Impact of Contaminated Sewage Effluent onthe Soil Arthropods: A Case Study from Polluted and Non-Polluted Site in Gondia District of Maharashtra

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Abstract:

The present investigation contain the results of an ecological study involving the impact of contaminated sewage effluents on various soil factors and on soil inhabiting arthropod from both polluted [Pangadi Nallah, Gondia] and non- polluted site [Bodalkasa, Tiroda] in Gondia District of Maharashtra. The soil samples were collected monthly over a period of one year from May, 2011 to April 2012 from each site. There was significant variation in the following soil factors temperature, moisture, hydrogen-ion-concentration and organic carbon of the two sites. Several groups of soil arthropods were recorded from soil samples, of which only Acarina, Collembola, Diptera, Coleoptera and Hymenoptera were universally present though their density and mode of population varied in different sites. The percentage of total population was found to be maximum in the non polluted plot.

Keywords:
Sewage effluent, Moisture, Organic carbon, Acarina, Collemmbola.

Introduction:

The average garbage production per day from Indian cities is estimated at 41,000 tones, i.e. 15 million tones per year. A total of 142 Class I cities produce around 9000 million liters of sewage per day and only one third of this waste receives some treatments. It is well established that the primary treatment of sewage can remove 60% of solids and perhaps one third of BOD, (Foster, 1959). Gondia district is mainly a paddy producing district. There are over 300 rice mills in the district of which 85 are generating par-boiled rice. Most of these mills release untreated wastewater to open land or nearby water bodies leading to environment deterioration and inconvenience to local people (Bhuskute and Jha, 2014).

Soil biota, despite their critical importance still remains an unexplored section of the earth (Swift *et al.*, 1979). There are three categories of soil invertebrates that live in the soil - Micro-fauna e.g. Protozoa and Nematoda; Meso-fauna e.g. Mites, Collembola and Diptera larvae; the Macro-fauna e.g. Myriapoda, Earthworms etc. (Abbott, 1989). The species composition 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 other environmental factors.

Although the problem of the effect of contaminated sewage effluent on the soil organisms has received due attention of the scientists in some countries (Petal, 1978) in India, however, no such attempts have yet been made, to assess the impact of effluent on soil arthropods. The present investigation was undertaken to know the impact of sewage effluents on soil arthropods in relation to both qualitative and quantitative arthropods population and also to evaluate the role of edaphic factors like, temperature, moisture, pH and organic carbon on the soil arthropods and their concentrations in both polluted and non-polluted sites.

Material and methods:

Study Area: The experiment was conducted in non-polluted site, Bodalkasa Canal built on Bhagdeogoti River a tiny stream near Tiroda in Gondia District of Maharashtra and the polluted site was identified at Pangadinallah (canal) situated on a local nallah near Gondia in Maharashtra.

Methods of Sampling: Soil samples were collected for a period of one year at the rate of 3 samples per plot every month from May, 2011 to April 2012. Samples were drawn by using a stainless steel corer (inner cross sectional diameter 8.5 sq/cm) from a depth of 5 cm. The soil samples thus collected were kept immediately in sterile Polythene packet and stored in 4°C in the laboratory.

Extraction of Samples: For extraction of soil microarthropods, modified Tullgren's Funnel apparatus was used. The extraction period was 72 Hrs. All soil microarthropods were identified up to the level of their order using a range of taxonomic keys (O'Connell 1994). A stereo zoom microscope with Camera attachment was used to capture the image for identification.

Analysis of edaphic factors: Fresh soil sample was dried at about 105°C in oven in order to stop further bacterial action. It was allowed to cool and stored in desiccators. The dried soil was passed through 2mm sieve, mixed and fractionated before analysis.

The soil pH measured by electric pH meter. Soil moisture was determined by the 'Oven dry method' (Dowdeswell, 1959) and soil organic carbon was estimated by rapid titration method as described by Walkley and Black (1934).

