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USE OF SEWAGE WASTEWATER IN AGRICULTURE AND ITS EFFECTS ON SOIL MACROFAUNA

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The irrigation with sewage wastewater is a severe threat for the existence of soil macro faunal communities. For this reason, it is a dire need to uphold their virtue for future concern. Current research was planned to check the impact of contaminated sewage wastewater on soil macro fauna in selected cauliflower and tomato fields, in district Faisalabad, Punjab, Pakistan. A total of 7845 specimens belonging to 160 species were observed during consecutive two years study. Tomato fields showed higher population 35.25% (N=2766) of soil macrofauna in control than treated 27.89% (N=2188) fields, similarly control cauliflower fields showed higher population 27.95% (N=2192) than treated 8.91% (N=699). Overall species richness was higher in tomato (12.57) than in cauliflower (11.54) fields. The Coleoptera was the most frequent order (44 species) in both fields. Maximum diversity index was recorded from control treatment in tomato field (2.937), maximum dominance was documented from tomato field treated with sewage water (0.497) and higher evenness (0.846) was recorded in cauliflower fields irrigated with sewage water. Canonical Correspondence Analysis (CCA) showed that selected micronutrients, macronutrients and edaphic factors were correlated to species distribution and a tool to figure out the soil macrofaunal diversity. So, it was concluded that when heavy metals; lead (Pb), chromium (Cr) and nickel (Ni) are present in wastewater they cause hazardous effects on inhabiting soil flora and fauna by reducing quality and quantity of food and functioning of soil macrofauna populations, moreover, decline the soil fauna density and abundance.
Keywords: Soil fauna, density, diversity, pollution, nutrients.

INTRODUCTION

Wastewater is a principal source of irrigation in developing countries. In world overall, more than 20 million hectares are being irrigated with this wastewater (Dreschsel *et al.,* 2002). Presently, great amount of the unprocessed sewage wastewater is being released into the natural environment and into other water bodies; also, farmers use this sewage waste water for irrigation purpose UNESCO 2003). Though, there are many environmental and health issues regarding wastewater, but on the other hand, it is a cheap source and contains many nutrients like phosphorus and nitrogen etc. that stand helpful for the enhanced crop production (Scott *et al.,* 2004; IWMI and Rauf, 2002). It also includes many inorganic pollutants such as heavy metals with significance tendency of absorption by soil colloids and subsequently these metals are released into the soil components (Bruins *et al*., 2000). Major sources of the wastewater are industries, households, commercial premises and municipal drains. This water contains undesired organic compounds, heavy metals and hazardous chemicals etc. (Cornish *et al.,* 1999), that eventually causes soil degradation and adversely affects the environment and ecosystem globally (Wei and Chen, 2001; Chen *et al*., 2012; Li *et al*., 2013).

The organisms require small quantities of some heavy metals such as Cu, Co, Fe, Mn, Ni and Zn. Though, excessive quantities of these elements can become detrimental to organisms. Furthermore, some heavy metals such as Pb, Cd, Hg, and As, do not have any valuable effect on soil organisms and therefore are considered as the main threats, being harmful, to both animals and plants (Bruins *et al*., 2000; Chibuike and Obiora, 2014).However, impact of sewerage sludge on soil veracity is not completely investigated yet (Kandeler *et al*., 1996). Bioaccumulation takes place when various metal substances are introduced to food chains of soil ecosystem via groundwater and becomes harmful if heavy metals concentrations exceed permissible limits in the prevailing soil (Ettler *et al*., 2004; Rodella and Chiou, 2009). Soil contamination may alter soil ecosystem performance; both quantitatively and qualitatively by imposing inappropriate decomposition, N-mineralization and carbon, nitrogen, sulphur and phosphorus cycling (Shah *et al*., 2005). Soil community generally includes a great number of species that participate in a variety of ecosystem functions e.g. development of the soil structure dynamics and organic matter turn-over etc. (Giller, 1996; Barros *et al*., 2004). They may be small (snails, ants); large (rodents) and they exert effects on soil physical properties directly or indirectly as well as biological processes, important for animal and plant life (Fackenath and Lalljee, 1999). The role of soil macrofauna largely depends upon their abundance and soil health (Lavelle, 1997). Amongst the invertebrates, macrofauna is of key importance for soil functioning by maintaining soil structure via digging burrows; regulate microbial diversity and activity, and modifying aggregation (Wolters, 2000).

