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Vertical Distribution and Seasonal Variation of Mesofauna In Polluted and Non-Polluted Sites Of Nagpur In Central India

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Abstract
The vertical distribution and seasonal variation of soil microarthropods extracted from the soil and litter from polluted site and non polluted site were investigated. The soil fauna were collected monthly for a period of one year, April, 2016- March 2017 from both sites. Samples were drawn monthly from each site at different depths i.e. 0-5cm, 5-10 cm, and 10-15cm. Extraction of soil microarthropods were carried out by 'Expedition Funnel Apparatus' modified by Macfadyen. The arthropods fauna obtained in this study belonged to different groups Acarina, Collembola, Diptera and their maggots, Hemiptera and their nymphs, Hymenoptera, Psocoptera , Araneida and Crustacea. Acarina and Collembola were dominant and predominant order of total arthropods population collected for vertical distribution study. The minimum numbers were recorded from lower most layers (10-15 cm. depth) in each site. The vertical distribution study revealed that in almost all cases the soil arthropod population was significantly in the uppermost layer (0-5 cms.). Species richness of mites and collembolans were significantly higher in the rainy season. Mite and Collembolan population were negatively correlated with depth. Probable reasons for data obtained are discussed; results are compared to those from other investigations.
Keywords: vertical distribution, soil microarthropods, Acarina and Collembola

Introduction

Power generating units are mega project, which require not only huge capital investment but also various natural resources like, fossil fuels and water thus create an immeasurable & everlasting impact on the environment and generate tremendous stress in the local eco-system in spite of stringent government norms to control and mitigate the damages to the environment by the power plants.

The species composition and vertical distribution of the soil fauna are influenced by the geographical location, climate, physical and chemical properties of the soil, type of vegetative cover, nature and depth of the litter and humus, and a variety of other environmental factors. Thus, the fauna of the soil may vary considerably from one locality to another. Vertical distribution patterns of most components of the soil fauna, however, are poorly known.

The problem of the effect of contaminated effluent of thermal plant on the soil organisms receive due attention of the scientists in some countries recently. In India, however, no such attempts have yet been made, to assess the impact of effluent on soil arthropods.

These apartment lacunae prompted to start the present investigation in order to have more or less comprehensive picture on soil and soil mesofauna in relation to their association with the edaphic factors.

Materials and Methods

Study Area

The experiment was conducted in Polluted site, sewage canal is situated near Koradi Thermal Power Station of Maharashtra (Fig. 1), at the geographic coordinate of 21°32'9"N latitude and 80°17'8"E longitudes and non- polluted site, Gorewada Reservoir in Nagpur District of Maharashtra (Fig. 2), situated at the geographic coordinate of 21°11' N latitude and 79°2' E longitudes.

Collection of soil

Soils Samples were collected at random from both polluted and non polluted site for a period of one year at the rate of three samples per plot from April to March during (2016-17). Samples collected by using soil corer (inner cross sectional area 5sq/cm, height 12 cm) from a depth of 5 cm. Representative composite samples for each site were prepared by homogenizing the replicates in sampling bags. The soil samples were dried in shed and ground gently after keeping some peds for bulk density and other analysis using wooden mortar and pestle and passed through 2 mm sieve. The soil was thoroughly mixed in order to obtain a representative soil and was stored at room temperature until further experimentation. Separate sample units were taken from each site for the soil mesofauna and estimations of soil parameters. The soil samples thus collected were kept immediately in sterile polythene packet.

