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The Impact of Physicochemical Parameters on The Density And Diversity of Water Mite Communities of The Downstream Zone of Song River in Dehradun, Uttarakhand.

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Abstract: The present study was conducted at the downstream zone of River Song from Dehradun in Uttarakhand state of India from September 2019 to August 2020 to investigate the monthly variation of water mites with its relation to physico-chemical parameters. During the study, a total of 19 species of water mites belonging to 4 families Feltriidae, Hygrobatidae, Torrenticolidae, and Sperchontidae were reported. The maximum average number of individuals in spots of the downstream zone was recorded as 188 individuals/m^2 in the month of December and the minimum was 9 individuals/m^2 in July. Various diversity indices were calculated using Past 3.26.

Keywords: Water mites • Physico-chemical parameters • Diversity indices • Downstream zone • Song River

Introduction

Water mites (Hydrachnidia) are an important group of freshwater invertebrates belonging to subclass Acari within the class Arachnida. They are the most successful among the different lineages of the Acari in terms of diversification, adaptation and ecological specialization (Sabatino et al, 2000). They are grouped into 8 superfamilies, 50 families and more than 300 genera including about 10,000 species worldwide (Sabatino et al, 2008, Bahuguna et al, 2020). Walter (1928) and Lundblad (1934) initiated the research on water mites in India at the beginning of the 20th century. Later Cook (1967) gave a detailed analysis on water mites followed by Prasad (1974) who gave a catalogue of water mites of India. Based on the various research in different parts of India, it is recorded that about 275 species in 70 genera and 25 families of Aquatic mites are present in India (Pesic et. al., 2010). Kumar and Dobriyal, (1992), Kumar et. al., (2007), Pesic et.al., (2007a,b, 2019a,b, 2020a,b), Bahuguna et.al., 2019, 2020, Negi et.al., 2021, Bahuguna and Dobriyal, (2022), Pesic et al., (2022a) and Pesic et al., (2022b) have worked on water mites of different Hill stream of Garhwal, Uttarakhand.

Song River is the largest river in the district and is the most important source of water supply. Flowing through a mountainous range, many streams run into the river, which brings several natural minerals to the river water. It is used for several purposes like fishing, domestic, agricultural, and other anthropogenic activities throughout the valley. Besides this, it has been a rich habitat for a diverse form of aquatic plants and animals contributing to the biodiversity of India. It is associated with different micro and macro fauna contributing to its productivity. A sustainable regulation of life in water resources is significantly dependent on its water quality that changes with the season, geological conditions, natural and man-made activities (Bansal and Joshi, 2014 and Bisht et al., 2017). Changes in water quality parameters like pH,

Temperature, Dissolved Oxygen, Conductivity, Stream Velocity greatly influence the flora and fauna of water ecosystem. So, regular assessment of these parameters is quite necessary to analyze their correlation with the biotic community.

Water mites have been used as important environmental quality indicators as they are very sensitive to any change in the physical or chemical characteristics of their aquatic ecosystems (Rousch et al, 1997; Di Sabatino et al., 2002; Dohet et al., 2008 and Goldschmidt, 2016). Water mites have been affected by biological water quality parameters (like temperature, depth, substrate and water velocity), the concentration of chemical composition, organic pollutants through agriculture, industrialization and water effluents and other man-made activities in freshwater ecosystems (Cicolani & Di Sabatino, 1991, 1992 and Di Sabatino & Cicolani, 1999). Any contamination in their ecosystem is easily sensed by water mites, which greatly affects their diversity, abundance and community structure (Young, 1969). So, it is important to study the ecological parameters of the area for a better understanding of its ecosystem along with the status, diversity and composition of water mites. This study is aimed to investigate the density and diversity of water mites in the downstream zone of Song River with its relation to the ecological parameters.

Material and method

Study area

The research was conducted on two different spots of the downstream zone of Song River in Dehradun, Uttarakhand with 30º 10’ 44” N Latitude and 78º 7’ 55” E Longitude. It originates from the mountains of the Dhanolti region and crosses with Sahastradhara streams to flow downwards towards Doon valley basins and meets with River Ganga at Raiwala. Samples were collected monthly from the selected spots of the downstream zone for the duration of twelve months i.e., September 2019 to August 2020.

Sample collection and physicochemical analysis

Samples of water mites were collected monthly from various habitats like submerged vegetation, stones by using brushes and from stream bed by hand netting. They were preserved in 70% ethanol on spot and were later on transferred to Koenike’s fluid. These were then identified using several keys provided by Cook (1967, 1974), Kumar et al. (2007), Pesic and Panesar (2008), Pesic et al. (2019a, b) and Pesic et al. (2020 a, b). Various diversity indices were then statistically analyzed using the PAST 3.26 version.

Physico-chemical analysis like Temperature, pH, Stream Velocity, Dissolved Oxygen, Free CO_2, Total Alkalinity, Total Hardness, and Conductivity was measured according to APHA (1998) Standard methods.