Soil pollution caused by heavy metals induces negative impacts on soil macrofauna (Nahmani *et al*., 2005; Tessaro *et al*., 2013). Heavy metal pollution decreases the biomass activities causing functional disturbance, protein denaturation and devastation of soil quality; follow-on growth imbalance. For example, earthworm a key bio-monitor organism for soil contaminant, its reproduction, population survival and functioning are affected by soil pollutants (Peijnenburg, 2002; Takeshi and Kazuyoshi, 2011).They can regulate the uptake of essential metals (like; Zn, Cu) to an extent from the soil, though the regulation of non-essential metals (such as; Cd, Pb) is possibly less, if any (Nahmani *et al*., 2009). Their efficiency declines with the increase in chromium levels; however, their reproduction and regeneration succeed accordingly. Pb can be stored permanently within waste nodules of earthworms (Soni and Abbasi, 1981; Lee, 1985; Mostafaii *et al*., 2016). Tessaro *et al.* (2013) endorsed that beetles responded when exposed to organic and chemical fertilizer, to improve the soil quality for better production. According to Brown (1999), beetles are important group of soil organism as soil bio-indicator. The objective of the current study was to record the impacts of sewage wastewater on soil macrofauna populations.

MATERIALS AND METHODS

***Study Area*:** Current study was done for two consecutive seasons i.e. 2014-15 and 2015-16 at district Faisalabad, Punjab, Pakistan. Cauliflower and tomato fields with similar topography were selected randomly from same vicinity (Chokera, Faisalabad; Fig. 1). Fields irrigated with tube-well water were taken as control; whereas, fields irrigated with untreated sewage wastewater were considered as treated fields.

***Experimental layout*:** The samples were collected from the selected fields of cauliflower and tomato, from the pre-harvesting to post-harvesting stage of each vegetable crop (in winter and spring seasons). Sampling was done through digging method on fortnightly base (7 samplings/field) from each vegetable field. Quadrate sampling was used to collect the specimens (by hand picking, hand sorting with help of forceps) from soil. Quadrate with side 1 foot in length was placed at random to the selected area of the fields and 1 cubic feet soil was dig (1foot length, 1footwidth and 1-foot depth). Three quadrat samples per microhabitat; viz. boundary, middle and center (Fig.2) of selected fields were taken, so, total nine quadrat samples were taken from every field per sampling.

Figure 1. Pictorial view of Chokera Sewage Treatment Plant Faisalabad, Pakistan

				B				
				M				
B		**M**		**C**		**M**		**B**
				M				
				B				

Figure 2. Micro-habitats of each field; B= Boundary of the field, M= Middle of the boundary and center of the field, C=Center of the field.

***Sorting and identification of macrofauna*:** To sort the soil macrofauna, soil samples (collected by quadrate sampling) were carried to Biodiversity Laboratory; Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad, Pakistan. Specimens from these samples were sorted following the Magurran (1988); Dangerfield (1990) and Rana *et al*. (2010) by hand sorting, with help of forceps and burlese funnel. Preservation of sorted organisms was done in labeled (collection date, locality, microhabitat and field type) glass vials that contain alcohol with few drops of glycerin. Then collected soil macrofauna specimens were being identified following taxonomic keys literature (Pocock, 1990; Holloway *et al*., 1992; Triplehorn and Johnson, 2005: Rafi *et al*., 2005).

