, and in between the soil factors for each site were determined. The equation of the Regression line (Y = a+bX) of total number of arthropods (Y) on different soil factors (X), of five dominant arthropod groups (Y) on different soil factors and of differnt soil (Y) on different edaphic factors (X), were calculated for each site. The result of all these analysis were summarised in the tables.

Tables 13-16 showed relationships between total arthropod population and soil factors at different sampling sites, which indicated negative significant relationships of total arthropods in all the three canals with the heavy metals; while at Botanical Garden site the total population did also show negative relationship but insignificant with the heavy metals. Regarding other soil factors, the relationships were different at different sites. While moisture and organic carbon showed strong positive relationships with the total arthropods at Botanical Garden, none of these factors had significant positive relationships with the total arthropods at Bagjola canal (Dumdum). Temperature showed negative, significant relationship, whole pH showed significant, positive relationship at Tollygunge nulah. The moisture too had a positive significant relationship at Beliaghata canal.

Sitewise analysis of relationships of five dominant arthropod groups with the soil factors revealed that at Dumdum pH had significant positive relationship, on the other hand lead had a significant negative relationship only with collembola. (Tables-19, 23). The relationships between the rest of the arthropod groups and the soil factors were not statistically significant although their correlation coefficient values were either positive or negative. (Tables- 17-23).

At Beliaghata site collembola had significant positive relationship with moisture (Table-25) and a significant negative relationships with copper, chromium and lead (Tables - 28-30). Acarina exhibited strong positive relationship with moisture (Tabale-25) but significant negative relationships with organic carbon and copper (Tables-27,28). The relationships of other groups of arthropods with the soil factors (Tables-24, 30) were not significant.

**Table 13**

Showing relationship between arthropod population and soil factors of Bagjola Canal, Dumdum

| | Mean | Correlation coefficient between no. of Arthropods & different soil factors | Regression line of no. of Arthropods (Y) on different soil factors (X). Y = a+bX |
|---|---|---|---|
| Y : No. of Arthropods | 11.70 | | |
| Temperature | 23.96 | - 0.02 | Y = 12.18–0.02X |
| Moisture | 27.74 | - 0.02 | Y = 16.42–0.17X |
| pH | 6.96 | - 0.12 | Y = 43.79–4.61X |
| Organic carbon | 2.68 | - 0.07 | Y = 18.64–2.59X |
| Copper | 62.36 | - 0.77* | Y = 21.05–0.15X |
| Cromium | 27.78 | - 0.59* | Y = 25.31–0.49X |
| Lead | 28.66 | - 0.63 | Y = 29.18–0.61X |

* Significant at P<0.01

**Table 14**

Showing relationship between arthropod population and soil factors at Beliaghata Canal

| | Mean | Correlation coefficient between no. of Arthropods & different soil factors | Regression line of no. of Arthropods (Y) on different soil factors (X). Y = a+bX |
|---|---|---|---|
| Y : No. of Arthropods | 5.81 | | |
| Temperature | 25.82 | - 0.06 | Y = 1.58–0.03X |
| Moisture | 29.64 | - 0.47* | Y = 0.77+0.17X |
| pH | 7.30 | 0.04 | Y = 7.64–0.25X |
| Organic carbon | 2.57 | - 0.35 | Y = 34.18–11.00X |
| Copper | 134.62 | - 0.62* | Y = 12.54–0.05X |
| Cromium | 145.38 | - 0.45* | Y = 7.26–0.01X |
| Lead | 160.91 | - 0.36 | Y = 7.42–0.01X |

* Significant at P<0.01

**Table 15**

Showing relationship between arthropod population and soil factors at Tollygunge Nulah.

| | Mean | Correlation coefficient between no. of Arthropods & different soil factors | Regression line of no. of Arthropods (Y) on different soil factors (X). Y = a+bX |
|---|---|---|---|
| Y : No. of Arthropods | 8.33 | | |
| Temperature | 23.29 | – 0.42** | Y = 16.05–0.31X |
| Moisture | 27.13 | – 0.10 | Y = 21.63–0.14X |
| pH | 7.36 | 0.48** | Y = 55.50–8.74X |
| Organic carbon | 1.00 | – 0.20 | Y = 21.47–12.64X |
| Copper | 27.90 | – 0.71* | Y = 35.89–0.97X |
| Cromium | 39.21 | – 0.54* | Y = 15.50–0.17X |
| Lead | 20.67 | – 0.57* | Y = 30.33–1.04X |

* Significant at $P<0.01$
** Significant at $P<0.05$

**Table 16**

Showing relationship between arthropod population and soil factors at Botanical Garden.

| | Mean | Correlation coefficient between no. of Arthropods & different soil factors | Regression line of no. of Arthropods (Y) on different soil factors (X). Y = a+bX |
|---|---|---|---|
| Y : No. of Arthropods | 18.62 | | |
| Temperature | 28.48 | – 0.16 | Y = 11.22–0.26X |
| Moisture | 23.53 | – 0.56* | Y = 1.68–0.72X |
| pH | 7.13 | – 0.08 | Y = 38.80–2.83X |
| Organic carbon | 2.43 | – 0.79* | Y = 24.34–17.68X |
| Copper | 11.12 | – 0.17 | Y = 21.73–0.28X |
| Cromium | 11.13 | – 0.28 | Y = 10.72–0.71X |
| Lead | 11.31 | – 0.07 | Y = 20.54–0.17X |

* Significant at $P<0.01$

**Table 17**

Showing relationship between temperature & different dominant arthropods at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between Temperature and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on Temperature (X). Y = a+bX |
|---|---|---|---|
| **X : Temperature** | 23.96 | | |
| **Diptera** | 1.08 | 0.10 | Y = 0.84+0.01X |
| **Collembola** | 1.86 | 0.11 | Y = 1.38+0.02X |
| **Coleoptera** | 0.63 | 0.36 | Y = 0.09+0.03X |
| **Hymenoptera** | 0.98 | 0.10 | Y = 0.50+0.02X |
| **Acarina** | 3.82 | 0.02 | Y = 3.74–0.005X |

**Table 18**

Showing relationship between moisture and different dominant arthropods groups at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between Moisture and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on Moisture (X). Y = a+bX |
|---|---|---|---|
| **X : Moisture** | 27.74 | | |
| **Diptera** | 1.08 | – 0.06 | Y = 1.22–0.005X |
| **Collembola** | 1.86 | – 0.27 | Y = 3.25–0.05X |
| **Coleoptera** | 0.63 | – 0.13 | Y = 0.91–0.01X |
| **Hymenoptera** | 0.98 | – 0.34 | Y = 2.64–0.06X |
| **Acarina** | 3.82 | 0.01 | Y = 3.68+0.005X |

**Table 19**

Showing relationship between pH and different dominant arthropods groups at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between pH and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on pH (X). Y = a+bX |
|---|---|---|---|
| X : pH | 6.96 | | |
| Diptera | 1.08 | 0.03 | Y = 0.18+0.13X |
| Collembola | 1.86 | 0.39* | Y = 23.06+3.58X |
| Coleoptera | 0.63 | 0.17 | Y = 3.95+0.66X |
| Hymenoptera | 0.98 | 0.04 | Y = 1.39+0.34X |
| Acarina | 3.82 | – 0.12 | Y = 18.99–2.18X |

* Significant at P<0.05

**Table 20**

Showing relationship between organic carbon and different dominant arthropods groups at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between Organic Carbon and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on Organic Carbon (X). Y = a+bX |
|---|---|---|---|
| X : Organic Carbon | 2.68 | | |
| Diptera | 1.08 | 0.07 | Y = 0.22+0.32X |
| Collembola | 1.86 | 0.21 | Y = 3.18+1.88X |
| Coleoptera | 0.63 | 0.17 | Y = 1.06+0.63X |
| Hymenoptera | 0.98 | 0.21 | Y = 3.60+1.71X |
| Acarina | 3.82 | 0.08 | Y = 0.04+1.41X |

**Table 21**

Showing relationship between copper and different dominant arthropod groups at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between Copper and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on Copper (X). Y = a+bX |
|---|---|---|---|
| **X : Copper** | 62.36 | | |
| **Diptera** | 1.08 | – 0.27 | Y = 1.39+0.005X |
| **Collembola** | 1.86 | – 0.18 | Y = 2.30+0.007X |
| **Coleoptera** | 0.63 | 0.12 | Y = 0.51+0.002X |
| **Hymenoptera** | 0.98 | – 0.27 | Y = 1.60+0.01X |
| **Acarina** | 3.82 | – 0.12 | Y = 4.44–0.01X |

**Table 22**

Showing relationship between chromium and different dominant arthropod groups at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between Chromium and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on Chromium (X). |
|---|---|---|---|
| **X : Chromium** | 27.78 | | |
| **Diptera** | 1.08 | – 0.10 | Y = 1.30–0.008X |
| **Collembola** | 1.86 | – 0.27 | Y = 3.25–0.03X |
| **Coleoptera** | 0.63 | 0.14 | Y = 0.35–0.01X |
| **Hymenoptera** | 0.98 | – 0.29 | Y = 2.37–0.05X |
| **Acarina** | 3.82 | 0.10 | Y = 4.93–0.04X |

**Table 23**

Showing relationship between lead and different dominant arthropod groups at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between Lead and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on Lead (X). Y = a+bX |
|---|---|---|---|
| X : Lead | 28.66 | | |
| Diptera | 1.08 | - 0.19 | Y = 1.65–0.02X |
| Collembola | 1.86 | - 0.56* | Y = 5.30–0.12X |
| Coleoptera | 0.63 | 0.20 | Y = 0.06–0.02X |
| Hymenoptera | 0.98 | - 0.20 | Y = 2.13–0.04X |
| Acarina | 3.82 | - 0.09 | Y = 4.97–0.04X |

* Significant at $P<0.05$

**Table 24**

Showing relationship between temperature and different dominant arthropod groups at Beliaghata Canal.

| | Mean | Correlation coefficient between Temperature and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Temperature (X). Y = a+bX |
|---|---|---|---|
| X : Temperature | 25.82 | | |
| Diptera | 0.72 | - 0.02 | Y = 0.80–0.003X |
| Collembola | 1.37 | - 0.27 | Y = 2.40–0.04X |
| Coleoptera | 0.35 | 0.10 | Y = 0.22–0.005X |
| Hymenoptera | 0.60 | 0.02 | Y = 0.52–0.003X |
| Acarina | 2.21 | 0.04 | Y = 2.03–0.007X |

**Table 25**

Showing relationship between moisture and different dominant arthropod groups at Beliaghata Canal.

| | Mean | Correlation coefficient between Moisture and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Moisture (X). Y = a+bX |
|---|---|---|---|
| X : Moisture | 29.64 | | |
| Diptera | 0.72 | 0.23 | Y = 0.47–0.04X |
| Collembola | 1.37 | 0.38* | Y = 0.18–0.04X |
| Coleoptera | 0.35 | 0.13 | Y = 0.17–0.006X |
| Hymenoptera | 0.60 | 0.24 | Y = 0.59–0.04X |
| Acarina | 2.21 | 0.53** | Y = 0.16–0.08X |

* Significant at P<0.05
** Significant at P<0.01

**Table 26**

Showing relationship between moisture pH and different dominant arthropod groups at Beliaghata Canal.

| | Mean | Correlation coefficient between pH and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on pH (X). Y = a+bX |
|---|---|---|---|
| X : pH | 7.30 | | |
| Diptera | 0.72 | – 0.01 | Y = 1.01–0.04X |
| Collembola | 1.37 | 0.08 | Y = 0.13–0.17X |
| Coleoptera | 0.35 | 0.03 | Y = 0.13–0.03X |
| Hymenoptera | 0.60 | – 0.15 | Y = 3.67–0.42X |
| Acarina | 2.21 | – 0.11 | Y = 4.55–0.32X |

**Table 27**

Showing relationship between organic carbon and different dominant arthropod groups at Beliaghata Canal.

| | Mean | Correlation coefficient between Organic Carbon and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on Organic Carbon (X). Y = a+bX |
|---|---|---|---|
| X : Organic Carbon | 2.57 | | |
| Diptera | 0.27 | – 0.11 | Y = 4.32–1.40X |
| Collembola | 1.37 | – 0.15 | Y = 4.97–1.40X |
| Coleoptera | 0.35 | 0.08 | Y = 0.42–0.30X |
| Hymenoptera | 0.60 | – 0.36 | Y = 12.17–4.50X |
| Acarina | 2.21 | – 0.40* | Y = 16.09–5.40X |

* Significant at $P<0.01$

**Table 28**

Showing relationship between copper and different dominant arthropod groups at Beliaghata Canal.