Physico-chemical and nutrients analysis of soils

Sr. No.	Parameters	Method
1.	Bulk density	Piper, (1950)
2.	Water holding capacity and porosity of soil	Keen-Rogenczkowski Box method described by Piper, (1950)
3.	Determination of Soil pH	Loeppert and Suarez, (1996)
4.	Electrical Conductivity (Total salts) of soil	Loeppert and Suarez, (1996)
5.	Moisture content	Oven dry method described by Piper, (1950)
6.	Cation exchange capacity (CEC)	Ammonium acetate (NH4OAc) method described by Burt, (2004)
7.	Organic carbon	Walkley and Black rapid titration method described by Jackson, (1973)
8.	Determination of Total Nitrogen (N)	Kjeldahl digestion and distillation method described by Black *et al.*, (1965)
9.	Total phosphorous & potassium	Ammonium vanadomolybdate as described by Black *et al.*, (1965)
10.	Determination of Carbonate and Bicarbonates	Burt, (2004)
11.	Determination of Calcium and Magnesium	Versenate (EDTA) method described by Burt, (2004)

Collection and Identification of soil microarthropods

The soil fauna were collected for a period of one year, April, 2016- March, 2017 from both the sites [3 sites X triplicate = 9 samples). The soil samples were made free from macro fauna (i.e. earth worms, archinids, macro arthropods etc. were sieved out with the help of 2 mm sieve). This mesofauna rich soil sample was placed in a plastic bag, labelled and taken to the laboratory for analyses; a 3 stage process (extraction, sorting, and identification). Extraction of soil samples were carried out by ' Expedition Funnel Apparatus' modified by Macfadyen (1953). From the extracted soil mesofauna all the Acarina and Collembola were sorted and deposited in 70% alcohol bottles. After this, the Acarina and Collembola were poured into petri dishes, and examined under the stereomicroscope using pipettes and needles. The identification of Collembola was followed to family level after Choudhuri (1963), Mitra (1967), Prabhoo (1971) & Hazra (1995) and the Acarina was followed to suborder level after Krantz and Walter (2009).

Results

I. Polluted site: Koradi Thermal Power Station (Nagpur)

(a) Edaphic factors: Soil pH ranged from 6.78 to 7.06. In the month of May, the values of temperature, pH and organic carbon were maximum 45.42±2.59 °C , 7.06±0.23 and 2.88% respectively. While other soil factor i.e. moisture was maximum in the month of September (40.00 ± 2.93%). The values of temperature, moisture, pH and organic carbon in this month are shown in Table - 1.

(b) Faunal makeup: It is evident from the Fig. -3 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 28.0±6.96. The population dropped down to minimum during August, the mean value and S.E. of 4.83±0.31, after which it gradually increased and in September it suddenly spurted up to 16.50±9.53.Final analysis indicated the presence of ten groups of arthropods, diptera and their maggot, hymenoptera, coleopetera ,psocopter , hemiptera with their nymphs, thysanoptera , aranedia *etc.* In this plot acarina had predominated by attaining 32.98% of the total population (Fig. - 3). Collembola came second having a population of 16.47 %. Diptera and their mggots (13.50%), Hymenoptera (8.56%) and Coleopteran (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- arthropods organisms were also present which remained unidentified (categorized as "other") and constituted 11.0% of the total population (Fig. - 3).

(c) Seasonal variation in the population of dominant arthropods: Acarines exhibited two annual peak , one in March and 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 acrine population fluctuated irregularly (Fig. 5).

In case of Diptera, April and July exhibited two annual peaks. Collembola, Hymenoptera and Coleoptera showed a single annual peak in the months of April.

(d) Vertical Distribution: The depth wise monthly mean population per sample of five major groups of arthropods collected, namely, acarina, collembolan, diptera, hymenoptera and coleoptera are given in table – 3. Beside the coleopterans (.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 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 o grubs were found in April of the initial year in a particular sample in 5-10 cm layer, which contributed largely to the increases in the population density in the lower layer. Similarly, in case of diptera, the maggots were found in the aggregated in the sample representing the lower layer (5-10 cm) in months of April and July of the year and April in the second year which might have caused the variation in respect of population of density of dipetra in both upper and lower layer.