***Soil Analysis*:** Soil samples were examined in Soil Chemistry Laboratory, Ayub Agriculture Research Institute (AARI), Faisalabad, following Ryan *et al.* (2001) and Rana *et al.* (2010a, b) and for macro-nutrients and micro-nutrients analyses following Tendon (1993). Macro-nutrients; phosphorus (P) was determined by Genesys 5 spectrophotometer, while potassium (K) estimation was done by flame photometer (Model Digi flame 2000; GDV, Italy) and Nitrogen (N) was estimated using Kjeldhal's Apparatus. Concentration of micronutrients; Lead (Pb), Chromium (Cr) and Nickel (Ni) in soil samples was determined by atomic absorption spectrophotometer (Varian Spectra AA-250 PLUS). Electrical conductivity (EC) was recorded by an EC meter (Corning model 220) and hydrogen ion concentration (pH) was determined by Acorning pH meter 10.

***Statistical Analysis*:** The data recorded were analyzed by GWBASIC programs (www.daniweb.com–online) and Microsoft Office 2007, following (Ludwig and James, 1988). However, to sustain the consistency and to decrease ambiguity, combined data of two seasons were used for results presentation. Diversity indices (diversity index, evenness, dominance and richness) were statistically calculated in accordance with Shannon's Diversity Index (Shannon, 1948; Kovach, 2003). CCA analysis was carried out on soil macrofauna data, collected from tomato and cauliflower (control and treated) fields with reference to soil macro- and micro- and macro-nutrients together with edaphic factors such as pH, EC, via MVSP software.

RESULTS

Among all four fields a total of 7845 specimens were recorded during complete sampling. After 7 samplings per field the population recorded was as follow: in tomato control fields 35.25% (N=2766) in tomato treated fields 27.89% (N=2188), in cauliflower control fields, 27.89% (N=2188) and 8.91% (N=699) from cauliflower treated fields (Table 1).

Table 1. Population record of soil macrofauna from Tomato and Cauliflower fields.

Field Type	Fauna Population
Tomato control	35.25% (N = 2766)
Tomato treated	27.89% (N = 2188)
Cauliflower control	27.95% (N = 2192)
Cauliflower treated	08.91% (N = 699)

In tomato control fields, among microhabitats, the highest relative abundance was recorded at boundary 44.46% (N=1230), while, from tomato treated fields, the highest relative abundance was recorded at center 41.77% (N=914). In cauliflower control fields at center 37.18% (N=815) and in treated fields 41.05% (N=287) was observed (Table 2).

Order Isopoda (75.16%) from phylum Arthropoda and order Stylommatophora (98.27%) from phylum Mollusca were the most abundant orders (Table 3) recorded in tomato fields. While order Hymenoptera (45.71%) from arthropods and order Stylommatophora (90.40%) from mollusks were the most abundant orders recorded from cauliflower fields (Table 4). Values of Shannon diversity index and richness index in tomato fields, were higher in control fields, while,

Table 2. Relative abundance of soil macrofauna in 2 microhabitats of the fields (tomato and cauliflower).

Field	Field Type	Side	Population Dynamics
Tomato	Treated	Boundary	28.74 % (N = 629)
		Middle	29.47 % (N = 645)
		Centre	41.77 % (N = 914)
	Control	Boundary	44.46 % (N = 1230)
		Middle	25.41% (N = 703)
		Centre	30.11% (N = 833)
Cauliflower	Treated	Boundary	26.89 % (N = 188)
		Middle	32.04 % (N = 224)
		Centre	41..05 % (N = 287)
	Control	Boundary	31.88 % (N = 699)
		Middle	30.93 % (N = 678)
		Centre	37.18 % (N = 815)

Table 3. Order-wise relative abundance of soil macrofauna in tomato fields.

Phylum	Order	Tomato Control	Tomato Treated
	Amphipoda	0.00 (0)	0.27 (6)
	Araneae	14.49 (208)	3.22 (70)
	Blattodea	0.00 (0)	0.00 (0)
Arthropoda	Coleoptera	9.82 (141)	4.19 (91)
	Dermaptera	5.22 (75)	7.09 (154)
	Diptera	0.00 (0)	0.00 (0)
	Hemiptera	0.00 (0)	0.09 (2)
	Hymenoptera	45.78 (657)	7.46 (162)
	Isopoda	22.29 (320)	75.16 (1631)
	Orthoptera	2.3 (34)	1.75 (38)
	Lithobiomorpha	0.00 (0)	0.00 (0)
	Lepidoptera	0.00 (0)	0.64 (14)
	Amphipoda	0.00 (0)	0.09 (2)
Annelida	Haplotaxida	0.00 (0)	100 (18)
	Stylommatophora	98.27 (1308)	0.00 (0)
Mollusca	Basommatophora	1.72 (23)	0.00 (0)

Table 4. Order-wise relative abundance of soil macrofauna in cauliflower fields.

