Journal Homepage: -www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI:10.21474/IJAR01/4406
DOI URL: http://dx.doi.org/10.21474/IJAR01/4406
ISSN NO. 2320-5407

RESEARCH ARTICLE

A STUDY ON VARIATION OF SOIL ACARINE POPULATIONS AT THREE ECOLOGICALLY MODIFIED HABITATS.

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Manuscript Info

Manuscript History

Received: 07 April 2017
Final Accepted: 09 May 2017
Published: June 2017

Key words:-
soil acarines, seasonal fluctuation, solid waste disposal site, roadside.

Abstract

Soil samples were collected from three ecologically modified sites- a waste disposal site, a roadside, bank of a sewage canal and a forest floor as a control site. One-way ANOVA indicated sites were different in terms of variance ($p<0.05$) while Tukey test indicated significant difference of means of abundance between the control site and the polluted sites. Annual and seasonal patterns of fluctuations were more or less same among the sites. Least abundant population of acarines was observed at the waste disposal site.

Introduction:-

Edaphic dynamics intricately encompasses several organisms of soil among which mites are often observed to constitute the most dominant community in the mesofaunal stratum (Sanyal, 1991; Heneghan et al., 1998; Rutigliano et al., 2013). Variable level of tolerance, diverse range of life cycle, high abundance and species diversity of soil acarines have made them an important subject of study for understanding edaphic condition, biomonitoring the environment and selecting indicator species and that is why several works were taken up on them around the globe (Zaitsev and van Straalen, 2001; Sarkar et al., 2015; Manu et al., 2017). In West Bengal however, elaborate works specifically targeting acarines groups at ecologically disturbed sites has remained limited leaving a few sporadic works (Hazra and Choudhuri, 1990; Bhattacharya and Chakraborti, 1994; Ghosh et al., 2007; Sarkar et al., 2015). The current study aimed at collecting basic data on population abundance of acarines, investigating its variation and the extent of the same in relation to the temporal and spatial factors covering three differently polluted sites and a control plot.

Methodology:-

Soil sampling:-

The selected sites for the study included a city waste disposal site (Site-I), side of a road with high traffic activities (Site-II), side of a sewage canal (Site-III) and a forest floor (Site-IV) in greater Kolkata.

Five 1 m^2 plots were taken at each of the four sites from which three cores of samples were collected during every sampling effort. Stainless steel core with 5cm high and same diameter was used for sampling (Dhillon and Gibson, 1962). The collection was continued for three years (2007-2009) with an interval of 30 days.

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Extraction of acarines and preservation:-
For extraction of mites, Tullgren funnel apparatus modified by Macfadyen (1953) was used which was run for three to four days for each phase of collection. The separated microarthropods were preserved in 80% alcohol.

Collection sites:-
Site-I: It is a disposal site of city wastes named 'Dhapa'. The subplots were selected adjacent to the dumping place. Sporadic vegetation included *Calotropis procera* (Asclepiadaceae), *Datura metel* (Solanaceae) and *Lantana camara* (Verbinaceae) etc.

Site-II: One side of VIP-Barasat road with moderate vegetation was selected for collection. *Colocasia esculenta, Datura metel* (Solanaceae), *Amaranthus* sp. (Amaranthaceae), *Acacia auriculiformis* (Mimoseae)were the common vegetation there.

Site-III: Adjacent soil of a sewage canal 'Tolly nullah' was sampled which carry a huge amount of wastes and sewages from human settlements around it. *Ricinus communis* (Euphorbiaceae), *Musa* sp. (Musaceae), *Poinciana regina,Tamarindus* sp. (Leguminosae) etc constituted the common vegetation at the site.

Site-IV: The forest floor at 'Chintmani Avhayaranya' in south Kolkata was selected as the control site for comparison. *Terminaliaarjuna* (Combretaceae), *Saracaindica* (Annonaceae), *Adina* sp. (Rubiaceae)*Tamarindus* sp. (Leguminosae), *Ricinus communis* (Euphorbiaceae) were among the chief components of vegetation cover.

Statistical Analysis:-
Statistical analysis was done with Minitab 13 software. Logarithmic transformation of data was done as per the necessity.

Results:-

Population abundance:-
The highest population abundance of soil mites was observed at Site-IV while the lowest was recorded at Site-I (Table 1, Fig. 1). Mite population reached the annual peak during the post monsoon season and the least abundance was noticed during the summer (Fig. 2). Population density of soil mites ranged from 576.47 / m^2 to 8168.07 / m^2.