| | Mean | Correlation coefficient between Copper and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on Copper (X). Y = a+bX |
|---|---|---|---|
| X : Copper | 134.62 | | |
| Diptera | 0.72 | – 0.16 | Y = 1.25–0.004X |
| Collembola | 1.37 | – 0.45* | Y = 2.72–0.01X |
| Coleoptera | 0.35 | – 0.21 | Y = 0.22–0.001X |
| Hymenoptera | 0.60 | – 0.37 | Y = 1.95–0.01X |
| Acarina | 2.21 | – 0.47* | Y = 3.56–0.01X |

* Significant at $P<0.01$

**Table 29**

Showing relationship between chromium and different dominant arthropod groups at Beliaghata Canal.

| | Mean | Correlation coefficient between Chromium and different dominant Arthropod groups | Regression line of different dominant Arthropod group (Y) on Chromium (X). Y = a+bX |
|---|---|---|---|
| X : Chromium | 145.38 | | |
| Diptera | 0.72 | – 0.16 | Y = 0.87–0.001X |
| Collembola | 1.37 | – 0.49* | Y = 1.95–0.004X |
| Coleoptera | 0.35 | – 0.07 | Y = 0.38–0.002X |
| Hymenoptera | 0.60 | – 0.00 | Y = 0.60–0.00X |
| Acarina | 2.21 | – 0.28 | Y = 2.65–0.003X |

* Significant at P<0.01

**Table 30**

Showing relationship between lead and different dominant arthropod groups at Beliaghata Canal.

| | Mean | Correlation coefficient between Lead and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on lead (X). Y = a+bX |
|---|---|---|---|
| X : Lead | 160.91 | | |
| Diptera | 0.72 | – 0.19 | Y = 1.04–0.002X |
| Collembola | 1.37 | – 0.55* | Y = 2.17–0.005X |
| Coleoptera | 0.35 | 0.02 | Y = 0.34–0.00007X |
| Hymenoptera | 0.60 | – 0.29 | Y = 1.08–0.003X |
| Acarina | 2.21 | – 0.36* | Y = 2.85–0.004X |

* Significant at P<0.01

At Tollygunge site collembola exhibited strong positive relationship with pH (Table-33) and negative relationship with copper (Table-35), while acarina exhibited a definite positive relationship with pH only (Table-33). Hymenoptera showed negative relationship with pH (Table-33), but in respcet of lead the relationship was positive (Table-37). Other groups of arthropods did not show any significant relationship with the soil factors (Tables - 31-37).

**Table 31**

Showing relationship between temperature and different dominant arthropod groups at Tollygunge Nulah.

| | Mean | Correlation coefficient between Temperature and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Temperature (X). Y = a+bX |
|---|---|---|---|
| X : Temperature | 23.29 | | |
| Diptera | 1.05 | – 0.08 | Y = 1.14–0.004X |
| Collembola | 2.88 | – 0.29 | Y = 5.91–0.13X |
| Coleoptera | 0.82 | – 0.32 | Y = 1.75–0.04X |
| Hymenoptera | 0.85 | 0.01 | Y = 0.83+0.001X |
| Acarina | 2.36 | – 0.09 | Y = 2.83–0.02X |

**Table 32**

Showing relationship between moisture and different dominant arthropod groups at Tollygunge Nulah.

| | Mean | Correlation coefficient between Moisture and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Moisture (X). Y = a+bX |
|---|---|---|---|
| X : Moisture | 27.13 | | |
| Diptera | 1.05 | 0.04 | Y = 0.94+0.004X |
| Collembola | 2.88 | 0.07 | Y = 1.52+0.05X |
| Coleoptera | 0.82 | 0.38 | Y = 1.35+0.08X |
| Hymenoptera | 0.85 | 0.34 | Y = 0.51+0.05X |
| Acarina | 2.36 | 0.04 | Y = 2.09+0.01X |

**Table 33**

Showing relationship between pH and different dominant arthropod groups at Tollygunge Nulah.

| | Mean | Correlation coefficient between pH and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on pH (X). Y = a+bX |
|---|---|---|---|
| **X : pH** | 7.36 | | |
| **Diptera** | 1.05 | 0.28 | Y = 1.89+0.40X |
| **Collembola** | 2.88 | 0.42* | Y = 32.67+4.83X |
| **Coleoptera** | 0.82 | 0.09 | Y = 1.02+0.25X |
| **Hymenoptera** | 0.85 | – 0.44* | Y = 8.06–0.98X |
| **Acarina** | 2.36 | 0.72** | Y = 19.87+3.02X |

* Significant at P<0.05
** Significant at P<0.01

**Table 34**

Showing relationship between organic carbon and different dominant arthropod groups at Tollygunge Nulah.

| | Mean | Correlation coefficient between Organic Carbon and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Organic Carbon (X). Y = a+bX |
|---|---|---|---|
| **X : Organic Carbon** | 1.00 | | |
| **Diptera** | 1.05 | – 0.19 | Y = 1.98–0.93X |
| **Collembola** | 2.88 | – 0.30 | Y = 15.09–12.21X |
| **Coleoptera** | 0.82 | – 0.35 | Y = 4.25–3.43X |
| **Hymenoptera** | 0.85 | 0.14 | Y = 0.22+1.07X |
| **Acarina** | 2.36 | 0.12 | Y = 0.57+1.79X |

**Table 35**

Showing relationship between copper and different dominant arthropod groups at Tollygunge Nulah.

| | Mean | Correlation coefficient between Copper and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Copper (X). Y = a+bX |
|---|---|---|---|
| X : Copper | 27.90 | | |
| Diptera | 1.05 | – 0.02 | Y = 1.11–0.002X |
| Collembola | 2.88 | – 0.44* | Y = 13.20–0.37X |
| Coleoptera | 0.82 | – 0.55** | Y = 3.89–0.11X |
| Hymenoptera | 0.85 | 0.20 | Y = 0.01+0.03X |
| Acarina | 2.36 | – 0.08 | Y = 3.20–0.03X |

* Significant at P<0.05
** Significant at P<0.01

**Table 36**

Showing relationship between chromium and different dominant arthropod groups at Tollygunge Nulah.

| | Mean | Correlation coefficient between Chromium and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Chromium (X). Y = a+bX |
|---|---|---|---|
| X : Chromium | 39.21 | | |
| Diptera | 1.05 | – 0.16 | Y = 1.17–0.003X |
| Collembola | 2.88 | – 0.23 | Y = 4.45–0.04X |
| Coleoptera | 0.82 | – 0.26 | Y = 1.21–0.01X |
| Hymenoptera | 0.85 | 0.28 | Y = 0.46+0.01X |
| Acarina | 2.36 | – 0.10 | Y = 2.60–0.006X |

**Table 37**

Showing relationship between lead and different dominant arthropod groups at Tollygunge Nulah.

| | Mean | Correlation coefficient between Lead and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Lead (X). Y = a+bX |
|---|---|---|---|
| X : Lead | 20.67 | | |
| Diptera | 1.05 | – 0.23 | Y = 1.67–0.03X |
| Collembola | 2.88 | – 0.31 | Y = 10.11–0.35X |
| Coleoptera | 0.82 | – 0.17 | Y = 1.85–0.05X |
| Hymenoptera | 0.85 | 0.41* | Y = 1.01+0.09X |
| Acarina | 2.36 | – 0.17 | Y = 3.81–0.07X |

* Significant at $P<0.05$

At Botanical garden site, both collembola and acarina showed strong positive relationships with moisture and organic carbon (Tables - 39-41).

Coleoptera at Botanical Garden showed negative relationship with temperature (Table - 38), the relationships between other dominant arthropods and soil factors were not significant (Tables - 38-44).

Analysis of sitewise intersoil-factors relationships indicated that at Dumdum, temperature had definite positive relationships with pH, chromium and lead (Tabl-45); moisture had a strong negative relationship with organic carbon but it was positively corelated with copper and chromium (Table-46). Copper, chromium and lead had significantly positive relationships amongst themselves (Tables-49, 50). The relationships amongst other soil factors did not bear any significance (Tables- 45-50).

At Beliaghata, temperature had significant positive relationships with organic carbon, copper, chromium and lead. (Table-51) but moisture had negative significant relationships with the same soil factors (Table-52). Soil pH showed positive relationship with organic carbon (Table-33). Organic carbon, copper, chromium and lead had strong positive relationship amongst themselves (Tables- 54-56). The rest of the interfactor relationships were not significant (Tables - 51-56).

**Table 38**

Showing relationship between temperature and different dominant arthropod groups at Botanical garden.

| | Mean | Correlation coefficient between Temperature and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Temperature (X). Y = a+bX |
|---|---|---|---|
| X : Temperature | 28.48 | | |
| Diptera | 0.49 | – 0.13 | Y = 0.77–0.01X |
| Collembola | 6.12 | 0.24 | Y = 1.56+0.16X |
| Coleoptera | 0.61 | – 0.46* | Y = 1.18–0.02X |
| Hymenoptera | 1.34 | 0.14 * | Y = 0.77+0.02X |
| Acarina | 0.35 | 0.14 | Y = 4.93+0.12X |

* Significant at P<0.05

**Table 39**

Showing relationship between moisture and different dominant arthropod groups at Botanical garden.

| | Mean | Correlation coefficient between Moisture and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Moisture (X). Y = a+bX |
|---|---|---|---|
| X : Moisture | 23.53 | | |
| Diptera | 0.49 | 0.36 | Y = 0.02+0.02X |
| Collembola | 6.12 | 0.88* | Y = 4.47+0.45X |
| Coleoptera | 0.61 | 0.25 | Y = 0.37+0.01X |
| Hymenoptera | 1.34 | 0.35 | Y = 0.63+0.03X |
| Acarina | 8.35 | 0.85* | Y = 5.53+0.59X |

* Significant at P<0.01

**Table 40**

Showing relationship between pH and different dominant arthropod groups at Botanical garden.

| | Mean | Correlation coefficient between pH and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on pH (X). Y = a+bX |
|---|---|---|---|
| **X : pH** | 7.13 | | |
| **Diptera** | 0.49 | 0.08 | Y = –0.44+0.13X |
| **Collembola** | 6.12 | – 0.08 | Y = 13.75–1.07X |
| **Coleoptera** | 0.61 | – 0.08 | Y = 1.25–0.09X |
| **Hymenoptera** | 1.34 | 0.06 | Y = 0.27+0.15X |
| **Acarina** | 8.35 | – 0.08 | Y = 18.90–1.48X |

**Table 41**

Showing relationship between organic carbon and different dominant arthropod groups at Botanical garden.

| | Mean | Correlation coefficient between Organic Carbon and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Organic Carbon (X). Y = a+bX |
|---|---|---|---|
| **X : Organic Carbon** | 2.43 | | |
| **Diptera** | 0.49 | 0.20 | Y = –0.02+0.21X |
| **Collembola** | 6.12 | 0.79* | Y = –11.8+7.12X |
| **Coleoptera** | 0.61 | 0.03 | Y = 0.56+0.02X |
| **Hymenoptera** | 1.34 | 0.27 | Y = 0.25+0.45X |
| **Acarina** | 8.35 | 0.77* | Y = –14.20+9.28X |

* **Significant at P<0.01**

**Table 42**

Showing relationship between copper and different dominant arthropod groups at Botanical garden.

| | Mean | Correlation coefficient between Copper and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Copper (X). Y = a+bX |
|---|---|---|---|
| X : Copper | 11.12 | | |
| Diptera | 0.49 | – 0.17 | Y = 0.60–0.01X |
| Collembola | 6.12 | – 0.04 | Y = 6.34–0.02X |
| Coleoptera | 0.61 | 0.06 | Y = 0.58+0.003X |
| Hymenoptera | 1.34 | 0.22 | Y = 1.01+0.03X |
| Acarina | 8.35 | – 0.07 | Y = 9.02–0.06X |

**Table 43**

Showing relationship between chromium and different dominant arthropod groups at Botanical garden.

| | Mean | Correlation coefficient between Chromium and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Chromium (X). Y = a+bX |
|---|---|---|---|
| X : Chromium | 11.13 | | |
| Diptera | 0.49 | – 0.15 | Y = 0.71–0.02X |
| Collembola | 6.12 | 0.27 | Y = 3.00+0.22X |
| Coleoptera | 0.61 | 0.16 | Y = 0.50+0.01X |
| Hymenoptera | 1.34 | 0.25 | Y = 0.78+0.05X |
| Acarina | 8.35 | 0.19 | Y = 5.46–0.26X |

**Table 44**

Showing relationship between lead and different dominant arthropod groups at Botanical garden.

| | Mean | Correlation coefficient between Lead and different dominant Arthropod groups | Regression line of different dominant Arthropod groups (Y) on Lead (X). Y = a+bX |
|---|---|---|---|
| X : Lead | 11.31 | | |
| Diptera | 0.49 | – 0.27 | Y = 0.83–0.03X |
| Collembola | 6.12 | – 0.08 | Y = 6.91–0.07X |
| Coleoptera | 0.61 | 0.00 | Y = 0.61+0.00X |
| Hymenoptera | 1.34 | 0.12 | Y = 1.11+0.02X |
| Acarina | 8.35 | – 0.15 | Y = 10.50–0.19X |