Phylum	Order	Cauliflower Control	Cauliflower Treated
	Amphipoda	0.00 (0)	0.00 (0)
	Araneae	10.61 (52)	12.66 (85)
	Blattodea	0.00 (0)	0.29 (2)
	Coleoptera	15.91 (78)	17.88 (120)
Arthropoda	Dermaptera	3.26 (16)	5.06 (34)
	Diptera	0.00 (0)	1.78 (12)
	Hemiptera	0.81 (4)	0.59 (4)
	Hymenoptera	45.71 (224)	45.15 (303)
	Isopoda	12.24 (60)	7.45 (50)
	Orthoptera	9.79 (48)	4.61 (31)
	Lithobiomorpha	0.00 (0)	0.29 (2)
	Lepidoptera	1.63 (8)	4.17 (28)
Annelida	Haplotaxida	0.91 (20)	4.00 (28)
	Stylommatophora	90.40 (1672)	0.00 (0)
Mollusca	Basommatophora	0.46 (10)	0.00 (0)

Simpson's evenness showed significant difference in both treatments of tomato fields. In cauliflower fields, values of Shannon diversity index and richness index were higher in treated fields, while, Simpson's evenness also showed significant difference in both treatments of cauliflower fields. Dominance of species was as well significantly different among treated and control fields of both vegetables (Table 5).Data presented in (Fig. 3; Table 6), interpreted the correlation structure of soil parameters, field's type and species among tomato treated and control. The values of P, K and Cr were highly positively correlated with micro habitats (boundary, middle, and center) in treated field of tomato. Species *Cheliso chesmorio*, *Porcellio scaber* and *Trachelipusrathkii*were positively correlated with nutrients P, Cr and K.

Table 5. Diversity indices of soil macrofauna of cauliflower and tomato fields

Field/Treatment	N	H' Shannon	Evenness (J)	Dominance (D=1-J)	R	D
					(Richness) Margalef richness index	Simpsons evenness index
Tomato Treated	2188	2.0598	0.5031	0.4969	7.6716	0.3115
Tomato Control	2766	2.9375	0.6804	0.3196	9.3374	0.1445
Cauliflower Treated	699	3.4512	0.8464	0.1536	8.8554	0.0474
Cauliflower Control	2192	1.8643	0.4742	0.5259	6.4998	0.3929

Table 6. Association of the soil macrofauna at the soil nutrients as result of CCA from tomato control and treated fields.