Quantitative variation of mite population:-
Coefficients of variation: Fluctuations of abundance at different sites were worked out in the form of coefficients of variation (CV) of average number of mites per core per month. Fluctuation of mite population (coefficient of variation) was highest at Site-III and was lowest at Site-I (Table 1).

ANOVA on abundance of mite populations between the sampling sites:-
One way ANOVA indicated significant difference among population abundance of soil mites of the sites ($p< 0.05$), *i. e.*, the mite populations of the sites could not be considered to belong to a single large population. 95% confidence intervals for the mean population of each site, based on pooled standard deviation suggested that the means of Site-IV differed from the means of the other sites (Table 2). The Tukey test conducted revealed that out of 6 pairs of sites (four sites compared to one another in pairs) compared, only 3 pairs actually had significant difference in mean of population abundance (Table 3). It was observed that, statistically significant difference of mean abundance existed only between Sites-I, IV; Sites-II, IV and Sites-III, IV.

ANOVA on abundance of mite populations within each of the sampling sites:-
ANOVA done on monthly fluctuation in the collection sites revealed significant variation of population abundance among the months ($p<0.01$). Individual 95% confidence intervals based on the pooled standard deviations for monthly variation of population abundance of the sites showed that the abundance of the month of August, September or October differed from most of the months for higher abundance and the population abundance of May differed from most of the months due to poor abundance (Tables 4 to 7). Seasonal fluctuation also differed significantly ($p<0.05$) in all the sites. Population abundance of summer season differed from that of most of the other seasons at every site (Table 8).

Site-wise observations on abundance and population fluctuation of soil mites:-

Site-I: The density of soil mites ranged from 576.47 individuals /m^2 to 2511.51 individuals /m^2 with a mean of 1318.92 + 96.08 individuals /m^2 (Table 1). Monthly abundance reached the peak during the month of September-October and was least during April-May as observed in the three years span of collection (Fig. 2). The monthly fluctuation was lowest in this site (CV= 43.47).

Site-II: The maximum and the minimum densities were 4129.29 individuals /m^2 and 989.22 individuals /m^2 respectively with an overall average of 1917.26 + 164.87 individuals /m^2 (Table 1). Monthly abundance was high during the post monsoon season and low during the summer (Fig. 2). Fluctuation of abundance of mites here was higher than that of the previous site (Table 1).

Site-III: The range of the density of mites varied within the values from 1005.42 individuals /m^2 to 3789.89 individuals /m^2 with a mean of 1900.92 + 167.57 individuals /m^2 (Table 1). Monthly abundance was highest during the month of August-September and declined to minima in May as observed during the collection period (Fig. 2). Fluctuation of abundance here was highest among the sites (CV= 52.89) (Table 1).

Site-IV: Abundance of soil mites was highest in this site. The density of the mite population at this site varied from 2047.93 individuals /m^2 to 8168.07 individuals /m^2 with an average of 4480.62 + 341.32 individuals /m^2) (Table 1). Monthly abundance like other sites reached the peak during the post monsoon season and was at minimum during the summer. Fluctuation of mite population was moderate in comparison to other sits (CV= 45.71) (Table 1).

Discussion:-

Though the mite population was significantly differentiable according to the sampling sites as ANOVA indicated, the difference of mean abundance of the same was not significant between most of the sites. The forest site (Site-IV) differed significantly in mean monthly abundance with the rest and besides this, only Sites-II and III exhibited significant difference. Site-IV with plenty of vegetation had the largest mite communities. It is in agreement with the observation that the diversity and the abundance of soil microarthropods including mites become higher in forest floor (Crossleyand Coleman, 1999; Coleman et al., 1999, 2004; Schneider, 2005; Sarkar et al., 2015). Of the four sampling sites selected, Site-I was a waste disposal site and therefore was prone to the detrimental effects of various pollutants including heavy metals. Concentrations of heavy metals were at maxima here among the selected sites. This site expectedly supported the least abundant microarthropod community and acarine population as well. Heavy metals may interfere with metabolic activities and also affect reproduction of soil organisms and thereby reduce their population abundance (Chattyopadhyay and Hazra, 2000; Iloba and Ekrakene, 2008; Skubala et al., 2016; Tyokumbur, 2016; Manu et al., 2017). The forest floor was significantly different from other three disturbed sites in terms of numerical abundance of soil mites, further the mode of fluctuation also appeared to differ conspicuously from the rests. Other three polluted sites, though having different source and mode of disturbance, did not exhibit significant variation of abundance among them.

Conclusion:-

It appeared evident from the study that the ecological modification due to anthropogenic interference rendered significant negative effect on the population of acarines. The nature and the intensity of the impact however did not vary much among the disturbed sites.