Result and discussion:

(A) Edapic factors

Site – I Bodalkasa (Tiroda): Soil pH varied from 6.99 to 7.37. The maximum temperature of soil was recorded in the month of May (44.33±0.36 °C) and minimum temperature in the month of December was (14.67±0.42°C). Soil moisture content least recorded in the month of May (16.19 ± 1.45%) and maximum in the month of August (35.78 ± 2.36%) in the site. The highest total organic carbon was recorded in the month of September (3.02 ±0.07%)

and the lowest in May (1.93 ±0.05%). The corresponding values of temperature, moisture, pH and organic carbon are shown in Table - 1.

Site – II PangadiNallah (Gondia): Soil pH ranged from 6.91 to 7.75. The maximum temperature of soil was recorded in the month of May (46.33 ± 0.36°C) and minimum temperature in the month of December was (14.67±0.42°C). Soil moisture content was lowest in the month of June (21.88 ± 1.22%) and highest in the month of September (35.06 ± 1.36%). The highest total organic carbon was recorded in the month of June (1.15 ±0.06%) and the minimum in August (0.80 ±0.04%). The corresponding values of temperature, moisture, pH and organic carbon are shown in Table -2.

(B) Faunal makeup

Site I – Bodalkasa (Tiroda): The total arthropod population (Table - 3) was found to be maximum in the month of August while the minimum population in the month of May.

On faunal analyses several groups of arthropods were found (Table – 3). Acarina was the most dominant group of the total population, followed by Collembola. Hymenoptera was the third major groups, while Diptera along with their maggots and Coleoptera occupied the fourth and fifth position respectively. Some unidentified non- arthropods soil fauna as "others" were recorded but either they were very low in concentration or were highly irregular in distribution.

Site II- Pangadi Nula (Gondia): The total micro arthropods 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 (3.5 ± 1.34) was found in the month of October (Table - 4).

The concentration of the Acarina was maximum (Table-4), Collembola came next. Diptera and their maggots occupied the third position followed by Hymenoptera and Coleoptera. Other groups of arthropods were found to be relatively irregular in distribution.

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 (Tables – 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 Bodalkasa site (Table – 3) and minimum from the Pangadi Nula (Table-4).

The Acarines were numerically dominant over other forms 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 polluted soils was maximum in September and minimum in April /May; while in the polluted area being maximum in January and minimum in April /May.

The next predominant order was Collembola. The number of this group exhibited similar fluctuation like Acarines being maximum in August/September and minimum in April / May in the non-polluted plot. In the polluted plots however their population varied.

The third important group in order of dominance was Diptera. It showed two maximum peaks in December and Septembers and one minimum peak in May in respect of Bodalkasa site but in the polluted plots, maximum population was witnessed in March while the minimum was obtained in May.

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 April/May (summer) and maximum in August/September (monsoon). This fluctuation pattern agreed with the findings of Choudhri and Roy (1972), Choudhri and Banerjee (1975), Hazra (1978), Roy and Ghatak (1977) and Sanyal (1982).

In the polluted plots however, the dominant froms like Collembola, Acarina, Coleptorea and Diptera showed their maximum peak in February & March (Table 4). This observation supported the earlier findings of Vanek (1967), Gorny (1975),Petal (1978),Bhattacharya and Roychoudhuri, (1979) andHazara and Choudhuri, (1983).

The 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.

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. This is probably due to the effect of heavy metals and other toxic substance discharge in the seweage canal by rice mills. Similar results of reduction of soil invertebrate fauna due to industrial pollution had been reported by Singh (1976), Bhattacharya and Joy (1977),Petal (1978), Bhattacharya and Bhattacharya (1981) and Hazra and Choudhuri (1983).

Among the edaphic factors studied, temperature show a marked variation with the change of season ranging between 14.67±0.42°C and 46.33 ± 0.36°C. Since temperature and moisture are interlinked they probably exert effect on the population conjointly (Schubert, 1930). At the Bodalkasa site in summer months the samples yielded minimum population when the temperature was significantly high. Similarly results were obtained by Welbe (1970) and Hazra (1978). At the polluted site the, range of the soil temperature was considerably low in comparison to the Bodalkasa site, more over at Pangodi site the maximum population was observed in February when the soil temperature was low.