II. Unpolluted site: Gorewada Reservoir (Nagpur)

(a) Edaphic factors: Soil pH varied from 6.99 to 7.21. The maximum temperature of soil was recorded in the month of May (44.00±2.45 °C) and minimum temperature in the month of January was (6.99±0.09°C). Soil moisture content least recorded in the month of May (16.02 ± 1.59%) and maximum in the month of September (35.78 ± 2.36%) in the site. During the investigation period, total organic carbon was recorded in which the higher value (3.02 ±0.07%) was recorded in the month of September and the minimum in May (1.93 ±0.05%). The corresponding values of temperature, moisture, pH and organic carbon are shown in Table - 2.

(b) Faunal makeup: The total arthropods population (Fig. – 4) was found to be maximum in the month of August while the minimum population in the month of May. The histogram of the total population showed a single annual peak in august and minimum in May (Fig. 6)

On faunal analyses several groups of arthropods were found (Fig. – 4). Acarina by constituting 48.08% of the total population 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 groups, while dipteral along with their maggots occupied the fourth position by virtue of comprising 4.60 of total population. In this respect coleopteran was found to be a 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- arthropods soil inmates as “others” were recorded and they together constituted 1.36% of the total population.

(c) Seasonal variation in the population of dominant arthropods: Here both acarines and collembolans exhibited similar trend of population fluctuation. The population reached peak during August (monsoon) and a semi-peak population was seen during November – December i.e., in Winter. In case of hymenoptera the trend of fluctuation was very much irregular, but the monsoon peaks prominent. Coleoptera also exhibited two annual peak, one in winter (December) while other in monsoon.

(d) Vertical Distribution: The Table 4 indicated the monthly mean population per sample of five dominants (major) arthropods groups collected from the soil. In all the groups the population were more concentrated in the upper layer (0- 5 cm) than in the lower (5- 10cm). In most of the year the arthropod population showed greater affinity the top soil than the lower depth of the soil.

Table 1: Showing mean values per sample along with S.E. of the different soil factors and arthropod population, per month, at Koradi Thermal Power Station (Nagpur)

Month	Arthropod Population Mean±SE	Temperature (°C)	Moisture (%)	pH	Organic carbon (%)
January	7.17±3.82	18.58±0.37	32.70±4.74	6.86±0.13	2.68±0.18
February	8.17±4.09	14.33±0.37	30.75±3.37	6.83±0.31	2.73±0.13
March	13.50±8.21	23.83±0.40	30.50±1.98	6.87±0.23	2.78±0.15
April	28.00±6.96	35.50±0.17	24.17±1.28	6.94±0.24	2.84±0.14
May	15.00±5.29	45.42±0.59	20.15±1.24	7.06±0.22	2.88±0.14
June	5.17±1.25	40.00±0.33	18.77±1.24	6.99±0.21	2.77±0.14
July	9.33±1.19	30.67±0.54	18.62±3.05	6.78±0.24	2.67±0.13
August	4.83±0.31	28.83±0.52	25.82±4.83	6.89±0.13	2.60±0.12
September	16.50±9.53	29.33±0.56	33.67±2.93	6.90±0.20	2.59±0.13
October	11.83±5.32	28.58±0.60	40.00±2.92	6.92±0.25	2.41±0.14
November	13.33±3.07	22.83±0.46	33.75±2.17	6.78±0.24	2.52±0.13
December	13.83±2.09	13.67±0.42	28.07±3.50	6.78±0.24	2.63±0.12

Table 2: Showing mean values per sample along with S.E. of the different soil factors and arthropod population, per month, at Gorewada Reservoir(Nagpur)