Call:
CCA (X = tomato species, Y = tomato soil)
Partitioning of mean squared contingency coefficient:
InertiaProportion
Total 1.315 1
Constrained 1.315 1
Unconstrained 0.000 0
Species scores
CCA1 CCA2 CCA3 CCA4 CCA5
Eratigena agrestis -0.30267-0.72516 0.96627 -0.175943 -0.434246
Malthonica pagana 0.42232 -0.80674 -1.00634 -0.055106 -0.275360
Tegenaria atrica -0.04184 -0.25400 -0.52342 -1.036467 -0.237923
Trochosa spp. 1.65105 1.10516 0.70818 0.122987 0.129877
Tigrosa helluo 0.17685-1.95177 1.98229 -0.050785-0.005033
Trochosa terricola 0.20475 -1.77704 2.45791 0.117335 0.145673
*Trochosa ruricola*0.48351 0.63597 0.69976 0.007521 -0.010321
*Pardosa pullata*0.32416 0.32829 0.54374 0.272962 0.124328
Trochosa spinipalpis 0.32899 0.39344-0.09118 0.303247 0.393763
Paederus littoralis 0.47617 -0.87800 -1.07939 0.406301 -0.077518
Pentodon idiota 0.92066 -1.31979 -1.43471 -0.051993 0.143373
Promethis nigra 0.37124 -1.68593 0.78594 0.382504 -0.185430
Chelisoches morio -0.33031 0.23478-0.01778-0.198920 -0.151172
Forficula auricularia 0.06305 -1.52303 1.42915 0.253898 -0.243492
Messor barbarous 0.89516 0.56463 0.03606 0.165176 -0.352779
*Solenopsis mandibularis*0.41668 -0.35521 0.08930 -0.299656 0.104748
Camponotus herculeanus 0.75474 0.96069 0.36058 0.069612 -0.021627
Trichorhina tomentosa -0.30274 -0.48834 0.59583 -0.400299 -0.100502
Cylisticus convexus 0.32456 0.87436-0.68750 0.5133240.144305
Oniscus asellus -0.55079 0.22988 -0.14305 -0.172585-0.247140
*Trichoniscus pusillus*1.17569 -1.60189 -1.67789 0.262957-0.009229
Porcellio scaber-0.54763 0.18962 -0.04487 0.172113-0.171186
Trachelipus rathkii 0.01408 0.09536 -0.25766 -0.649587 0.515870
Acheta domesticus -0.05361 -0.28440 -0.58262 0.129330 -0.004176
Gryllus pennsylvanicus-0.04080 -0.74729 0.15617 0.432983 -0.092456

Table 7. Association of the soil macrofauna at the soil nutrients as result of CCA from the cauliflower control and treated fields

Call:
CCA (X = cauliflower species, Y = cauliflower soil)
Partitioning of mean squared contingency coefficient:
Inertia Proportion
Total 1.39 1
Constrained 1.39 1
Unconstrained 0.00 0
Species scores
CCA1 CCA2 CCA3 CCA4CCA5
Tegenariaatrica-0.06917 0.8263 -0.02721 -1.303579 0.29765
*Rabidosarabida*0.28646 0.8878 0.43683 -0.053609-0.27770
Pardosapullata 0.41280 0.4851 0.24143 0.1933520.44794
Hognalenta -0.03270 1.3671 0.54597 -0.464256-0.09535
*Paederuslittoralis*0.22499 0.6904 0.11063 -0.0022470.36242
Coccinellaseptempunctata-1.45961 -0.7591 0.57490 0.041404-0.10069
Forficulaauricularia-0.32119 0.4904 -0.68385 0.4535630.14322
Messorbarbarous -0.07897 0.1092 -0.48713 0.002474-0.08317
*Camponotusvagus*0.59201 0.6522 0.60754 0.899677-0.06374
*Formica*spp. -1.34663 -0.5751 0.56965 -0.120781 -0.03882
*Monomorium pharaonis*1.12368 -0.7785 0.09108-0.108001-0.01274
Camponotuschromaiodes-1.23366 -0.3912 0.56441 -0.2829650.02306
Oniscusasellus-1.37367-0.7207 0.09886 0.247230-0.01232
*Galleria mellonella*0.30015 -0.2683 -1.38825 -0.205971-0.40808
Spilosomalubricipeda-0.17608-0.8122 0.61442 0.3796790.57310
*Phragmatobiafuliginosa*0.01335 1.3928 0.55316 -0.144664-0.26418
Aporrectodeacaliginosa-0.72623 -0.1585 -0.18321 -0.2916300.04526