The moisture content of the soil showed wide range of variation from 16.19 ± 1.45% to 35.78 ± 2.36% at the Bodalkasa site (Table-1). The soil moisture content at the polluted site was a bit more than that at the Bodalkasa site. This was probably due to the soil and the resultant alteration of the water holding capacity of the soil. In both the sites the total arthropod populations were found to be considerably low in summer months. When the soil moisture content were minimum, whereas as both the sites the arthropod populations were maximum when the soil moisture content were also maximum.

The content of organic carbon varied from 0.80 ±0.04%to 3.02 ±0.07% at the two sites. At Bodalkasa site, the organic carbon concentration underwent a regular pattern of fluctuation at different seasons (Table-1), This organic carbon fluctuation influenced positively the growth of the arthropods population. These results agreed with the finding of earlier worker (Haarlov, 1960; Christiansen *et al.* 1964; Davis, 1964; Choudhuri and Banerjee, 1975; Singh and Pillai, 1975 and Ghatak and Roy, 1979).

The Pangadi site (Gondia) organic carbon content was quite low in comparison to non polluted plots, the reason for this might be attributed to 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 and therefore it is statistically not possible to correlate the fluctuation of organic carbon with variation in arthropod population at this polluted site.

Although the pH value of soil sample varied in the polluted (6.91 - 7.75) and non-polluted sites (6.99 - 7.37) there was concomitant slight variation in the population of arthropod group (Table-1,2). Most of the soil arthropods can tolerate such a range of pH (Frenzel, 1936;and Choudhury and Roy, 1972), thus indicating soil arthropods preference for a weak alkaline environment. Edawards and Lofty (1975), earlier observed a significant fall in soil animals in the acidic environment. Thus it would be clear from the results of the present study 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.

From the above discussion in would be evident that the prevalence of contaminated sewage effluent in soil did indirectly create an adverse impact on the population structure of the soil arthropods. Whether they acted singly or conjointly was a matter of conjecture. The concentration of effluents 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 at the effluents sites. From the present investigation it might be assumed that the susceptibility of Collembola to the exposure of contaminated sewage effluents is more than any other arthropod group. Greater susceptibility of Collembola to pollution has also been observed by Aoki and Kuriki (1980), Tadros (1980) and Bengtsson *et al.,* (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.

Table 1: Showing mean values per sample along with S.E. of the different soil factors and arthropod population, per month, at Bodalkasa site (Tiroda)

Month	Arthropod Population Mean ± SE	Temperature (°C) Mean ± SE	Moisture (%) Mean ± SE	pH Mean ± SE	Organic carbon(%) Mean ± SE
January	13.83 ± 3.25	15.58 ± 0.37	22.22 ± 2.39	6.99 ± 0.09	2.12 ± 0.09
February	12.83 ± 3.70	17.33 ± 0.37	20.13 ± 2.33	7.11 ± 0.06	2.09 ± .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 2: Showing mean values per sample along with S.E. of the different soil factors and arthropod population, per month, at Pangadi Nula (Gondia)