Month	Arthropod Population Mean±SE	Temperature (°C)	Moisture (%)	pH	Organic carbon (%)
January	13.83±3.25	15.58±0.37	22.22±2.39	6.99±00.09	2.12±0.09
February	12. 83±3.70	17.33±0.37	20.13±2.33	7.11±0.06	2.09±0.05
March	11.85±3.96	22.83±0.40	18.23±1.93	7.03±0.08	2.32±0.05
April	9.00±1.75	36.50±0.17	16.21±1.69	7.21±0.04	2.05±0.07
May	7.50±1.95	44.33±0.36	16.19±1.45	7.19±0.04	1.93±0.05
June	8.67±2.26	40.00±0.33	26.42±1.59	7.30±0.03	2.43±0.05
July	29.83±6.73	30.67±0.54	32.03±2.27	7.03±0.07	2.71±0.04
August	32.67±6.49	28.83±0.52	35.78±2.36	7.02±0.06	2.75±0.06
September	27.00±6.45	29.33±0.56	30.09±1.18	7.09±0.08	3.02±0.07
October	22.50±4.66	29.58±0.60	25.37±1.64	7.37±0.64	2.88±0.06
November	23. 00±5.05	22.83±0.46	22.01±2.07	7.01±0.07	2.93±0.05
December	18.17±5.25	14.67±0.42	22.08±1.45	7.08±0.05	2.27±0.14

Table 3. Showing vertical distribution of the dominant groups of arthropods at Nanda Talav (Koradi) in mean number/sample

	Collembola		**Acarina**		**Diptera**		**Coleoptera**		**Hymenoptera**	
Depth (c.m.)	**0- 5**	**5-10**	**0-5**	**5-10**	**0-5**	**5-10**	**0-5**	**5-10**	**0-5**	**5-10**
Months										
April	3.00	-	9.33	2.33	-	3.00	-	3.67	3.33	8.00
May	1.67	1.33	4.33	1.00	1.00	0.33	0.33	0.33	1.00	0.33
June	1.33	1.00	3.33	0.67	0.67	-	-	0.33	1.00	0.33
July	3.00	0.33	3.00	3.33	2.00	2.00	2.00	-	1.33	0.33
August	1.67	-	2.33	1.67	0.33	1.33	0.33	0.67	1.00	0.33
September	1.33	-	2.00	2.00	1.00	0.67	0.67	-	2.33	0.67
0ctober	2.33	-	1.67	-	3.00	1.67	1.00	0.67	0.33	-
November	2.00	1.33	3.67	3.00	1.00	0.67	0.67	1.33	2.33	-
December	-	1.00	1.00	2.67	1.00	1.67	0.33	1.00	-	0.33
January	1.67	1.33	9.67	1.67	0.33	0.67	0.67	-	0..33	0.67
February	1.67	-	7.33	0.33	0.33	0.67	-	-	1.33	-
March	1.33	1.00	16.00	2.33	1.00	0.33	-	-	-	0.67

Table 4. Showing vertical distribution of the dominant groups of arthropods at Gorewada Reservoir (Nagpur) in mean number/sample

	Collembola		**Acarina**		**Diptera**		**Coleoptera**		**Hymenoptera**	
Depth(c.m.)	**0- 5**	**5-10**	**0-5**	**5-10**	**0-5**	**5-10**	**0-5**	**5-10**	**0-5**	**5-10**
Months										
April	6.67	1.00	7.33	1.67	1.33	0.33	0.67	0.67	1.67	-
May	3.33	1.00	4.33	1.67	0.33	0.33	1.00	0.33	-	3..33
June	3.00	0.67	3.33	1.33	0.67	0.67	-	0.33	1.33	-
July	4.67	1.00	3.00	1.67	1.00	0.67	0.67	0.33	1.33	0.33
August	11.3	7.00	17.00	21.67	1.00	0.33	2.00	0.33	2.67	2.33
September	13.33	12.33	20.67	13.00	0.67	1.33	-	1.00	1.67	-
0ctober	9.67	9.33	15.67	9.67	0.67	1.00	1.00	0.33	0.67	0.67
November	10.33	4.00	12.67	7.67	2.33	-	0.67	0.33	2.67	1.00
December	9.00	3.00	14.00	4.67	2.33	1.00	2.00	0.67	2.67	1.00
January	4.67	4.00	7.00	3.33	0.67	0.67	2.00	0.32	1.00	2.00
February	5.00	1.67	9.67	2.67	1.00	0.33	1.33	1.00	1.33	-
March	8.67	2.00	13.67	4.33	1.33	-.	-	2.00	3.00	0.33