Table 1:-Fluctuation, Minimum, maximum and mean values of density (individuals/ m^2) of soil mites at different sites.

	Mean (+ SE)	Max	Min	CV
S-I	1318.92 + 96.08	2511.51	576.47	43.71
S-II	1917.26 + 164.87	4129.29	989.22	51.6
S-III	1900.92 + 167.57	3789.89	1005.42	52.89
S-IV	4480.62 + 341.32	8168.07	2047.93	45.71

(Max= Maximum, Min= Minimum, CV= Coefficient of variation, SE= Standard error)

Table2:- ANOVA for abundance (mean number of individual per sample in a month) of soil mites at different sites.

```
Analysis of Variance
Source     DF        SS        MS        F        P
S1          3    28.884     9.628    35.25    0.000
Error     140    38.238     0.273
Total     143    67.122

                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  ----------+---------+---------+------
S-I        36    4.6773    0.4393  (---*--)
S-II       36    4.9961    0.5435        (---*--)
S-III      36    4.9616    0.6082        (--*---)
S-IV       36    5.8724    0.4840                          (--*---)
                                  ----------+---------+---------+------
Pooled StDev =   0.5226                  5.00      5.50      6.00
```

deviation, CIs = Confidence Intervals. [Individual confidence intervals given in dotted line indicates (with 95% confidence) the probable range of occurrence of the mean. The asterix in the middle of the line marks the present mean. The ranges of mean within parentheses not overlapping implies that those menas are different]

Table3:-Tukey test showing the difference of mean abundance of soil mites between the collection sites.

```
Tukey's pairwise comparisons
   S-I          S-II         S-III
   S-II       -0.6393
               0.0017
   S-III      -0.6048      -0.2860
               0.0363       0.3551

   S-IV       -1.5156      -1.1968      -1.2314
              -0.8745      -0.5557      -0.5903
```

Table4:- ANOVA for monthly abundance (mean number of individual per sample in a month) of soil mites at Site-I.

```
Source     DF        SS        MS        F        P
Factor     11    4.9683    0.4517     6.06    0.000
Error      24    1.7876    0.0745
Total      35    6.7560

                          Individual 95% CIs For Mean Based on Pooled StDev
Level       N      Mean     StDev  ----------+---------+---------+------
Jan         3    4.4232    0.3162          (-----*----)
Feb         3    4.2426    0.3869       (-----*----)
Mar         3    4.5006    0.1393            (----*----)
Apr         3    4.4550    0.0988           (----*-----)
May         3    3.9755    0.1466   (----*-----)
Jun         3    4.7388    0.2696               (----*----)
Jul         3    4.8076    0.2460                (----*-----)
Aug         3    5.1807    0.1197                      (----*-----)
Sept        3    4.9878    0.4628                   (----*-----)
Oct         3    4.5364    0.3649            (-----*----)
Nov         3    5.0647    0.2682                     (----*-----)
Dec         3    5.2148    0.1634                       (-----*----)
                                  ----------+---------+---------+------
Pooled StDev =   0.2729                  4.20      4.80      5.40
```

DF = Degree of Freedom, SS = Sum of square, MS = Mean square, F = F statistics, StDev = Standard deviation, CIs = Confidence Intervals

[Individual confidence intervals given in dotted line indicate (with 95% confidence) the probable range of occurrence of the mean. The asterix in the middle of the line marks the present mean. The ranges of mean within parentheses not overlapping implies that those means are different]

Table5:- ANOVA for monthly abundance (mean number of individual per sample in a month) of soil mites at Site-II.

```
Source      DF        SS        MS         F        P
Factor      11     6.843     0.622      4.27    0.001
Error       24     3.494     0.146
Total       35    10.337
                                Individual 95% CIs For Mean Based on Pooled StDev
Level        N      Mean     StDev  ------+---------+---------+---------+
Jan          3    4.8008    0.1330           (-------*-------)
Feb          3    4.8160    0.7592            (------*-------)
Mar          3    4.4732    0.1132     (-------*------)
Apr          3    4.7416    0.1865         (-------*-------)
May          3    4.3423    0.5961   (------*-------)
Jun          3    4.4173    0.1280    (-------*------)
Jul          3    5.0803    0.4192                (-------*------)
Aug          3    5.3071    0.2720                    (------*-------)
Sept         3    5.5005    0.3459                       (-------*------)
Oct          3    5.3951    0.5485                     (-------*------)
Nov          3    5.5134    0.0146                       (-------*------)
Dec          3    5.5660    0.2512                        (-------*------)
                                     ------+---------+---------+---------+
Pooled StDev =    0.3815               4.20      4.80      5.40      6.00
```