**Table 45**

Showing relationship between temperature and other soil factors at Bagjola Camal, Dumdum.

| | Mean | Correlation coefficient between Temperature and other soil factors | Regression line of soil factors (Y) on Temperature (X). Y = a+bX |
|---|---|---|---|
| X : Temperature | 23.96 | | |
| Moisture | 27.74 | 0.08 | Y = 29.90–0.09X |
| pH | 6.96 | 0.43* | Y = 6.74+0.009X |
| Organic Carbon | 2.68 | 0.23 | Y = 2.56+0.005X |
| Copper | 62.36 | 0.25 | Y = 33.37+1.21X |
| Chromium | 27.78 | 0.55** | Y = 13.16+0.61X |
| Lead | 28.66 | 0.67** | Y = 12.09+0.65X |

* Significant at $P<0.05$

** Significant at $P<0.01$

**Table 46**

Showing relationship between moisture and other soil factors at Bagjola Canal., Dumdum.

| | Mean | Correlation coefficient between Moisture and other soil factors | Regression line of other soil factors (Y) Moisture (X). Y = a+bX |
|---|---|---|---|
| X : Moisture | 27.74 | | |
| pH | 9.96 | – 0.36 | Y = 6.77–0.007X |
| Organic Carbon | 2.68 | – 0.70** | Y = 3.23–0.02X |
| Copper | 62.36 | 0.42* | Y = 12.15+1.81X |
| Chromium | 27.78 | 0.43* | Y = 15.85+0.43X |
| Lead | 28.66 | 0.29 | Y = 21.72+0.25X |

* Significant at $P<0.05$
** Significant at $P<0.01$

**Table 47**

Showing relationship between pH and other soil factors at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between pH and other soil factors | Regression line of other soil factors (Y) on pH (X). Y = a+bX |
|---|---|---|---|
| X : pH | 6.96 | | |
| Organic Carbon | 2.68 | 0.21 | Y = 1.22+0.21X |
| Copper | 62.36 | 0.04 | Y = 9.39+7.61X |
| Chromium | 27.78 | 0.06 | Y = 7.46+2.92X |
| Lead | 28.66 | 0.18 | Y = 22.77+7.39X |

**Table 48**

Showing relationship between organic carbon and other soil factors at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between Organic Carbon and other soil factors | Regression line of other soil factors (Y) on Organic Carbon (X). Y = a+bX |
|---|---|---|---|
| X : Organic Carbon | 2.68 | | |
| Copper | 62.32 | 0.05 | Y = 37.14+9.41X |
| Chromium | 27.78 | – 0.10 | Y = 39.81–4.49X |
| Lead | 28.66 | 0.06 | Y = 22.71+2.22X |

**Table 49**

Showing relationship between copper and other soil factors at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between copper and other soil factors | Regression line of other soil factors (Y) on copper (X). Y = a+bX |
|---|---|---|---|
| X : Copper | 62.36 | | |
| Chromium | 27.78 | 0.76* | Y = 16.56+0.18X |
| Lead | 28.66 | 0.76* | Y = 19.31+0.15X |

* Significant at $P<0.01$

**Table 50**

Showing relationship between chromium and lead at Bagjola Canal, Dumdum.

| | Mean | Correlation coefficient between Chromium and Lead | Regression line of lead (Y) on chromium (X) Y = a+bX |
|---|---|---|---|
| X : Chromium | 27.78 | | |
| Lead | 28.66 | 0.86* | Y = 8.10+0.74X |

* Significant at P<0.01

**Table 51**

Showing relationship between temperature and other soil factors, at Beliaghata Canal.

| | Mean | Correlation coefficient between Temperature and other soil factors | Regression line of soil factors (Y) on Temperature (X). Y = a+bX |
|---|---|---|---|
| X Temperature | 25.82 | | |
| Moisture | 29.64 | – 0.14 | Y = 34.03–0.17X |
| pH | 7.30 | – 0.16 | Y = 7.56–0.01X |
| Organic Carbon | 2.57 | 0.52* | Y = 2.39+0.007X |
| Copper | 134.62 | 0.57* | Y = 45.28+3.46X |
| Chromium | 145.38 | 0.81* | Y = 166.53+12.08X |
| Lead | 160.91 | 0.58* | Y = 50.30+8.18X |

* Significant at P<0.01

**Table 52**

Showing relationship between moisture and other soil factors, at Beliaghata Canal.

| | Mean | Correlation coefficient between Moisture and other soil factors | Regression line of soil factors (Y) on Moisture (X). Y = a+bX |
|---|---|---|---|
| X : Moisture | 29.64 | | |
| pH | 7.39 | – 0.07 | Y = 7.21–0.003X |
| Organic Carbon | 2.57 | – 0.82* | Y = 2.84–0.009X |
| Copper | 134.62 | – 0.71* | Y = 238.66–3.51X |
| Chromium | 145.38 | – 0.56* | Y = 349.60–6.89X |
| Lead | 160.91 | – 0.69* | Y = 398.33–8.01X |

* Significant at $P<0.01$

**Table 53**

Showing relationship between pH and other soil factors, at Beliaghata Canal.

| | Mean | Correlation coefficient between pH and other soil factors | Regression line of soil factors (Y) on pH (X). Y = a+bX |
|---|---|---|---|
| X : pH | 7.30 | | |
| Organic Carbon | 2.57 | 0.82* | Y = 1.18+0.19X |
| Copper | 124.62 | 0.05 | Y = 99.87+4.76X |
| Chromium | 145.38 | – 0.21 | Y = 510.09–49.96X |
| Lead | 160.91 | – 0.08 | Y = 295.81–18.48X |

* Significant at $P<0.01$

**Table 54**

Showing relationship between organic carbon and other soil factors, at Beliaghata Canal.

| | Mean | Correlation coefficient between Organic Carbon and other soil factors | Regression line of soil factors (Y) on Organic Carbon (X). Y = a+bX |
|---|---|---|---|
| X : Organic Carbon | 2.57 | | |
| Copper | 134.62 | 0.67* | Y = 548.72+279.90X |
| Chromium | 145.38 | 0.44* | Y = –1050.18+465.20X |
| Lead | 160.91 | 0.63* | Y = –1434.80+620.90X |

* Significant at P<0.01

**Table 55**

Showing relationship between copper and other soil factors, at Beliaghata Canal.

| | Mean | Correlation coefficient between copper and other soil factors | Regression line of soil factors (Y) on Copper (X). Y = a+bX |
|---|---|---|---|
| X : Copper | 134.62 | | |
| Chromium | 145.38 | – 0.91* | Y = 158.66+2.26X |
| Lead | 160.91 | – 0.94* | Y = 135.25+2.20X |

* Significant at P<0.01

**Table 56**

Showing relationship between chromium and lead at Beliaghata Canal.

| | Mean | Correlation coefficient between Chromium and Lead | Regression line of Lead (Y) on Chromium (X). Y = a+bX |
|---|---|---|---|
| X : Chromium | 145.38 | | |
| Lead | 160.91 | 0.94* | Y = 32.98+0.88X |

* Significant at P<0.01

At tollygunge site again temperature had positive relationships with organic carbon, copper and lead (Table-57). Moisture showed a negative relationship with organic carbon, but its relation with chromium was positive (Table -58), pH and organic carbon were negatively correlated (Table-59), while copper, chromium and lead showed positive relationship amongst themselves (Tables-61, 62). The relationships of the rest of the inter-soil factors were not significant (Tables-57-62).

At Botanical Garden site also the temperature maintained a similar positive relationships with organic carbon, copper, chromium and lead (Table-63), as encountered in the other sites. Moisture had a positive relationship with organic carbon, while the relationships with chromium and lead (Table-64) were negative. Here also copper, chromium and lead exhibited significant positive relationships amongst themselves (Tables - 67-68). The relationships of other inter-soil factors were insignificant (Tables - 63-68).

**Table 57**

Showing relationship between temperature and other soil factors, at Tollygunge Nulah.

| | Mean | Correlation coefficient between Temperature and other soil factors | Regression line of soil factors (Y) on Temperature (X). Y = a+bX |
|---|---|---|---|
| X : Temperature | 23.29 | | |
| Moisture | 27.13 | 0.11 | Y = 28.53–0.06X |
| pH | 7.36 | 0.35 | Y = 7.13–0.01X |
| Organic Carbon | 1.00 | 0.71* | Y = 0.84+0.007X |
| Copper | 27.90 | 0.60* | Y = 20.45+0.32X |
| Chromium | 39.21 | 0.35 | Y = 30.35+0.81X |
| Lead | 20.67 | 0.87* | Y = 12.75+0.34X |

* Significant at P<0.01

**Table 58**

Showing relationship between moisture and other soil factors, at Tollygunge Nulah.

| | Mean | Correlation coefficient between Moisture and other soil factors | Regression line of soil factors (Y) on Moisture (X). Y = a+bX |
|---|---|---|---|
| X : Moisture | 27.13 | | |
| pH | 7.36 | – 0.33 | Y = 7.90–0.02X |
| Organic Carbon | 1.00 | – 0.56** | Y = 1.27–0.01X |
| Copper | 27.90 | 0.12 | Y = 23.09+0.12X |
| Chromium | 39.21 | 0.43* | Y = 10.98+1.85X |
| Lead | 20.67 | 0.38 | Y = 13.34+0.27X |

* Significant at P<0.05
** Significant at P<0.01

**Table 59**

Showing relationship between pH and other soil factors, at Tollygunge Nulah.

| | Mean | Correlation coefficient between pH and other soil factors | Regression line of other soil factors (Y) on pH (X). Y = a+bX |
|---|---|---|---|
| X : pH | 7.36 | | |
| Organic Carbon | 1.00 | – 0.80* | Y = 2.62–0.22X |
| Copper | 27.90 | – 0.26 | Y = 53.22–3.44X |
| Chromium | 39.21 | – 0.24 | Y = 144.97–14.37X |
| Lead | 20.67 | 0.18 | Y = 7.35+1.81X |

* Significant at P<0.01

**Table 60**

Showing relationship between organic carbon and other soil factors, at Tollygunge Nulah.

| | Mean | Correlation coefficient between Organic Carbon and other soil factors | Regression line of other soil factors (Y) on Organic Carbon (X). Y = a+bX |
|---|---|---|---|
| X : Organic Carbon | 1.00 | | |
| Copper | 27.90 | 0.20 | Y = 37.33+9.43X |
| Chromium | 39.21 | – 0.18 | Y = 75.92–36.71X |
| Lead | 20.67 | – 0.08 | Y = 23.53–2.86X |

**Table 61**

Showing relationship between copper and other soil factors at Tollygunge Nulah.

| | Mean | Correlation coefficient between Copper and other soil factors | Regression line of other soil factors (Y) on Copper (X). Y = a+bX |
|---|---|---|---|
| X : Copper | 27.90 | | |
| Chromium | 39.21 | 0.67* | Y = –43.37+2.96X |
| Lead | 20.67 | 0.64* | Y = 7.28+0.48X |

*Significant at P<0.01

**Table 62**

Showing relationship between chromium and lead at Tollygunge Nulah.

| | Mean | Correlation coefficient between Chromium and Lead other soil factors | Regression line of other soil factors (Y) on Chromium and Lead (X). Y = a+bX |
|---|---|---|---|
| X : Chromium | 39.21 | | |
| Lead | 20.67 | 0.89* | Y = 14.79+0.15X |

*Significant at P<0.01

**Table 63**

Showing relationship between temperature and other soil factors at Botanical garden.

| | Mean | Correlation coefficient between Temperature and other soil factors | Regression line of soil factors (Y) on Temperature (X). Y = a+bX |
|---|---|---|---|
| X : Temperature | 28.48 | | |
| Moisture | 23.53 | 0.11 | Y = 19.54+0.14X |
| pH | 7.13 | 0.26 | Y = 6.85+0.01X |
| Organic Carbon | 2.43 | 0.97* | Y = 0.44+0.06X |
| Copper | 11.12 | 0.45* | Y = –1.70+0.45X |
| Chromium | 11.13 | 0.48* | Y = 2.77+0.30X |
| Lead | 11.31 | 0.68* | Y = –2.36+0.48X |

* Significant at P<0.01

**Table 64**

Showing relationship between moisture and other soil factors at Botanical garden.