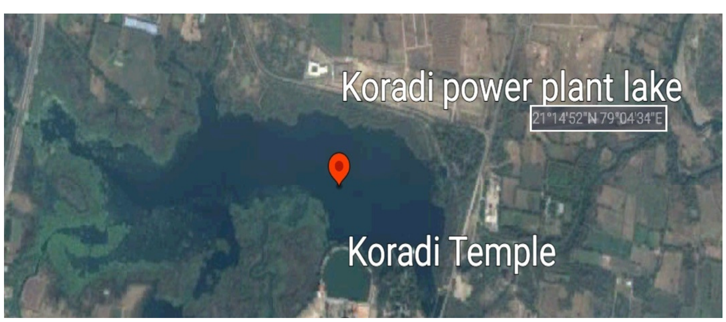

Fig.1: A satellite view of Nanda Talav near Koradi Power Plant at Koradi in Nagpur district of Maharsahtra

Fig.2: A satellite view of Gorewada Lake in Nagpur district of Maharsahtra

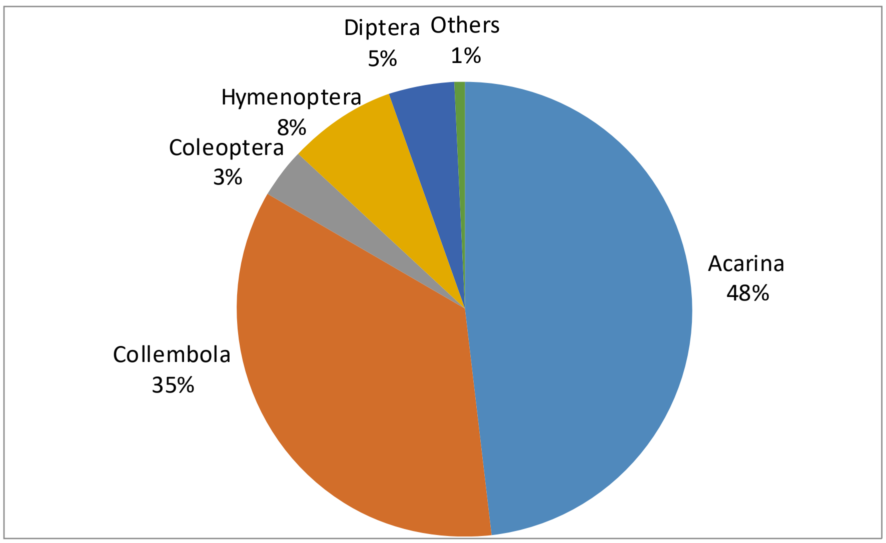

Fig 3. Pie Chart showing of individual groups of arthropods population in percentage, at Koradi Thermal Power Station (Nagpur)

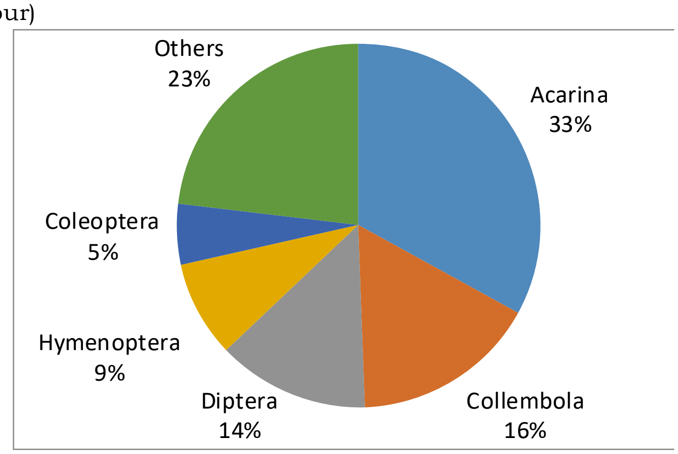

Fig 4. Pie Chart Showing individual groups of arthropods population in percentage, at Gorewada Reservoir (Nagpur)