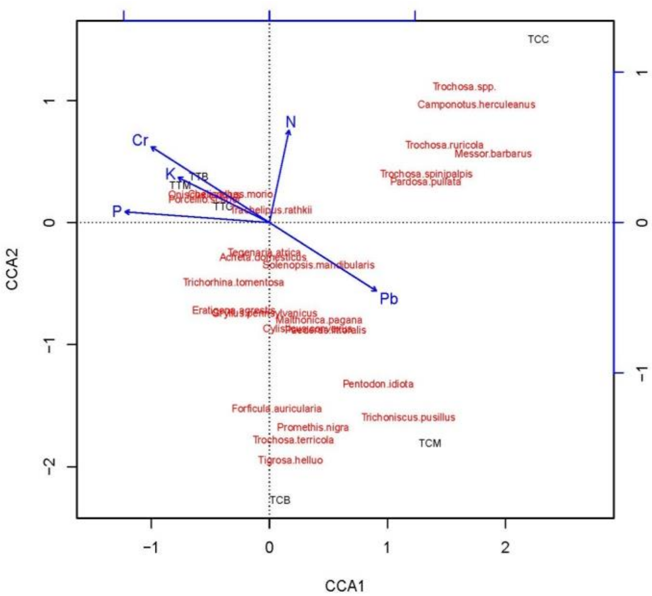

Figure 3. CCA analysis of abundance of soil macrofauna related to soil nutrients in tomato control and treated fields

The N concentration had slight impact and was positively correlated to the following species *Camponotusherculeanus, Trochosaruricola, Messorbarbarus, Trochosaspinipalpis, Pardosapullata*among tomato control fields at center. While, the Pb showed positive correlation with species*Tegenariaatrica, Acheta domesticus, Solenopsismandibularis, Trichorhinatomentosa, Eratigenaagrestis, Grylluspennsylvanicus, Malthonicapaganaand Cylisticusconvexus.*

Data presented in (Fig. 4; Table 7), interpreted that Pb and P showed negative correlation with each other in first two axes. Concentration of P was highly correlated with *Forficulaauricularia* in cauliflower treated fields. Whereas, K, N and Cr were highly positively correlated to each other and they also showed association at center with cauliflower control. Nutrients such as K and Cr showed a positive correlation to the soil macrofauna species*Aporrectodeacaliginosa, Aporrectodeacaliginosa, Formica*. spp.,*Oniscusasellus* and *Coccinellaseptempunctata*. Nitrogen was recorded positively correlated to the species *Spilosomalubricipeda*. On other hand, Pb was correlated with the cauliflower treated at center and with the species, *Galleria mellonella*. However, *Monomorium pharaonis*, showed high correlation with cauliflower treated field at boundary.

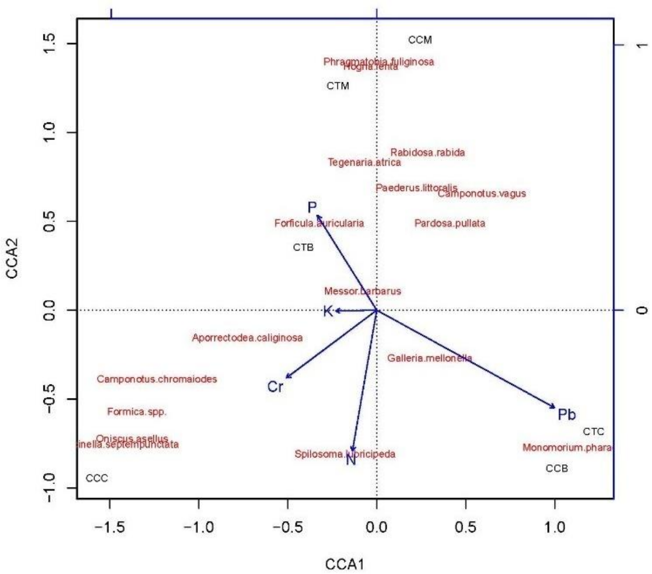

Figure 4. CCA analysis of abundance of soil macrofauna related to soil nutrients in cauliflower control and treated fields.

DISCUSSION

In present study the examined soil samples were sampled from the same urban district, but their physico-chemical characters strongly differed. The soils had a variation in soil macrofauna density, while they differed to some extent in taxa richness as well. The density decreased at the maximum concentrations of nutrients in both tomato and cauliflower fields. Therefore, it may be stated that abundance and density of organism is more subjected by soil characteristics as compared to taxa richness, since also accounted by Nahmani and Lavelle (2002) and Siqueira *et al.* (2014).