| | Mean | Correlation coefficient between Moisture and other soil factors | Regression line of soil factors (Y) on Moisture(X). Y = a+bX |
|---|---|---|---|
| X : Moisture | 23.53 | | |
| pH | 7.13 | – 0.01 | Y = 7.14–0.0005X |
| Organic Carbon | 2.48 | 0.84* | Y = 1.25+0.05X |
| Copper | 11.12 | – 0.33 | Y = 17.24–0.26X |
| Chromium | 11.13 | – 0.69* | Y = 19.13–0.34X |
| Lead | 11.31 | – 0.48* | Y = 17.66–0.27X |

* Significant at P<0.01

**Table 65**

Showing relationship between pH and other soil factors at Botanical garden.

| | Mean | Correlation coefficient between pH and other soil factors | Regression line of soil factors (Y) on pH (X). Y = a+bX |
|---|---|---|---|
| X : pH | 7.13 | | |
| Organic Carbon | 2.43 | – 0.23 | Y = 0.07–0.35X |
| Copper | 11.12 | 0.23 | Y = 309.51–41.85X |
| Chromium | 11.13 | 0.24 | Y = 10.76+3.07X |
| Lead | 11.31 | 0.28 | Y = 18.28+4.15X |

**Table 66**

Showing relationship between organic carbon and other soil factors, at Botanical garden.

| | Mean | Correlation coefficient between Organic Carbon and other soil factors | Regression line of soil factors (Y) on Organic Carbon (X). Y = a+bX |
|---|---|---|---|
| X : Organic Carbon | 2.43 | | |
| Copper | 11.12 | – 0.17 | Y = 5.53–2.30X |
| Chromium | 11.13 | – 0.34 | Y = 18.25–2.93X |
| Lead | 11.31 | – 0.23 | Y = 16.75–2.24X |

**Table 67**

Showing relationship between copper and other soil factors, at Botanical garden.

| | Mean | Correlation coefficient between Copper and other soil factors | Regression line of soil factors (Y) on Copper (X). Y = a+bX |
|---|---|---|---|
| X : Copper | 11.12 | | |
| Chromium | 11.13 | 0.66* | Y = 6.46+0.42X |
| Lead | 11.31 | 0.69* | Y = 5.86+0.49X |

* Significant at $P<0.01$

**Table 68**

Showing relationship between Chromium and other soil factors, at Botanical garden.

| | Mean | Correlation coefficient between Chromium and other soil factors | Regression line of soil factors (Y) on Chromium (X). Y = a+bX |
|---|---|---|---|
| X : Chromium | 11.13 | | |
| Lead | 11.31 | 0.52* | Y = 4.85+0.58X |

* Significant at P<0.01

## DISCUSSION

The embankment sites under this study were sparcely vegetated with macroflora except the Botanical Garden site which was richly vegetated and well shaded. Choudhuri and Roy (1972) and Hazra and Choudhuri (1983) reported an indirect influence of vegetation on a group of soil microarthropods i.e., collembola through the formation of humus with the resultant increase in the moisture holding capacity of soil.

Since these sites were on the sewage canal embankments, the quantity of humus in each of them was higher than the surrounding soil. The nature of macro and microflora in all the sampling sites considered here were more or less similar though, the density of vegetation at the Botanical Garde site varied considerably from that of the others. There might be a partial agreement between the flora and the microarthropod community, and the intensity of vegetation might directly or indirectly influence the population density but whether the macroflora exerted any effect on the species composition of the soil arthropods could not be confirmed. In the opinion of Torn (1961 and 1967), Choudhuri and Banerjee (1975) the soil microflora specially the fungi served as the sources of food for some soil microarthropods. As these microarthropods specially the collembola showed strong feeding preference for the fungal hypae and spores suggesting thereby that the distribution of these soil animals might have some relation with the distribution of fungi (knight, 1961). Moreover, the direct competition between the soil arthropods and the soil fungi might exert a limiting effect on their distribution, especially when these groups were found to compete for the available soil moisture.

The arthropod fauna obtained in this study belonged to different groups (Acarina, Collembola, Diptera and their maggots, Hemiptera and their nymphs, Hymenoptera, Thysanoptera, Psocoptera, Protura, Araneida and Crustacea). Some of them differed in their abundance from one site to other (Tables - 5, 6, 7, and 8). Again, the number of individuals in a group also varied from plot to plot of the sampling sites; maximum being obtained from the Botanical Garden site (Table-8) and minimum from the Beliaghata canal site (Table-6).

The acarines were numerically dominant over other forms and they comprised about 36.98% of the total arthropod population (Table-A). They were widespread being found in all the sampling sites. Such a wide distribution and numerical dominance suggested their capability to exist in varying ecological conditions. Their population in the non-polluted soils was maximum in August and minimum in April/May (Table-B); while in the polluted areas both maximum; and minimum populations varied sitewise being maximum in January, March and March at Tollygunge, Dum Dum and Beliaghata sites respectively and minumum in April, October and May respectively in those sites.

**Table A**

Showing mean population percentage of individual groups of arthropods of all the plots together.

| | | | |
|---|---|---|---|
| 1. | Acarina | — | 36.98% |
| 2. | Collembola | — | 26.98% |
| 3. | Diptera & maggot | — | 11.45% |
| 4. | Hymenoptera | — | 8.91% |
| 5. | Coleoptera | — | 6.08% |
| 6. | Psocoptera | — | 2.26% |
| 7. | Hemiptera & nymph | — | 2.18% |
| 8. | Thysanoptera | — | 1.03% |
| 9. | Diplura | — | 0.26% |
| 10. | Araneida | — | 0.23% |
| 11. | Pseudoscorpion | — | 0.21% |
| 12. | Crustacea | — | 0.21% |
| 13. | Protura | — | 0.02% |
| 14. | Others | — | 3.30% |
| | Total | — | 100.00% |

The next predominant order was Collembola. It comprised 26.98% of the total arthropod population being found in all the sampling sites (Table-A). The number of this group also exhibited similar fluctuation like the acarines being maximum in August and minimum in April/ May in the non-polluted plot. In the polluted plots however their population varied from one site to the other.

## Table B

Showing individual groups of arthropods and their monthly population (mean %) at Polluted (A) and Non polluted (B) sites

| Month | Diptera | | Collembola | | Coleoptera | | Hymenoptera | | Acarina | | Thysanoptera | | Hemiptera | | Pseudoscorpion | | Psocoptera | | Crustacea | | Araneida | | Diplura | | Protura | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B |
| Dec. | .30 | .91 | .99 | 1.36 | .23 | .26 | .28 | .44 | .95 | 2.08 | .02 | .02 | .08 | .10 | .01 | .02 | .11 | .10 | .08 | — | .01 | — | — | .14 | — | — |
| Jan. | .01 | .53 | 1.14 | .96 | .33 | .14 | .29 | .23 | 1.43 | 1.38 | .01 | .04 | .02 | .04 | — | .02 | .05 | — | — | .05 | — | .04 | — | .02 | — | .02 |
| Feb. | .68 | .32 | 2.64 | .86 | .62 | .18 | .37 | .26 | 1.69 | 1.56 | .07 | — | .08 | .44 | — | — | .04 | — | — | — | — | .02 | — | .06 | — | — |
| Mar. | .62 | .22 | 1.26 | .82 | .12 | .14 | .13 | .14 | 2.62 | 1.28 | .12 | .04 | .05 | .02 | — | — | .01 | .10 | — | .04 | — | .02 | — | — | — | — |
| Apr. | .57 | .12 | .70 | .64 | .18 | .14 | .67 | .34 | 1.35 | 0.78 | — | .04 | .05 | .06 | .01 | — | .02 | .02 | — | — | — | — | — | .06 | — | — |
| May | .45 | .12 | .84 | .54 | .21 | .06 | .31 | .18 | 1.22 | 0.70 | .10 | .04 | .10 | .08 | — | .02 | .47 | .06 | — | — | — | — | — | .02 | — | — |
| Jun. | .43 | .16 | .55 | .78 | .20 | .10 | .41 | .22 | 0.86 | 0.90 | .03 | .04 | .07 | .06 | .04 | — | .08 | .04 | — | .02 | — | .02 | — | .04 | — | — |
| Jul. | .52 | .18 | 1.13 | 2.24 | .23 | .22 | .17 | .58 | 1.21 | 3.02 | .02 | .04 | .02 | .10 | — | .06 | .10 | .06 | — | .02 | .02 | .08 | — | .10 | — | — |
| Aug. | .56 | .18 | 1.03 | 3.16 | .24 | .08 | .50 | .32 | 1.42 | 4.30 | .16 | .02 | .05 | .06 | — | .02 | .08 | .08 | — | — | .01 | — | — | .04 | — | — |
| Sep. | .56 | .36 | 0.74 | 2.32 | .32 | .16 | .40 | .48 | 2.01 | 2.94 | .02 | .04 | — | .04 | — | .04 | .16 | .02 | — | — | — | .06 | — | .04 | — | — |
| Oct. | .52 | .24 | 0.75 | 1.96 | .55 | .14 | .66 | .42 | 0.97 | 2.62 | .02 | .02 | .04 | .04 | — | — | .03 | .04 | — | .02 | — | .02 | — | .04 | — | .02 |
| Nov. | .47 | .14 | 0.86 | 2.00 | .45 | .12 | .46 | .14 | 1.09 | 2.48 | .05 | .06 | .11 | .02 | — | — | .12 | .02 | — | — | .01 | .02 | — | — | — | — |

The third important group in order of dominance was Diptera. It was represented mainly by the maggots being extracted from all the polluted sampling sites. It comprised 11.45% of the total arthropod population (Table-A) and showed two maximum peaks in December and September and one minimum peak in May in respect of Botanical Garden site, but in the polluted plots the population fluctuation was highly irregular except at Beliaghata canalsite where maximum population was witnessed in March and August while the minimum population was obtained in May.

The other important forms encountered were Hymenoptera, Coleoptera, Psocoptera, Hemiptera and their nymphs and Thysanoptera constituting 8.91%, 6.08%, 2.26%, 2.18% and 1.03% of the total arthropod population respectively (Table-A).

The forms belonging to the groups Diplura, Araneida, Crustacea, Protura taken separately constituted a minor portion of the arthopodan community and were strictly localised forms being restricted to one or two sampling sites.

The above mentioned variations in the faunal make up might be due to the occurence of differences in the edaphelogical conditions. Some forms as already stated were wide spread occuring regularly in the different sampling sites while others were localised.

The total population of arthropods as obtained from the sampling sites under the purview of this study when considered together showed numerical variation with the change of season (Table-C). It was lowest in June (summer) and maximum in August (monsoon). This fluctuation pattern agreed with the findings of Choudhuri and Roy (1972), Choudhuri and Banerjee (1975), Hazra (1976 and 1984), Roy and Ghatak (1977), Sanyal (1981 a, b, and 1982). In case of some microarthropod groups in Indian conditions where as such pattern appeared to be different from those met with in Aarthropods reported from Europe and America. Weis-Fogh (1948), Macfadyen (1952), Sheals (1967), Haarlov (1960) and Rapoport and Najt (1966) observed that a microarthropod (collembola) population became maximum at some period between late autumn and early spring and minimum in summer months. In this study the two most dominant forms like acarina and collembola attained their respective population peak in August (Table-B) in the non-polluted plot. Most of these and other forms obtained from these plots showed a very low population in May-June.

Individuals of the groups belonging to Thysanoptera, Hemiptera, Psocoptera, Diplura, etc., were numerically high during monsoon season, but they showed highly irregular trend of fluctuation and were altogether absent in many sampling months.

Besides the clear monsoon peak. the arthropod population considered as a whole also showed a partial (minor) winter peak which might be due to the population spurt of some forms of the groups like Diptera, Coleoptera and Acarina in winter in the non-polluted plots.

The prevalence of similar two peaks was also previously observed in Japan by Takeda (1973) and in India by Choudhuri and Roy (1972), Hazra (1978) and Pillai and Singh (1977). Thus the pattern of seasonal variation appeared to be different in different orders which perhaps indicated the existence of different breeding period. Again the existence of a single population peak suggested the probability of having a single generation a year (Bellinger, 1954) while the occurance of two peaks might be due to the existence of more than one generation (Hale, 1966).

**Table C**

Showing fluctuation of total arthropod population of all the sites (Mean no.)

| | |
|---|---|
| Dec. | 11.48 |
| Jan | 11.46 |
| Feb. | 12.63 |
| Mar. | 10.66 |
| Apr. | 10.46 |
| May | 8.92 |
| Jun. | 6.44 |
| Jul. | 13.69 |
| Aug. | 13.90 |
| Sep. | 13.33 |
| Oct. | 12.43 |
| Nov. | 12.08 |

In the polluted plots however the dominant forms like Colembola, Acarina, Coleoptera and Diptera showed their maximum peaks in February/March (Table-B). The populations of Hymenoptera, Thysanoptera, Hemiptera and Psocoptera attained their maxima respectively in April, May, October and May.