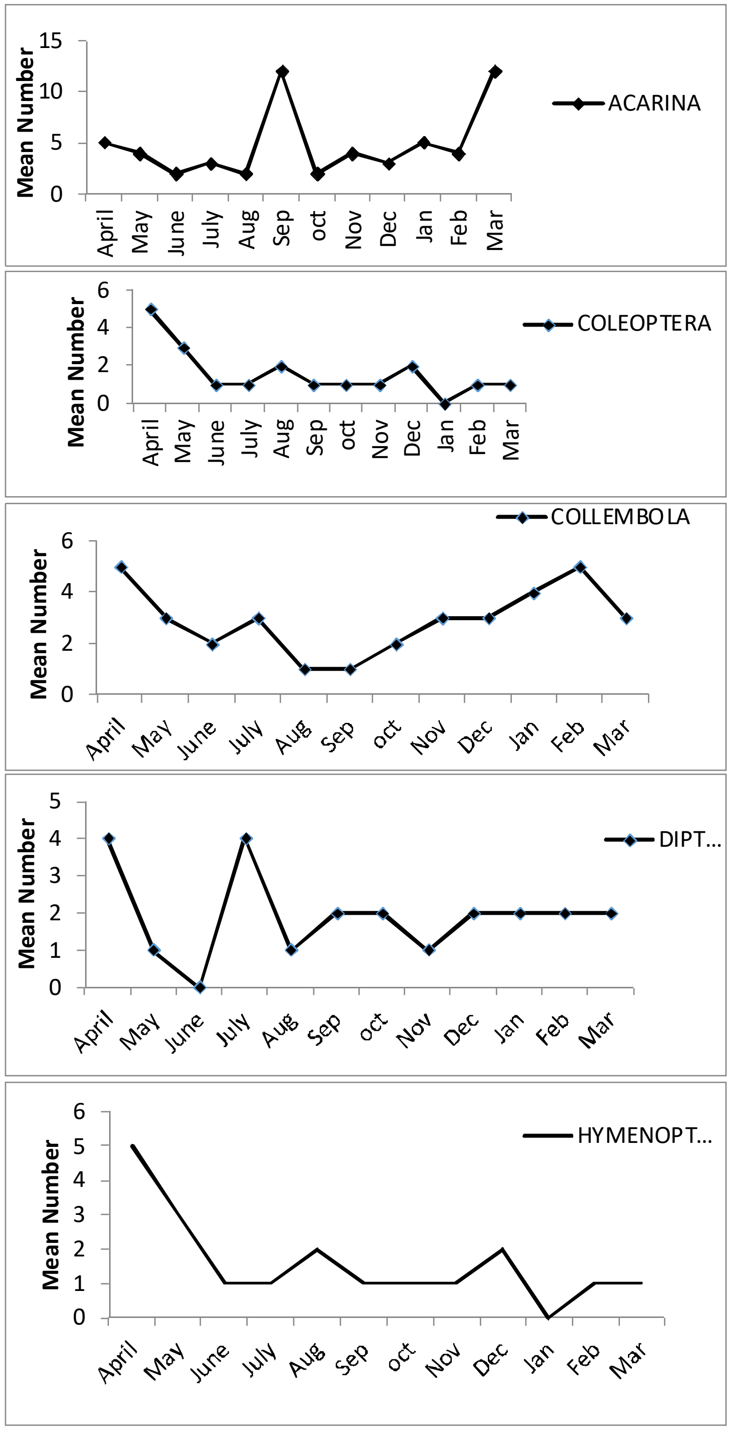

Fig 5. Showing seasonal fluctuation of dominant arthropods groups at Koradi Thermal Power Station (Nagpur)