In present study, the order Hymenoptera (Formicidae; ants), was a dominant taxonomic group of arthropods showing that they are tolerant to a wide range of soil properties (Table 4), as earlier reported by Tessaro *et al*. (2013). Contrary to this, Marinho *et al*. (2002) and Ribas *et al*. (2012), stated that ants (Hymenoptera) are excellent indicators of anthropogenic activities related to soil, industrial toxic waste as well as thriving treatment of ruined areas, the findings of their studies were analogous to our result in case of tomato fields, where Hymenopterans density decreases with elevating level of pollution (Table 3). Existence of order Stylommatophora from phylum Mollusca in only control fields showed that they have potential prospective to be exercised in environmental check-based studies as a good bio-indicator of heavy metals pollution (Nica *et al.*, 2012).

As reported by Lavelle (1997) the soil type with elevated concentration of micronutrients/ macronutrients or organic matter, supports more faunal diversity over there. In another study by Menta (2012), he acknowledged that anthropogenic

Appendix: Species-wise relative abundance of tomato and cauliflower fields (most abundant species)

Order	Family	Species	Tomato Treated	Tomato Control	Cauliflower Treated	Cauliflower Control
Araneae	**Agelenidae**	*Eratigena agrestis*	0.457 (10)	0.216 (6)	0.00(0)	0.547 (12)
		Tegenaria atrica	0.365 (8)	0.072 (2)	1.716 (12)	0.091 (2)
	Lycosidae	*Tigrosa helluo*	0.365 (8)	1.265 (35)	0.00 (0)	0.091(2)
		Pardosa pullata	0.365 (8)	1.301 (36)	0.00 (0)	0.182 (4)
		Pardosa amentata	0.091 (2)	0,00 (0)	0.00 (0)	0.091 (2)
		Hogna lenta	0.0919(2)	0.144 (4)	0.00 (0)	0.456 (10)
Coleoptera	**Staphylinidae**	*Paederus littoralis*	0.365 (8)	0.361 (10)	0.286 (2)	0.273 (6)
	Coccinellidae	*Coccinella septempunctata*	0.457 (10)	0.00 (0)	0.00 (0)	1.003 (22)
Dermaptera	**Forficulidae**	*Forficula auricularia*	0.548 (12)	1.193 (33)	0.00 (0)	0.729 (16)
		Aporrectodea caliginosa	0.182 (4)	0.00 (0)	1.144 (8)	0.912 (20)
Hemiptera	**Cimicidae**	*Cimex lectularius*	0.091 (2)	0.00 (0)	0.572 (4)	0.182 (4)
Hymenoptera	**Formicidae**	*Messor barbarus*	0.365 (8)	5.350(148)	0.286 (2)	2.965 (65)
		Camponotus vagus	1.553 (34)	0.00 (0)	8.583 (60)	0.775 (17
		Camponotus pennsylvanicus	0.091 (2)	0.00 (0)	2.002 (14)	0.547 (12)
		Formica spp.	0.731 (16)	0.00 (0)	0.00 (0)	0.456 (10)
		Monomorium pharaonis	0.00 (0)	1.482 (41)	0.00 (0)	2.463 (54)
		Camponotus chromaiodes	0.00 (0)	0.00 (0)	0.00 (0)	0.547 (12)
Isopoda	Platyarthridae	*Trichorhina tomentosa*	3.244 (71)	1.012 (28)	1.716 (12)	1.414 (31)
	Oniscidae	*Oniscus asellus*	1.828(40)	0.00 (0)	0.00 (0)	1.322 (29)
Orthoptera	Gryllidae	*Acheta domesticus*	1.005 (22)	0.289 (8)	0.00 (0)	1.003 (22)
Lepidoptera	Erebidae	*Spilosoma lubricipeda*	0.182 (4)	0.00 (0)	0.572 (4)	0.182 (4)
		Phragmatobia fuliginosa	0.091 (2)	0.00 (0)	0.286 (2)	0.091 (2)
Haplotaxida	Lumbricidae	*Lumbricus terrestris*	0.365 (8)	0.00 (0)	1.716 (12)	0.00 (0)
		Aporrectodea caliginosa	0.182 (4)	0.00 (0)	1.144 (8)	0.912 (20)
Stylommatophora	Succineidae	*Succinea putris*	0.00 (0)	8.857 (245)	0.00 (0)	7.572(166)
		Succinea spp.	0.00 (0)	35.249(975)	0.00 (0)	61.724 (1335)