It could be inferred, therefore, that the monsoon peaks of fauna had been shifted to spring in case of dominant groups and to summer for other minor groups. Such an alteration might be due to the presence of high concentration of pollutants like heavy metals, where some of these faunal groups seem to possess a great resistance than others.

This observation supported the earlier findings of Vanek (1967), Gorny (1975), Petal *et al.* (1975), Petal (1978), Bhattacharya *et al.* (1980), Bhattacharya and Bhattacharya (1981) and Hazra and Chattopadhyay (1985). Both the non-polluted and the polluted sampling sites experienced heavy rainfall in monsoon which resulted to an exhuberent growth of macro and microflora. Thus an optimum condition was set for supporting a larger population of the soil arthropod fauna at non-polluted plots, on the other hand during summer months an adverse situation was found to prevail due to high rate of evaporation of soil moisture combined with low rainfall, which led to a considerable reduction in the number possibly through increased mortality of the delicate and susceptible forms.

The situation was different in the polluted plots where the microarthropod population decreased during monsoon months due to the prevalence of higher level of heavy metals which eventually let to a catastrophic effect on the total soil fauna although other edaphic factors were more or less same with that of the non-polluted plots.

In the present investigation the total population extracted in the polluted plots was significantly low in comparison to that extracted from the non-polluted plots (Table-D). As stated earlier this might be due to the effect of heavy metals and other toxic substances discharged into the sewage canal. Similar results of reduction of soil invertebrate fauna due to industrial pollution had already been reported by Singh (1976), Bhattacahrya and Joy (1977), Petal (1978), Bhattacharya and Bhattacharya (1981), Hazra *et al.* (1982) and Hazra and Chattopadhyay (1985).

**Table D**

Showing monthly distribution of total arthropod population (mean no.) at Polluted and Non-polluted sites.

| Months | Polluted | Non-polluted |
|---|---|---|
| Dec. | 8.53 | 20.34 |
| Jan. | 9.47 | 13.42 |
| Feb. | 12.28 | 13.67 |
| Mar. | 10.14 | 12.17 |
| Apr. | 10.95 | 9.67 |
| May | 9.17 | 8.17 |
| Jun. | 5.17 | 10.25 |
| Jul. | 7.37 | 29.50 |
| Aug. | 5.73 | 34.34 |
| Sep. | 7.73 | 27.34 |
| Oct. | 8.89 | 23.25 |
| Nov. | 8.97 | 21.42 |
| $\overline{X}$ | 8.70 | 18.63 |

The vertical distribution study (Table - 9-12) revealed that in almost all cases the soil arthropod population was significantly high in the uppermost layer (0-5 cms.). Such a finding was in agreement with the results reported by Murphy (1953), Poole (1959), Dhillon and Gibson (1962), Davis (1963), Christiansen (1964), Choudhuri and Roy (1967, 1971 and 1972), Singh and Singh (1975) Choudhuri *et al.* (1978), Choudhuri and Pande (1979) and Hazra and Choudhuri (1983). The maximum concentration of fauna (most of the dominant forms) in the uppermost layer of soil in case of most of the plots under this study might be associated with a possibility that with increasing depth there would be reduction in the pore space because of compaction of soil and for which the larger forms would be unable to penetrate to the deeper layers. This possibility would be strengthened if the corelation between the size of soil arthropods and their depthwise distribution was taken into consideration (Hazra and Choudhuri, 1981; Dhillon and Gibson, 1962; and Wood, 1967).

As the present study did not take into consideration the species composition of each group obtained from different layers, it was not possible to ascertain the reason for greater concentration of the different species in the uppermost layers of all the plots. However, the abundance of the juvenile forms of most of the microarthropods in the top layer of soil as observed in this study confirmed the earlier findings of Choudhuri and Banerjee (1975), Takeda (1976) and Hazra and Choudhuri (1983).

As to the role of soil factors it might be assumed that the edphalogical parameters analysed in this investigation exerted their effects either singly or in a cumulative way. This could be substantiated from an analysis as to the extent of importance of the different factors by taking into consideration the mean value of the soil factors during maximum and minimum population peaks in different sampling sites (Tables 1,2,3, and 4).

The data in these tables would reveal that in the three polluted sites the population was recorded maximum when the concentration of the heavy metals in the soil was considerably low and it did not depend on the maximum availability of moisture or organic carbon, whereas in the Botanical Garden site the maximum population was recorded in August when the soil moisture and available carbon content were fairly high and other conditions were optimum. The minimum populations were recorded in the polluted plots when the concentrations of the heavy metals were considerably high and were independent of soil factors (at least those considered here) in a specific month of the year as evident from Tables 1,2,3 and 4. This pattern of low population might be due to the fact that the contamination of toxic pollutants like heavy metals with soil produced an adverse effect on the soil fauna. On the contrary the heavy metals did not alter the range of other soil factors like temperature, moisture, pH and organic carbon. The season of maximum and minimum values of these parameters were more or less identical with those of non-polluted plots i.e., maximum during monsoon and minimum during summer.

The types and properties of soils varied from one site to other. This variation and reduction in the amount of heavy metals in different polluted plots in different months might be due to soil's unique and inherent ability of detoxification of pollutants as suggested by Moore and Moore (1976).

Among the edaphic factors studied, temperature showed a marked variation with the change of season ranging between 7.17°C and 34.5°C (Fig.-9). Temperature and moisture being interlinked might exert their effects on the population conjointly (Schubert, 1930). At the Botanical Garden site in summer months the samples yielded minimum population when the temperature was significantly low. Similar results were obtained by Weble (1970), and Hazra (1976).

At the polluted sites the range of soil temperature was considerably low in comparison to the Botanical Garden site, more over at Dum Dum and Beliaghata sites the arthropod populations recorded were maximum when the soil temperature was in the higher range of each of them, whereas at Tollygunge site the maximum population was observed in February when the soil temperature was low. At the polluted sites the prevalence of high amount of moisture in the soil might have resulted into the reduction of soil temperature and the arthropods surviving in such polluted soils might have adapted themselves to exploit the optimum condition of soil for the population growth and this might have resulted into differential seasonal population growth pattern of them at the different sites.

The results of statistical analysis (Tables-15) showed a strong negative correlation of temperature with the total arthropod population at Tollygunge site. This was probably due to the presence of maximum number of low-temperature adapted forms at this particular site. There are collembolans in particular and some forms of this group of microarthropods survived well at low temperature (Paclt, 1956 and Pryor, 1962). A strong negative correlation of temperature with the coleoptera at the Botanical Garden site (Table-38) indicated the possibility of thin presence of high temperature tolerant forms. In other plots and for other dominant groups of arthropods temperature did not show any significant relationship (Tables-17,24,31 and 38). According to Christiansen (1964) the relationship between collembolan population and temperature optima was not clear.

The moisture contents of the soil showed wide range of variation from 14.97% at the Botanical Garden site to 40.00% at the Dum Dum Bagjola Canal site (Fig.-10). The soil misture contents at the polluted sites were a bit more than that at the Botanical Garden site. This was probably due to the soil and the resultant alteration of the water holding capacity of the soil.

Moreover, the lower zones of the polluted sites frequently remaining drenched with sewage water have induced an increase of the mean moisture content of the soil of these sites. In all the sites the total arthropod populations were found to be considerably low in summer months

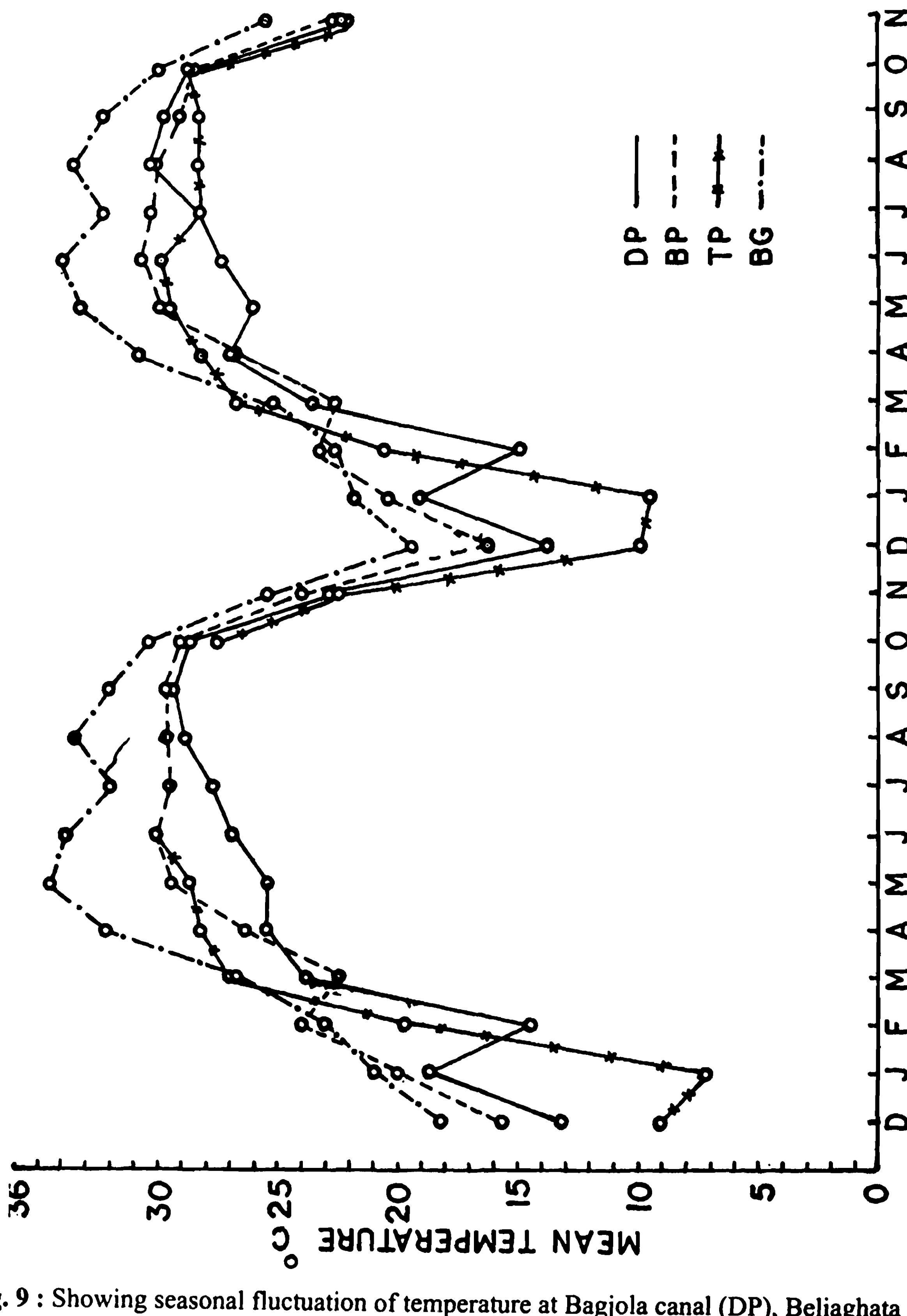



**Fig. 9** : Showing seasonal fluctuation of temperature at Bagjola canal (DP), Beliaghata canal (BP), Tollygunge Nulah (TP) and Botanical Garden (BG) sites.