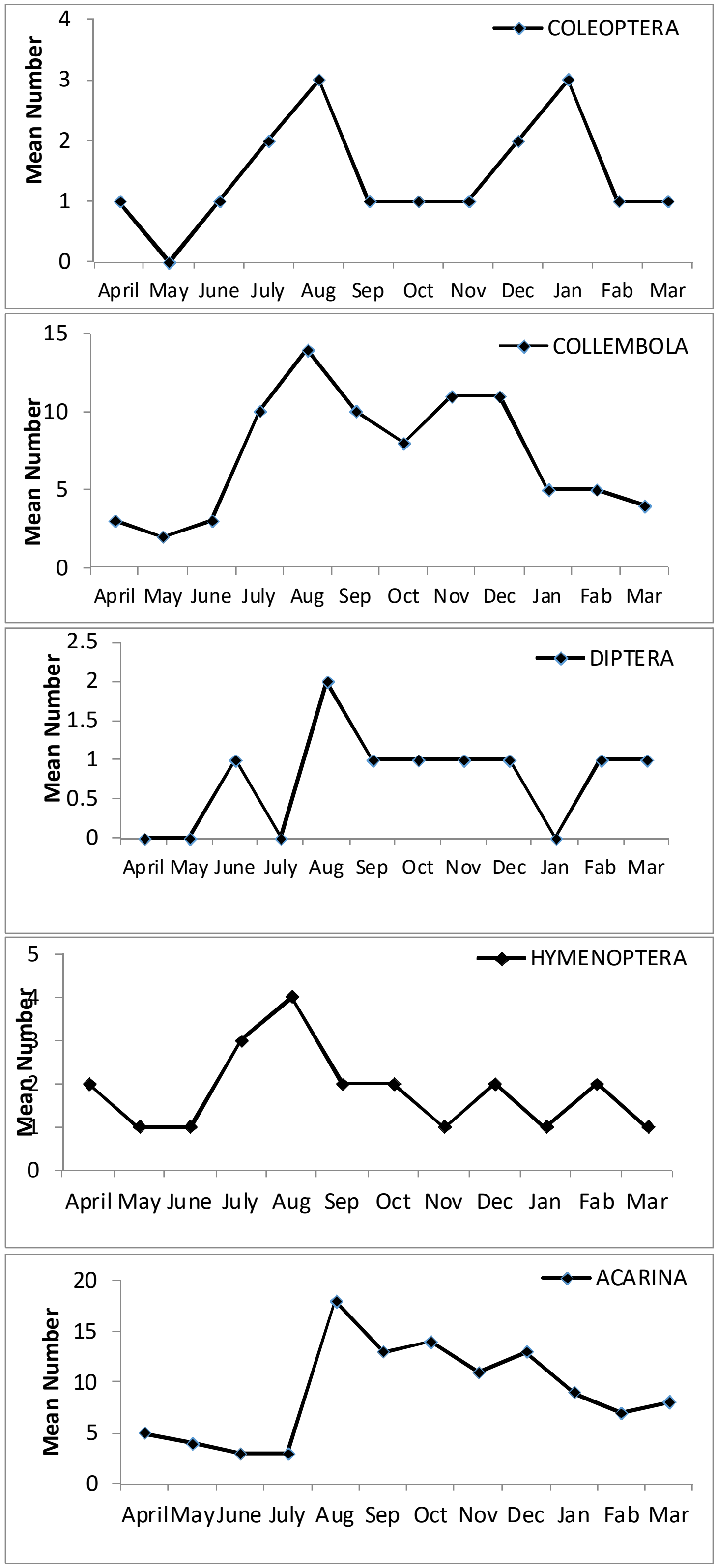

Fig 6. Showing seasonal fluctuation of dominant arthropods groups at Gorewada Reservoir (Nagpur)

Discussion

The arthropods fauna obtained in this study belonged to different groups (Acarina, Collembola, Diptera and their maggots, Hemiptera and their nymphs, Hymenoptera, Psocoptera , Araneida and Crustacea). Some of them differed in their abundance from one site to other (Figs. – 3 and 4). Again, the number of individuals in a group also varied from plot to plot of the sampling sites; maximum being obtained from the non polluted Gorewada Wildlife Rescue Center (Fig. 4).