activities, resulting environmental changes, often have several effects on biodiversity, species composition, and ecosystem functioning. Considering interactions of soil macrofauna to the soil elements (Fig. 1), present study showed that macronutrient N and micronutrient Pb has positive interaction with few species while negative for others. The results were analogous to the findings of some researchers who worked on sewage sludge disposal in the soil (Matos *et al*., 2004; Ratan and Datta, 2005; liu *et al*., 2013). In present study, only Pb, Cr and Ni were measured as indicators of urban pollution. When the concentration of micro- and macro-nutrients exceed beyond limit it have negative effects on species abundance and population density. Similarly, Chrzan (2017) determined the content of the heavy metals Pb, Cd, Ni, Zn and Cu in the soil of selected habitats of Niepołomice Forest the fauna inhabiting them and reported these heavy metals affect negatively on the abundance, density, diversity and trophic structure of the fauna studied during their research.

Heavy-metal contaminated soils may transfer pollutants to further levels/elements of the trophic chain. Right assessment of soil pollution with heavy metals and resulting threats there, is very important to the environment, and, consequently, to the living organisms *(*Rana, *et al*., 2010).

The sewage effluents were loaded with organic matter (OM) and nutrients like N, P, K with eminent level of heavy metals when getting into cultivating fields (Singh *et al*., 2004). In our study, increase in macronutrients level, owing to sewage water irrigation, stimulates modifications in soil faunal population abundance, functioning and growth rate. This result was consistent to former studies (Bunemann and McNeill, 2004; Wang *et al*., 2016). In present study, macro-nutrients concentration increases in the soils, due to sewage water irrigation, stimulate modification in soil faunal populations. This result was consistent by former studies (Wang *et al*., 1998). On other hand, Pb was correlated with the cauliflower treated at center and with the species, *G. mellonella*. However, *M. phoranis*, showed high correlation with cauliflower treated field at boundary. Heavy metals do not degrade and are accumulated into soil fauna, which cause damage depending on level of exposure i.e. severe or chronic exposure (Nahmani *et al*., 2002; D'Amore *et al*., 2005).

Heavy-metal contaminated soils may transfer pollutants to further levels/elements of the trophic chain. Right assessment of soil pollution with heavy metals and resulting threats there, is very important to the environment, and, therefore, to the living organisms *(*Rana, *et al*., 2010*).* The sewage effluents were loaded with organic matter (OM) and other nutrients like N, P, K along with elevated level of heavy metals (Fe, Mn, Cu, Zn, Hg, Pb, Cr, Ni, Cd and Co) when reaching to the cultivating fields (Singh *et al*., 2004). Heavy metals do not degrade and are accumulated into soil fauna, which cause damage depending on level of exposure i.e. severe or chronic exposure (D'Amore *et al*., 2005). Positive correlation between N and species *S. lubricipeda* was recorded, as documented by Sun *et al*. (2016) who studied effect of N on soil fauna, as a result negative. impact on soil arthropods population was recorded. Silva *et al*. (2008) observed that the total amount of heavy metals in soil are higher in plots fertilized with Barueri sewage sludge in relation to those quantified in areas treated with sludge (domestic waste). In other studies, it was observed that soil pH strongly affects soil macrofauna abundance and distribution. Soil pH significantly affects earthworm and beetle taxa distribution (Stork and Eggleton, 1992; Ayuke *et al*., 2009; Auclerc *et al*., 2012), these studies were consistent with present study results in which we observed that pH induced alterations in soil macrofaunal communities.

Conclusion: The sewage wastewater has many vital micro- and macro-nutrients for flora and fauna but on the other hand, they execute harmful effects on soil biota, as their concentration exceed permissible limits; consequently, soil and eco-efficiency of cultivated crop become malfunctioned. The negative impacts of polluted waters interpose harmful effects on abundance, density, diversity and distribution of soil macrofaunal populations. Hence, to ensure future and safeguard living beings, strategic plans may have to launch to sustain the integrity of biogeochemical cycling for soil capitalization along with the biotic and abiotic components.

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