Table6:- ANOVA for monthly abundance (mean number of individual per sample in a month) of soil mites at Site-III.

```
Source      DF        SS        MS         F        P
Factor      11   11.5796    1.0527    18.50    0.000
Error       24    1.3658    0.0569
Total       35   12.9455
                           Individual 95% CIs For Mean Based on Pooled StDev
Level        N      Mean     StDev  -------+---------+---------+---------
Jan          3    4.8621    0.3305              (---*----)
Feb          3    4.9339    0.3593               (---*----)
Mar          3    4.4195    0.1506        (---*---)
Apr          3    4.4275    0.1457        (---*---)
May          3    4.0176    0.3005  (---*---)
Jun          3    4.1769    0.3362     (---*---)
Jul          3    4.9927    0.3661                (---*---)
Aug          3    5.7279    0.0814                          (---*---)
Sept         3    5.6189    0.1080                        (---*---)
Oct          3    5.5457    0.0785                      (---*---)
Nov          3    5.3662    0.0929                    (---*---)
Dec          3    5.4496    0.1738                     (---*---)
                                -------+---------+---------+---------
Pooled StDev =    0.2386            4.20      4.90      5.60
```

Table7:- ANOVA for monthly abundance (mean number of individual per sample in a month) of soil mites at Site-IV.

Source	DF	SS	MS	F	P
Factor	11	7.6984	0.6999	33.51	0.000
Error	24	0.5013	0.0209		
Total	35	8.1997			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
Jan	3	5.6600	0.1273	(--*---)
Feb	3	5.9368	0.1816	(---*--)
Mar	3	5.4252	0.1579	(---*--)
Apr	3	5.4720	0.1159	(--*---)
May	3	5.1396	0.2255	(---*--)
Jun	3	5.2650	0.0575	(--*---)
Jul	3	5.7443	0.0497	(---*--)
Aug	3	6.3463	0.2041	(---*--)
Sept	3	6.4429	0.1085	(---*--)
Oct	3	6.4374	0.1247	(---*--)
Nov	3	6.2959	0.1688	(---*--)
Dec	3	6.3033	0.0947	(--*---)

Pooled StDev = 0.1445

5.00 5.50 6.00 6.50

Table8: ANOVA for seasonal abundance (mean number of individual per sample) of soil mites at Site-I.

Site-I

Source	DF	SS	MS	F	P
Factor	3	2.028	0.676	4.58	0.009
Error	32	4.728	0.148		
Total	35	6.756			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
W	9	4.6269	0.5193	(------*-------)
S	9	4.3104	0.2760	(------*-------)
M	9	4.9090	0.2815	(------*-------)
A	9	4.8630	0.4073	(-------*------)

Pooled StDev = 0.3844

4.20 4.55 4.90 5.25

Site-II

Source	DF	SS	MS	F	P
Factor	3	4.138	1.379	7.12	0.001
Error	32	6.199	0.194		
Total	35	10.337			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
W	9	5.0609	0.5548	(-----*-----)
S	9	4.5190	0.3631	(-----*-----)
M	9	4.9349	0.4763	(-----*-----)
A	9	5.4697	0.3291	(-----*-----)

Pooled StDev = 0.4401

4.50 5.00 5.50 6.00

Site-III

Source	DF	SS	MS	F	P
Factor	3	6.921	2.307	12.25	0.000
Error	32	6.024	0.188		
Total	35	12.945			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
W	9	5.0819	0.3797	(-----*-----)
S	9	4.2882	0.2734	(-----*-----)
M	9	4.9658	0.7175	(-----*-----)
A	9	5.5103	0.1389	(-----*-----)
Pooled StDev =		0.4339		4.00 4.50 5.00 5.50

Site-IV

Source	DF	SS	MS	F	P
Factor	3	5.0762	1.6921	17.34	0.000
Error	32	3.1235	0.0976		
Total	35	8.1997			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
W	9	5.9667	0.3044	(----*----)
S	9	5.3456	0.2159	(-----*----)
M	9	5.7852	0.4817	(-----*----)
A	9	6.3920	0.1384	(-----*----)
Pooled StDev =		0.3124		5.20 5.60 6.00 6.40

DF = Degree of Freedom, SS = Sum of square, MS = Mean square, F = F statistics, StDev = Standard deviation, CIs = Confidence Intervals. [Individual confidence intervals given in dotted line indicate (with 95% confidence) the probable range of occurrence of the mean. The asterix in the middle of the line marks the present mean. The ranges of mean within parentheses not overlapping implies that those means are different]