The arthropods fauna obtained in this study belonged to different groups (Acarina , Collembola, Diptera and their maggots ,Hemiptera and their nymphs, Hymenoptera , Psocoptera , Araneida and Crustacea). Some of them differed in their abundance from one site to other (Figs. – 3 and 4). Again, the number of individuals in a group also varied from plot to plot of the sampling sites; maximum being obtained from the Gorewada Reservoirsite (Fig. – 4 and minimum from the at Koradi Thermal Power Station site (Fig. - 3).

The acarines were numerically dominant over other forms and they comprised about 36.98% of the total arthropods population. 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 populated soils at Gorewada Reservoirand at Koradi Thermal Power Station site was maximum in September; while minimum population varied site wise in April at Gorewada Reservoirand in October and December at Koradi Thermal Power Station sites.

The next predominant order was collembolan. It comprised 26.98% of the total arthropods population being found in all the sampling sites. The number of this group exhibited similar fluctuation like acarines being maximum in August and minimum in May in the Gorewada Wild Life Rescue Center. In the polluted Koradi Thermal Power Station site however the population show three maximum peaks in the months of January, April and June and one minimum peak in the month of December.

The third important group in order of dominance was diptera. It was represented mainly by the maggots being extracted from all the population sampling sites. It comprised11.45% of the total arthropods population and showed two maximum peaks in December and Septembers and one minimum peak in May in respect of Gorewada Reservoirsite but in the pollulted plots where maximum witnessed in August and October while the minimum population was obtained in December.

The other important forms encountered were Hymeoptera, 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.

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

The above mentioned variation in the faunal make up might be due to the occurrences of differences in the edaphelogical conditions. Some froms as already stated were wide spread occurring regularly in the different sampling sites while others were localized

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. It was lowest in June (summer) and maximum in August (monsoon). This fluctuation pattern agreed with the findings of Choudhri and Roy (1972), Choudhri and Banrjee (1975), Hazra (1978), Roy and Ghatak (1977), Sanyal (1982). In the case of some micro arthropod groups in Indian condition where as such pattern appeared to be different from those met with in arthropod reported and Rapport and Najit (1966) observed that a micro arthropod 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 collembolan attained their respectively and other forms obtained from these plots showed a very low population in May – June.

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

Beside 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 prevalance of similar two peaks was also previously observed in Japan by Takeda (1973) and in India by Choudhri 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 single population peak suggested the probability of having a single generation a year (Bellingere, 1954) while the occurrence of two peak might be due to the existence of more than one generation (Hale, 1966).

In the polluted plots however the dominant froms like Collembola, Acarina, Coleptorea and Diptera showed their maximum peak in February / March (Table B). The population of Hymenoptera, Thysanoptera, Hemiptera and Psocoptera attained their maxima respectively in April, May, October and May.

It could be inferred, therefore, that the monsoon peak 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 residence than others.

This observation supported the earlier findings of Vanek (1967), Gorny (1976), Petal et al.. (1975), Bhattacharya (1981) and Hazara and Chattopadhyay (1985). Both the non –polluted samplings sites experience heavy rainfall in monsoon which resulted to an exuberant 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 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 led to a catastrophic on the total soil fauna other edphaic factors were more or less same with that of the non-polluted plots.

The vertical distribution study revealed that in almost all cases the soil arthropod population was significantly in the uppermost layer (0-5 cms.). Such a finding was in agreement with the result reported by Murphy (1953), Poole (1961), Dhillion and Gibson (1962), Davis (1963), Chrisitiansen (1964) and Hazra and Choudhuri (1983). The maximum concentration of fauna (most of the dominant froms) in the uppermost layer of soil in case of most of the plots under this study might be associated with associated with a possibility that with increasing depth there would be reduction in the pore space because compaction of soil and for which larger forms would be strengthened if the correlation between the size of soil arthropods and their depthwise distrubition was taken into consideration (Hazra and Choudhri, 1990; Dhillon and Gibson, 1962).

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 upper most layers of all plots. However, the abundance of juvenile forms of most of the the microarthropod 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 Chouduhri (1983).

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 up to the species level.

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