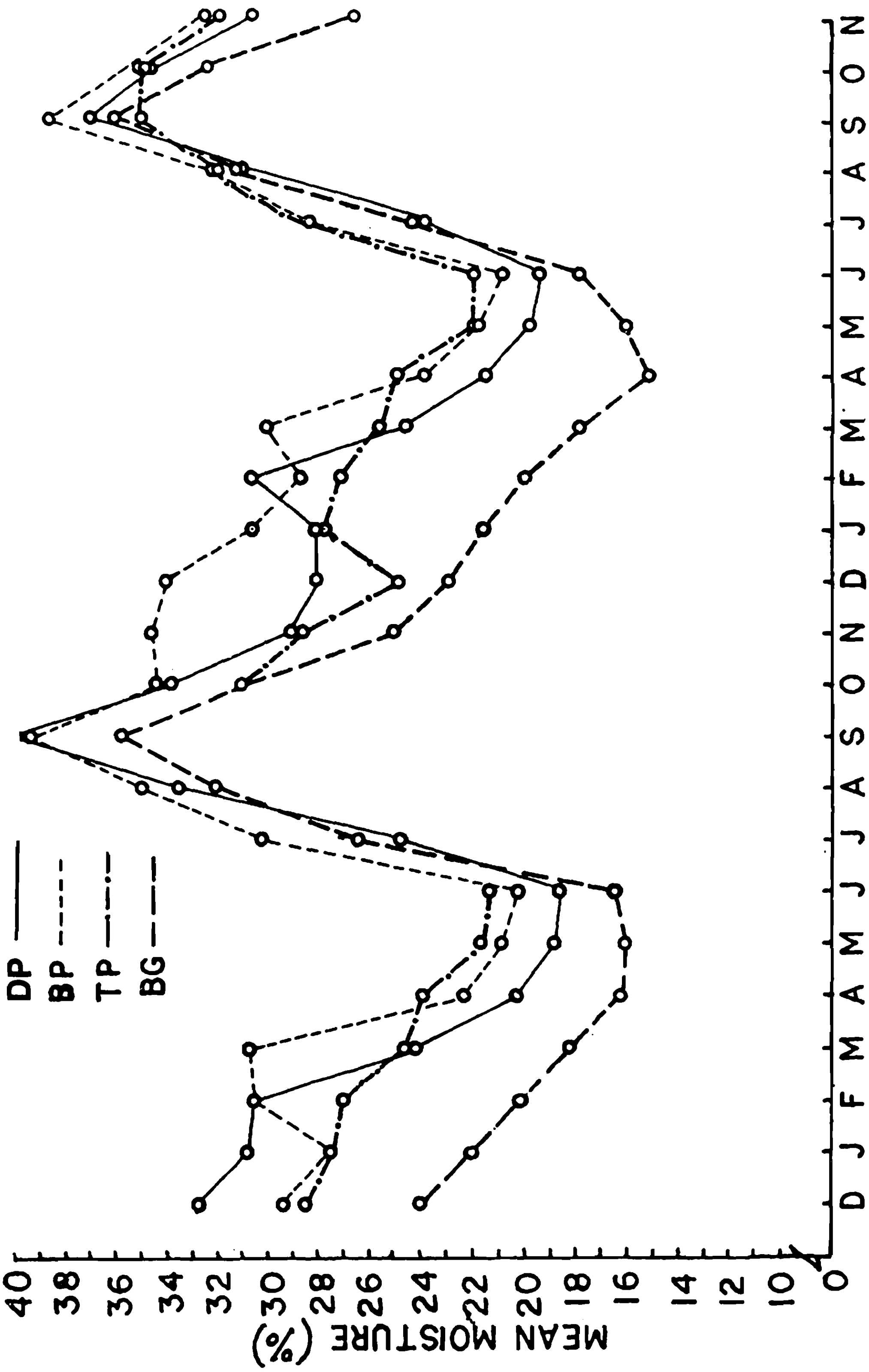



**Fig. 10 :** Showing seasonal fluctuation of soil moisture at Bagjola canal (DP), Beliaghata canal (BP), Tollygunge Nulah (TP) and Botanical Garden (BG) sites.

when the soil moisture contents were minimum, where as in all the sites the arthropod populations were maximum when the soil moisture contents were also maximum. Both at the Botanical Garden site and the Beliaghata Canal site the arthropod populations exhibited a positive significant relationship with soil moisture, while at other two sites (namely Bagjola Canal and Tollygunge Nulah) their relationship were not significant (Tables - 13-16). Both Collembola and Acarina showed positive significant relationship with soil moisture at the Botanical Garden site and also at the Beliaghata Canal site (Tables-25 and 39). At the other sites, however, these two dominant groups of soil arthropods did not show any significant relationship with moisture.

Results of this study showing positive relationship between the moisture content and the arthropod population agreed with those of Agrel (1941), Backlaund (1945), Poole (1961), Christiansen *et at.* (1961), Davis (1963), Choudhuri and Roy (1972) and Singh (1975). Negative relationship of some soil mites with soil moisture were, however, reported by Hammer (1953). In the opinion of Haarlov (1960) the favourable habitats of micro-arthropods were characterised by stable, humid conditions with plant material available all the year round. An increase in the population during monsoon months suggested the probability of the existence of hydrophilic forms, having some preference to moisture condition. Besides the variable capacity of the soil arthropods withstand the drought condition occasionally prevailing in nature might have resulted to varied pattern of population fluctuation at different sites.

The contents of organic carbon varied from 0.48% to 3.02% at the different sites. Figure-11 showed that at Botanical Garden site the organic carbon concentration underwent a regular pattern of fluctuation at different seasons, and that at this plot organic carbon influenced positively the growth of the arthropod population could be justified by the maximum population growth as obtained at the time of highest concentration of organic carbon.

Thus a very significant positive correlation was obtained at this site between the organic carbon and the total arthropod population (Table-16) and also with Collembola and Acarina (Table-41). In fact, it was the density and type of soil vegetation influenced by temperature and moisture augmented the carbon content of the soil, which not only served as a food source but also influenced the volume of space available for living organisms. These results agreed with the findings of earlier workers (Haarlov, 1960; Christiansen *et al.* 1961; Holler-land, 1962; Davis, 1963; Choudhuri and Banerjee, 1975; Singh and Pillai, 1975; Choudhuri *et al.* 1978 and Ghatak and Roy, 1979).

At Dum dum and Beliaghata sites the mean concentration of organic carbon did not undergo much fluctuation (Fig.-11). This indicated perhaps the probability of a steady flow of organic matter into the soil from the sewage source. At Dum dum site the organic carbon did not show any significant relationship either with the total arthropod or with any group of arthropods (Tables-13 and 20), while at the Beliaghata site organic carbon showed a near negative significant

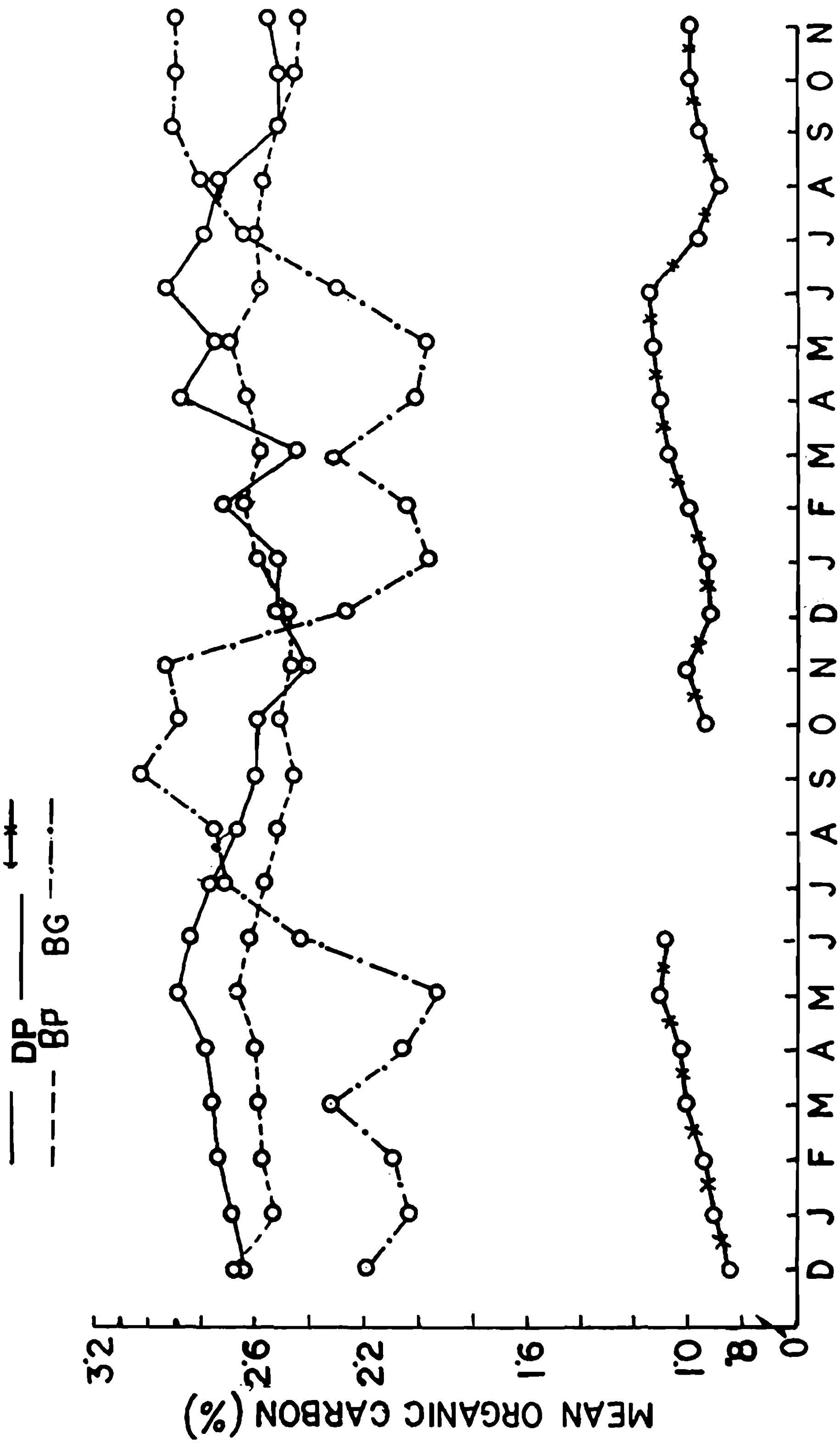



**Fig. 11** : Showing seasonal fluctuation of organic carbon at Tollygunge canal (TP), Botanical Garden (BG), Beliaghata canal (BP) and Bagjola canal (DP) sites.

relationship with the total arthropods and hymenoptera, but a distinct negative relationship with mites (Tables - 14 and 27).

From Figure - 11 it would be evident that at the Tollygunge site organic carbon content was quite low in comparison to other two polluted plots, the reason for this might be attributed to the regular (systematic) inundation of the embankments by the tidal waves and also total inundation of the embankments during monsoon, which caused leaching and removal of the valuable soil organic matter. At this site no significant effect of organic matter was recorded either in respect of the total arthropods or in relation to any particular group (Tables - 15 and 34).

Such a discrete effect of organic carbon on the soil arthropods at the polluted sites might be due to the fact that the presence of heavy metals in these sites probably prevented the soil organisms to exploit the organic matter present in the soil even when their concentration was maximum. When the contents of the heavy metals were low then the pollution tolerant species took the opprotunity to utilise whatever organic matter was present at that time and augmented their populations growth and this eventually resulted into the development of significant relationship or no significant relationship. Thus Choudhuri and Roy (1972) rightly observed that in order to establish a relationship with any edaphic factor the behavioral pattern of each species should be studied in relation to individual factors at the controlled laboratory conditions.

The values of pH of the soil samples varied from 6.78 to 7.75 (Fig.-12). Most of the soil arthropods could tolerate such a range of pH had been well established by Frenzel (1936), and Choudhury and Roy (1972). At the Tollygunge site the mean value of pH (7.36) had a strong positive correlation with the total soil arthropods (Table-15) thus indicating the preference for a weak alkaline environment there. Edwards and Lofty (1975) earlier observed a significant fall in soil animals in the acidic environment. This would be further confirmed by looking at a strong positive correlation of pH with collembola and mites at this site. Hymenoptera, however, exhibited a strong negative relationship (Tables 15 and 33). But at Dum dum site collembola again showed a strong positive relationship with pH (mean value - 6.96, Table-19), thus indicating again tolerance of collembola to a wide range of pH. This corroborated the findings of Edwards and Lofty (1974) according to whom collembola were more tolerant to the change of the soil pH.

For all other plots neither the total arthropods nor the dominant group exhibited any significant relationship with pH. This conformed to the observations of Agrell (1941), Bellinger (1954), Dhillon and Gibson (1962) and Davis (1963). Thus it would be clear from the results of the present study and also from the findings of the previous workers that the direct influence of pH on the soil arthropods was little, but it might have contributed to the fluctuation of population by indirectly influencing vegetation and other physico-chemical properties of the soil.