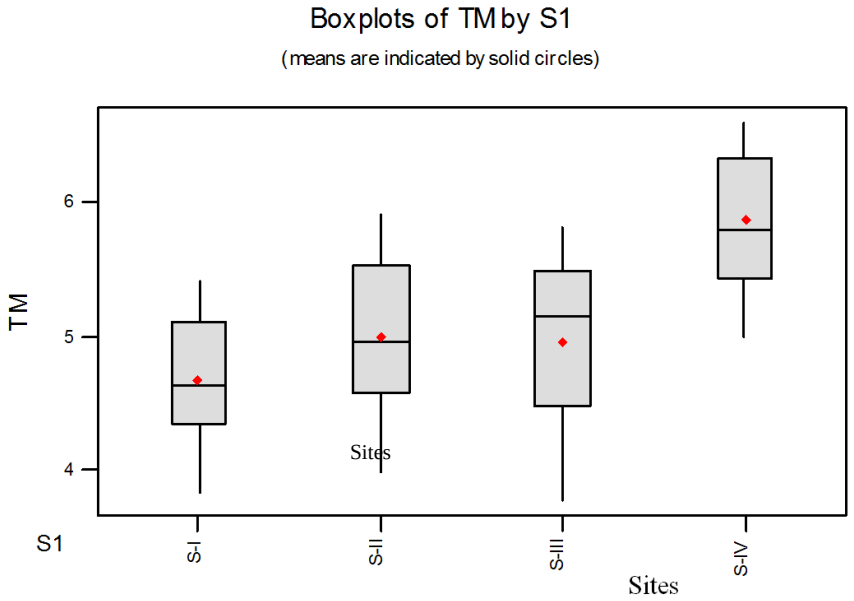

Fig. 1:-Box plot on the summary of monthly data of numerical abundance (individuals per sample) of soil mite population of each site. (Boxes depicts the ranges of middle 50% data of total observations, while lines shows rests

of the upper (25%) and lower (25%) part. Mean and median are indicated by solid circle and midline of each box. (TM= Total mites)

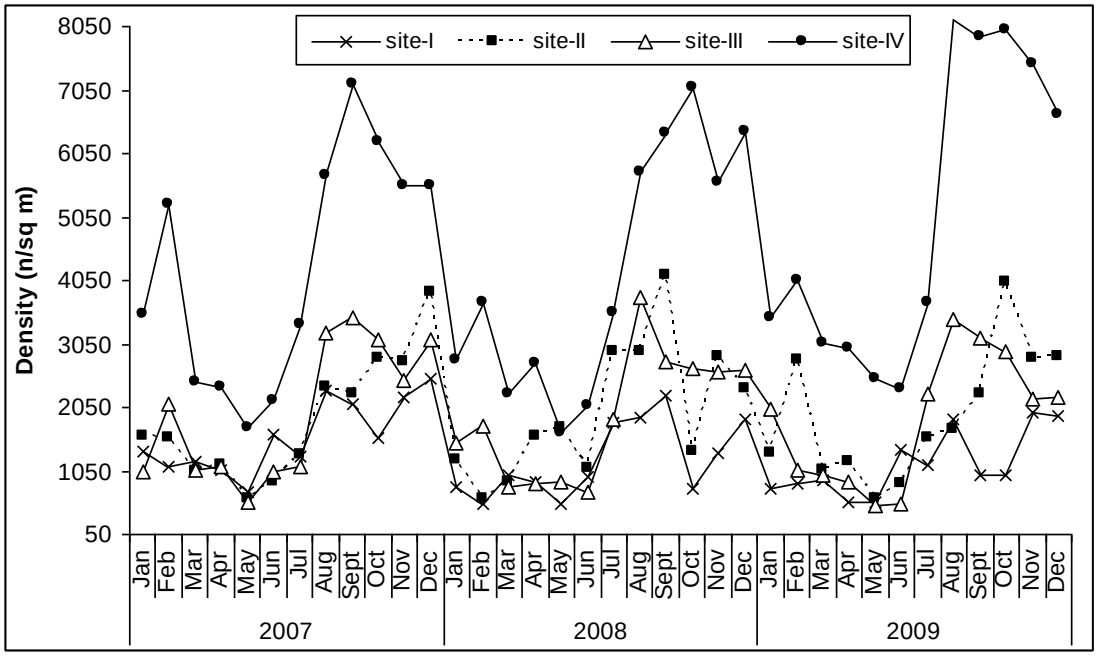

Fig. 2:-Variation of monthly population density of soil mites at different sites.

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