Month	Arthropod Population Mean ± SE	Temperature (°C) Mean ± SE	Moisture (%) Mean ± SE	pH Mean ± SE	Organic carbon(%) Mean ± SE
January	16.67 ± 2.43	17.58 ± 0.37	27.70 ± 2.77	7.75 ± 0.05	0.84 ± 0.05
February	26.83 ± 2.55	18.33 ± 0.37	27.03 ± 1.86	7.73 ± 0.09	0.94 ± 0.02
March	8.67 ± 1.86	23.83 ± 0.40	24.90 ± 1.34	7.55 ± 0.10	1.00 ± 0.03
April	4.00 ± 0.67	37.50 ± 0.17	21.88 ± 1.22	7.45 ± 0.10	1.02 ± 0.04
May	9.33 ± 1.28	46.33 ± 0.36	21.92 ± 1.04	7.31 ± 0.08	1.15 ± 0.06
June	5.83 ± 1.54	42.00 ± 0.33	28.37 ± 1.24	7.21 ± 0.08	1.08 ± 0.28
July	6.83 ± 1.35	32.67 ± 0.54	32.00 ± 1.32	7.29 ± 0.04	0.94 ± 0.03
August	7.67 ± 1.06	29.83 ± 0.52	33.06 ± 1.67	7.23 ± 0.03	0.80 ± 0.04
September	3.83 ± 1.43	28.33 ± 0.56	35.06 ± 1.36	7.32 ± 0.02	0.92 ± 0.02
October	3.50 ± 1.34	28.58 ± 0.60	34.75 ± 1.42	6.99 ± 0.01	0.98 ± 1.42
November	8.00 ± 1.66	22.83 ± 0.46	31.80 ± 1.92	6.91 ± 0.03	1.01 ± 0.02
December	7.83 ± 1.41	14.67 ± 0.42	24.80 ± 2.96	7.57 ± 0.07	1.01 ± 0.07

Table 3: Showing individual groups of arthropods and their monthly population in percentage, at Bodalkasa site (Tiroda)

Month	Diptera	Collembola	Coleoptera	Hymenoptera	Acarina	Others
January	0.28	1.04	0.16	0.44	2.44	----
February	0.18	0.80	0.28	0.16	1.24	----
March	0.18	0.92	0.20	1.08	1.44	----
April	0.54	0.52	0.16	0.40	0.04	----
May	0.24	0.40	0.04	0.16	0.72	----
June	0.12	0.68	0.12	0.24	0.56	---
July	0.42	2.29	0.28	0.60	0.56	---
August	0.08	3.32	0.12	0.20	2.96	---
September	0.78	2.28	0.16	0.32	4.04	---
October	0.20	1.72	0.12	0.44	3.04	0.12
November	0.12	1.96	0.12	0.16	2.44	0.04
December	0.78	1.28	0. 42	0.44	2.84	0.12

Table 4: Showing individual groups of arthropods and their monthly population in percentage, at Pangadi Nula (Gondia)

Month	Diptera	Collembola	Coleoptera	Hymenoptera	Acarina	Others
January	0.48	0.60	0.40	0.24	1.96	----
February	0.36	1.32	0.12	0.12	1.69	0.54
March	0.68	1.32	0.12	0.12	1.92	0.45
April	0.54	0.48	0.48	0.72	0.72	---
May	0.30	0.60	0.24	0.12	0.60	---
June	0.48	0.36	0.36	0.12	1.44	---
July	0.36	1.32	0.12	0.12	1.44	0.36
August	0.36	1.20	0.36	---	1.04	---
September	0.36	0.84	0.12	---	1.56	---
October	0.48	1.20	0.36	---	1.20	---
November	0.48	0.96	0.12	0.72	1.20	----
December	0.48	0.84	0.36	0.36	1.34	---

Summary:

The result of the present study are summarised as follows:-

1. The investigation contained the result of an ecological study involving the impact of contaminated sewage effluents on various soil factors and on soil inhabiting arthropod from both polluted (Pangadi Nallah (Gondia)) and non-polluted site (Bodalkasa (Tiroda)) in Gondia District of Maharashtra.
2. Soil factors considered in this study were temperature, moisture, hydrogen-ion-concentration and organic carbon all of which were found to vary in different sites and samples.
3. A total of 720 soil samples were collected from all plots at monthly interval over a period of 12 months from May, 2011 to April, 2012.

4. Several groups of arthropods namely Collembola, Acarina, Diptera, Hymenoptera, Diplura, Crustacea, Araneida were recorded from 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 population was found to be maximum in the non polluted plot than the polluted ones. The same was true for the dominant arthropod groups, except for Hymenoptera and Diptera.

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. The possibility of greater susceptibly of the Collembola among all the arthropod groups was suggested.

8. The need of further study involving the species of the dominant groups like Collembola and Acarina was also stressed.

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