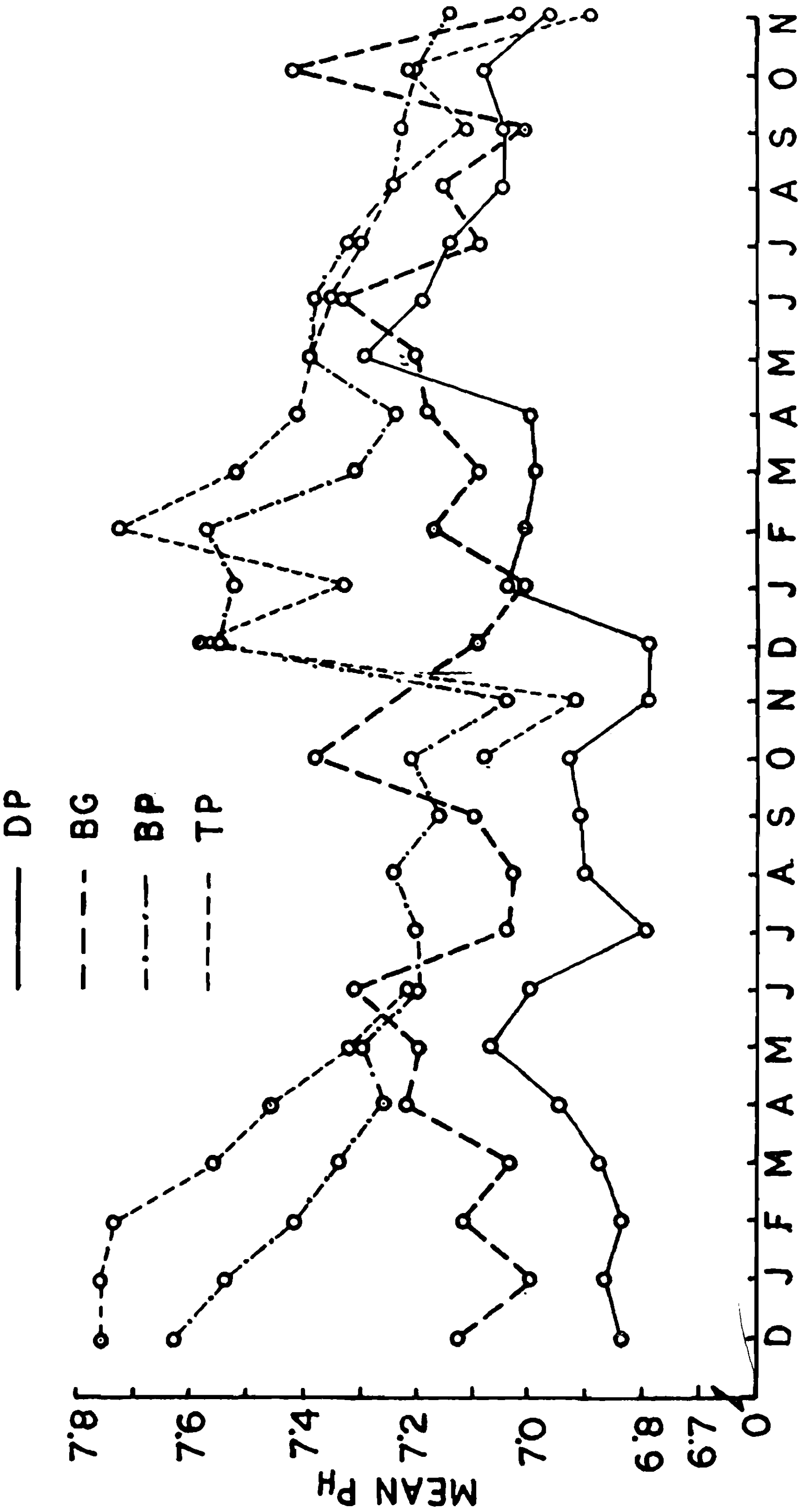



**Fig. 12 :** Showing seasonal fluctuation of pH at Bagjola canal (DP), Botanical garden (BG), Beliaghata canal (BP) and Tollygunge Nulah (TP) sites.

While analysing the impact of heavy metals, it was observed that the concentrations of heavy metals varied at the different sites (Figs.-13 to 15). At the Beliaghata Canal site the levels of all the three heavy metals were quite high, due to regular sewage discharge into the canal, while at the Botanical Garden site the concentrations of the same heavy metals were lowest.

At Dum dum site the level of copper was higher than both chromium and lead, and at Tollygunge site chromium was considerably high in concentration than either copper or lead. Such a variation in the concentrations of heavy metals at different sites might be attributed to the discharge of different types of effluents into the sewage canals at different sites.

It was interesting to note that the population structure of soil arthropods was considerably influenced by some heavy metals. At the Beliaghata site the total population dropped down to a mean value of around 3 per soil sample (Table-2), where the concentrations of all the three heavy metals had a mean value of more than 200 ppm. On the other hand the Botanical Garden site has a maximum mean population of around 30 per sample when the concentration of each such heavy metal was less than 10 ppm (Table-4).

Dum dum and Tollygunge sites, where the maximum concentration of heavy metals never exceed 100 ppm, had a population density more than that of Beliaghata site but less than that of Botanical Garden site. Thus the heavy metals either singly or conjointly produced deletarious effect directly or indirectly on the population growth. This corroborated the findings of Bhattacharya and Bhattacharya (1981) according whom not only the number of the species but also species diversity decreased considerably in the polluted area. Similar observations were also made by Vanek (1967), Gorny (1975), Petal *et al.* (1975), Petal (1978) and Bhattacharya et al. (1980). and Hagvar and Abrahamsen (1990).

The results of statistical analyses (Tables- 13-16) showed that at all the polluted sites the heavy metals bore a significant negative correlation with the total arthropod population whereas at the Botanical Garden site the relationship was not significant.

The content of copper at the Beliaghata site was maximum, while the lowest concentration of copper was recorded at the Botanical Garden site (Fig-13). In all the three polluted sites the maximum populations of total arthropods were recorded when the concentrations of copper was low, and the minumum populations were obtained when the levels of copper were quite high. When the dominant arthropod groups were considered separately it was noticed that in all the plots acarines, collembolans and other dominant forms had a low density and abundance imporved only when the level of copper decreased.

The results of statistical analyses revealed (Tables-28 and 35) that at the Tollygunge site collembola and coleoptera and at the Beliaghata site acarina and collembola were negatively correlated with copper.

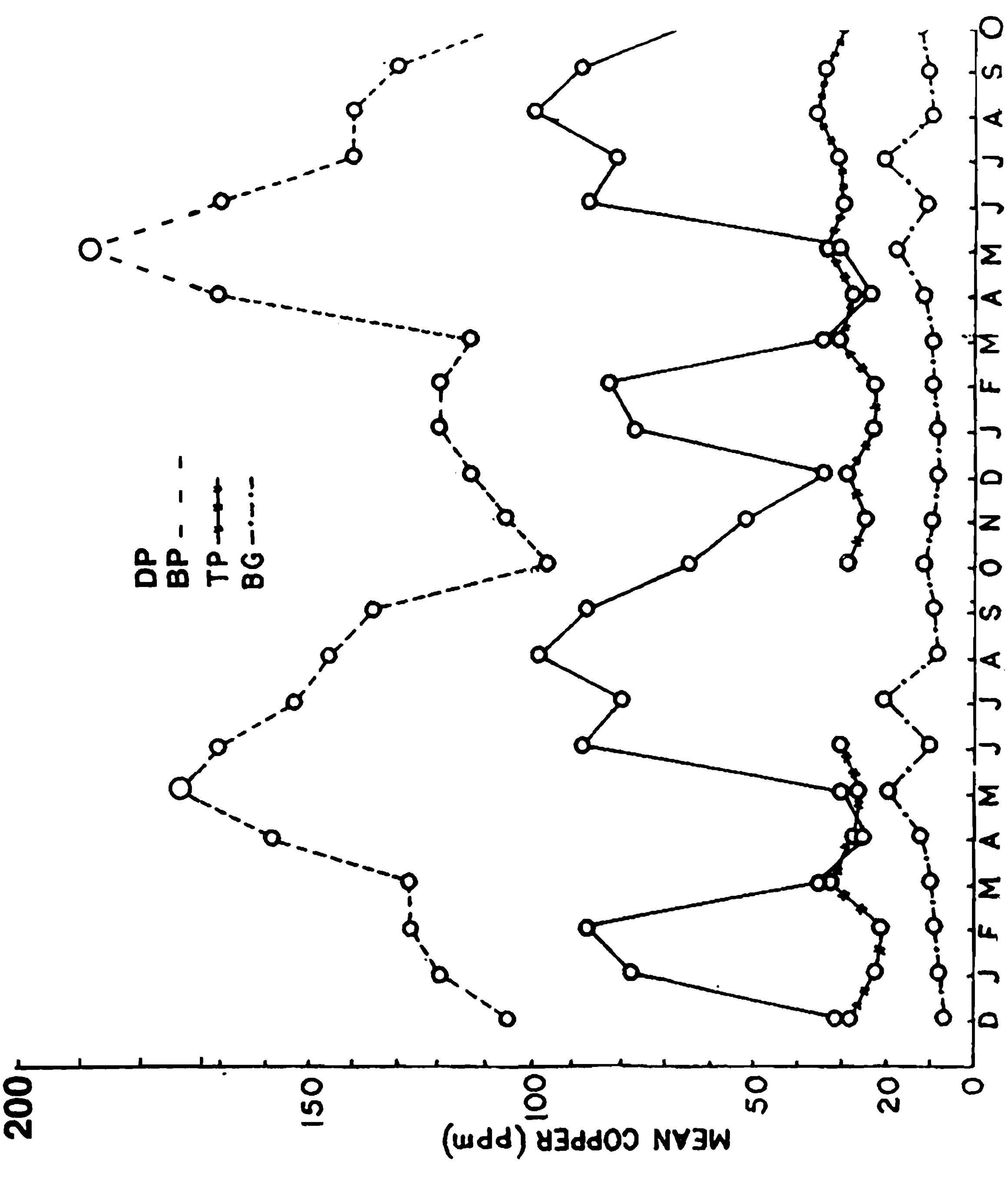



**Fig. 13 :** Showing seasonal fluctuation of copper at Botanical Garden (BG), Tollygunge Nulah (TP), Bagjola canal (DP) and Beliaghata canal (BP) sites.

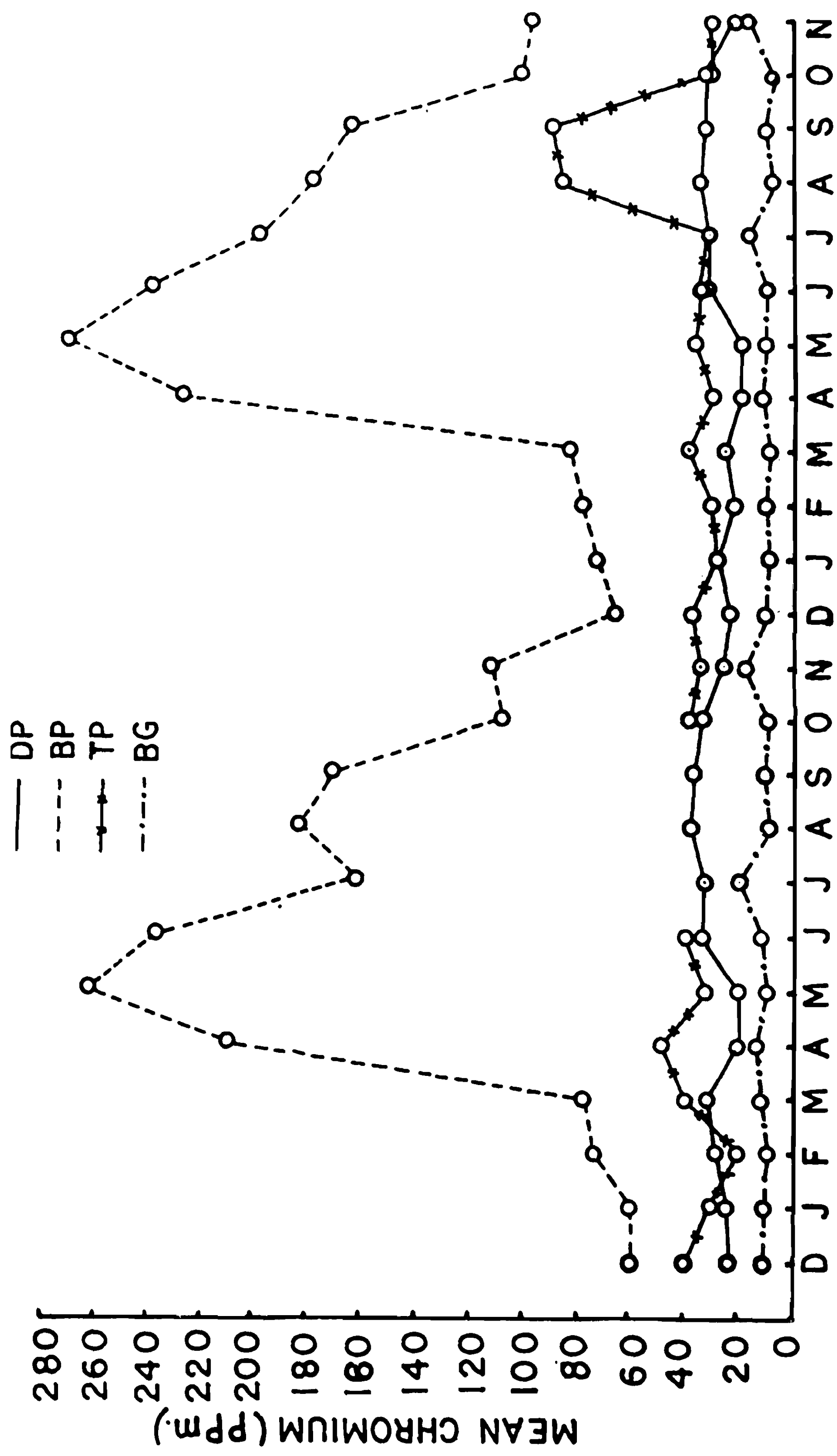



**Fig. 14** : Showing seasonal fluctuation of chromium at Botanical Garden (BG), Bagjola canal (DP), Tollygunge Nulah (TP) and Beliaghata canal (BP) sites.

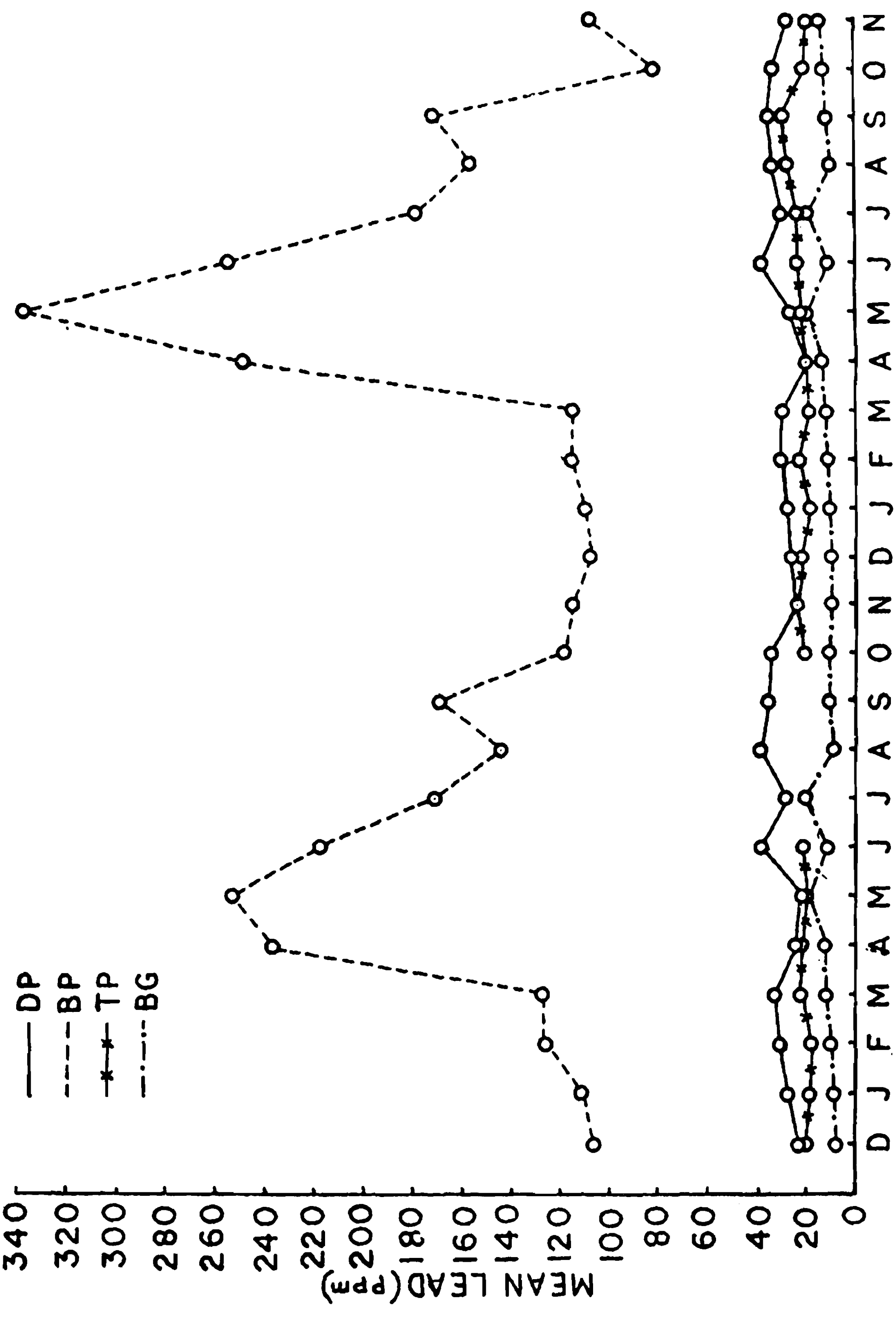



**Fig. 15 :** Showing seasonal fluctuation of lead at Botanical Garden (BG), Tollygunge Nulah (TP) Bagjola canal (DP) and Beliaghata canal (BP) sites.

The content of chromium was maximum at the Beliaghata Canal site followed by Tollygunge Canal and Dum dum, while its concentration was minimum at the Botanical Garden site (Fig.-14). Like copper, chromium also was in high concentration when the total arthropod population was minimum at all the polluted plots, while the maximum population was obtained when the chromium concentration was low. So far the effect of chromium on individual dominant arthropod group was concerned, in most of the cases it was observed that collembola, acarina and other dominant groups had their maximum populations when the level of chromium was low.

The results of statistical analyses indicated (Table-29) that only at the Beliaghata site chromium had a negative significant relationship with collembola, but for other dominant groups and at other sites no significant relationship (positive or negative) could be established (Tables-22, 36 and 43).

Lead was found to have a concentration of as high as 337 ppm at the Beliaghata site (Fig-15), while at Dum Dum and Tollygunge sites it had a concentration range of 15-40 ppm, and at Botanical Garden site it's level was still lower. Most of the dominant arthropod groups showed their respective population mixima at a time when the concentration of lead in soil was low, and the results were reversed when the concentration of lead was high.

The results of statistical analyses showed that collembola had a significant negative correlation with lead both at the Dum dum site and Beliaghata Canal site. A significant negative correlation was also found with acarina at the Beliaghata Canal site, and interestingly a significant positive correlation with hymenoptera was witnessed at the Tollygunge site. However, at the Botanical Garden site and at the other sampling sites, other groups of dominant arthropods did not show any significant relationship (Tables-23, 30, 37 and 44).

From the above discussion in would be evident that the prevalence of heavy metals in soil did create and adverse impact on the population structure of the soil arthropods. Whether they acted singly or conjointly was a matter of conjecture. The concentrations of dirrerent heavy metals at the different sites varied and consequently the growth of arthropod population was also different. However, this study revealed that collembola as a group suffered more than acarina in the polluted plots as evidenced in the negative significant correlationship of collembola with the heavy metals at many sites.

Besides these two predominant groups, the forms belonging to coleoptera and diptera suffered to some extent; while hymenoptera only once exhibited strong positive correlation with lead.

Form the present investigation it might be assumed that the susceptibility of collembola to the exposure of high concentration of heavy metals was more than any other arthropod group. the greater susceptibility of collembola to pollution has also been earlier observed by Aoki and Kuriki (1980), Tadros (1980), Bengtsson et. at. (1983) and Joosse and Verhoef(1983)

It was also certain that the tolerance of acarina was more than collembola and the arthropod group like hymenoptera contained certain forms which flourished better in a such polluted environment. Aoki and Kuriki (1980), Tadros (1980) and Bhattacharya and Bhattacharya (1981), reported that mites could thrive better in polluted environment.

Several workers like Karg (1962), Edwards (1969), Edwards and Lofty (1969), Imhoff *et al.* (1971), Dindal *et al.* (1975), Van-rhee (1975) and Posthuma and straalen (1993) were of the view that pollutants (heavy metals or other industrial pollutants) exerted considerable negative effects on the soil arthropods and these negative effects caused reduction in the species diversity of the arthropod population. Only those species which possesed high tolerance level could survive in such extreme soil conditions.

Gorny (1976) found certain forms of ants that thrived better in soils polluted with the industrial effluents. That the sewage pollution could disturb the structure and function of soil organisms was consistent with the findings of Dindal *et al.* (1977) Hazra *et. al.* (1999). Mitchel (1978) observed less amount of mites and collembola found in soils ammended with sewage sludge; the present study agreed with the observation of Mitchel.

According to Ireland (1975); CAST (1976); Getz, *et al.* (1977); Andersen (1979); Hartenstein *et al.* (1981); Jaggy and Streit (1982); Streit and Jaggy (1983) and Hazra and Chattopadhyay (1985) and Hopkins (1989), the heavy metals like lead and copper could interfere with and accumulate in the body of the soil organisms. In the opinion of Andersen (1980) the heavy metals could affect the reproduction of soil organisms.

In the opinion of Williamson and Evans (1973), Joose and Bucker (1979) high concentration of lead exerted little effect on the litter-dwelling collembolans: Mitchel *et al.* (1978) observed ten times richer population of collembola than acarina in polluted area. According to Huhuta, *et al.* (1977 and 1980) collembola propagated in soils ammended with sewage sludge much faster. The findings of Petal *et al.* (1975) and Petal (1978) that the industrial pollution decreased the richness and species diversity of ant community considerably contradicted the results of the present study.

It would be perhaps clear from the above account that soil represented a very complex habitat having its various factorial components interwined with each other in such a manner that it would be difficult to consider their effects separately. It might be inferred that the factorial components not considered in this study collectively contributed to the population fluctuation and the distribution pattern of soil arthropods in the tropical climate of West Bentgal.

Choudhuri and Roy (1972) rightly pointed out that any attempt to unravel the interactions between edaphic factors and collembolan population would be abortive unless the behaviour of individual species in relation to each factor was studied separately under controlled condition in the laboratory.

This contention perhaps could be justified by taking into account the results obtained here. The results of this study corroborated mostly the findings of earlier workers, but in certain aspects they showed striking differences from those reported earlier. The descrepancies so observed might be due to the prevalance of local environmental factors which were likely to exert profound influences on the pattern of population structure (Wallwork, 1970).

To have an insight as to the influence of each factorial component of the soil sub-system (Polluted or unpolluted) on the population of soil fauna it would be necessary to take up more extensive studies upto the species level.

## SUMMARY

The results of the present study are summerised as follows :-

1. The investigation contained the results of an ecological study involving the effects of various soil factors and three heavy metals, on soil inhabiting arthropod population from both polluted (Bagjola Canal, Dumdum, Beliaghata Canal and Tollygunge Nulah) and non-polluted (Shibpur Botanical Garden) sites in and around Calcutta.

2. Soil factors considered in this study were temperature, moisture, hydrogen-ion-concentration, organic carbon and the heavy metals namely copper, chromium and lead, all of which were found to vary in defferent sites and in different seasons.

3. A total of 2240 soil samples were collected from all the plots at monthly interval over a period of 24 months.

4. Several groups of arthropods namely acarina., collembola, diptera and maggots, hymenoptera and nymphs, coleoptera, thysanoptera, hemiptera, psocoptera, diplura, portura, pseudoscorpion, crustacea, diplura, portura, crustacea, araneida were recorded from the soil samples, of which only acarina, collembola, diptera, coleoptera and hymenoptera were universally present, though their density and mode of population fluctuation varied in different sites.

5. The density of total arthropod population was found to be maximum in the non-polluted plot than the polluted ones. The same was true for the dominant arthropod groups, though some forms like hymenoptera and diptera showed a little affinity towards the polluted soil.

6. Though monsoon maxima and summer minima were observed while studying the population fluctuation of total arthropods at the non-polluted site, the fluctuation pattern varied considerably in different polluted sites. In case of the dominant arthropod groups the pattern of population fluctuation was also found to have shifted in different polluted plots from the general pattern as observed in the non-polluted sites.

7. In all the plots the soil arthropods were found to occupy mostly the upper (0-5 cms.) layer of the soil.

8. Ecological parameters like temperature, moisture, pH and organic carbon were observed to be more or less similar both in the non-polluted and the polluted sites. But the heavy metals varied widely in their concentrations from site to site, being minimum in the non-polluted plot. The Beliaghata Canal site registered a maximum concentration of heavy metals followed by Bagjola Canal and Tollygunge Canal sites.

9. Statistical analyses indicated significant negative relationship of heavy metals with the total arthropod population in all the three polluted sites, but no significance could be recorded in the relationship of heavy metals and the total arthropods at the non-polluted site. Moisture and organic carbon showed significant positive relationship with the total arthropods at the non-polluted site while it was not so in the polluted sites, except at Beliaghata Canal. Many of the dominant arthropod groups exhibited strong negative relationships with some of the heavy metals at different polluted sites, while collembola and acarina showed significant positive relationships with moisture and organic carbon at the non-polluted site. Temperature was found to have a significant positive relationship with most of the heavy metals in all the plots. The inter heavy metal relationships were always observed to have significant positive relations.

10. The possibility of the role of heavy metals to preclude the arthropods in utilizing the optimum soil temperature, moisture and organic carbon, by creating a kind of physiological imblalnce was also discussed.

11. The possibility of greater susceptibility of the collembolans among all the arthropod groups was suggested.

12. The need of further study involving the species of the dominant groups like collembola and acarina was also stressed.

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