Result

The comparative analysis of monthly average variation in density and diversity of water mites in two different spots of the downstream zone of Song River during 2019-2020 is presented in Table-1. The monthly mean values of density and diversity of water mite in spot-1 and 2 showed the maximum density of 188 individuals/m^2 was noted in December whereas a minimum 9 individuals/m^2 were noted in July. Similarly, water mite density was noted high during winter and least during monsoon. The average family and season-wise density of water mites is shown in Table-2. A total of 19 water mite species belonging to 4 families i.e., Feltriidae, Hygrobatidae, Sperchontidae and Torrenticolidae were identified from both Spots.

Family Torrenticolidae dominated followed by Sperchontidae, Hygrobatidae and Feltriidae. *Sperchon indicus*, *Monatractides garhwalensis*, *Atractides indicus* were documented as the abundant species at Spot-1 while *Sperchon indicus*, *Torrenticola uttarakhandensis* and *Atractides garhwali* were noted as the abundant species of Spot-2 in the downstream zone..

Table 1: Monthly average variation of density and diversity of water mites in the Upstream Zone of Song River during 2019-2020.

S. No.	Family/Genus/Species	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1	**Family – Feltriidae K.Viets, 1926, Genus – Feltria Koenike, 1892**												
a	*Feltria gereckei*	0 ±0.00	1 ±1.41	1.5 ±0.71	2.5 ±0.71	0 ±0.00	1 ±0.00	0 ±0.00	0 ±0.00	1 ±1.41	1 ±0.00	0 ±0.00	1.5 ±0.71
b	*Feltria indica*	0 ±0.00	1.5 ±0.71	0 ±0.00	3 ±2.83	0 ±0.00	1 ±0.00	0 ±0.00	0 ±0.00	0 ±0.00	0 ±0.00	0 ±0.00	0 ±0.00
	Total	**0.0**	**2.5**	**1.5**	**5.5**	**0.0**	**2.0**	**0.0**	**0.0**	**1.0**	**1.0**	**0.0**	**1.5**
2	**Family – Hygrobatidae Genus – Atractides Koch**												
c	*Atractides garhwali*	4.5 ±2.12	6 ±1.41	7.5 ±2.12	17 ±2.83	13.5 ±2.12	11 ±1.41	9.5 ±0.71	3 ±1.41	0 ±0.00	2.5 ±0.71	0 ±0.00	0 ±0.00
d	*Atractides incertus*	1 ±0.00	0 ±0.00	1.5 ±0.71	5.5 ±2.12	1 ±1.41	2 ±0.00	2 ±1.41	0 ±0.00	1 ±0.00	0 ±0.00	0 ±0.00	0 ±0.00
e	*Atractides indicus*	3 ±1.41	5.5 ±2.12	8 ±1.41	15.5 ±2.12	12 ±1.41	9.5 ±2.12	10 ±0.00	6 ±2.83	0 ±0.00	1 ±0.00	1 ±1.41	0 ±0.00
f	*Atractides ootacamundis* (Cook)	1 ±0.00	1.5 ±0.71	2 ±1.41	3 ±1.41	0 ±0.00	1 ±1.41	1.5 ±0.71	0 ±0.00	0 ±0.00	1 ±0.00	0 ±0.00	0 ±0.00
	Genus – Hygrobates Koch												
g	*Hygrobates dobriyali*	0 ±0.00	1 ±0.00	0 ±0.00	4 ±1.41	2 ±1.41	2.5 ±0.71	1 ±0.00	0 ±0.00	1.5 ±1.71	0 ±0.00	0 ±0.00	0 ±0.00
	Total	**9.5**	**14**	**19**	**45**	**28.5**	**26**	**24**	**9**	**2.5**	**4.5**	**1**	**0**
3	**Family – Torrenticolidae Piersig 1902, Genus – Torrenticola Piersig**												
h	*Torrenticola episce*	1 ±1.41	2 ±1.41	0 ±0.00	8.5 ±2.12	4.5 ±0.71	4.5 ±0.71	2.5 ±0.71	0 ±0.00	1 ±0.00	0 ±0.00	1 ±0.00	0 ±0.00
i	*Torrenticola kumari*	0 ±0.00	2 ±1.41	4.5 ±0.71	9 ±1.41	5.5 ±2.12	9.5 ±0.71	6 ±1.41	5.5 ±0.71	2 ±1.41	0 ±0.00	1 ±1.41	1 ±0.00
j	*Torrenticola semisuta*	0 ±0.00	1 ±0.00	1 ±0.00	10.5 ±2.12	7.5 ±2.12	6 ±0.41	3.5 ±0.71	6 ±1.41	0 ±0.00	1 ±0.00	0 ±0.00	1 ±1.41
k	*Torrenticola muranyii*	1 ±1.41	1 ±1.41	2 ±1.41	9.5 ±2.12	6.5 ±0.71	5 ±1.41	2.5 ±0.71	4 ±1.41	2 ±0.00	0 ±0.00	0 ±0.00	1 ±0.00
l	*Torrenticola uttarakhandensis*	0 ±0.00	3 ±1.41	6.5 ±0.71	15 ±2.83	13.5 ±2.12	10 ±2.83	7 ±0.00	9.5 ±3.54	3 ±1.41	1 ±0.00	1 ±0.00	2.5 ±0.71
m	*Torrenticola wonchoeli*	0 ±0.00	0 ±0.00	1 ±0.00	10.5 ±0.71	8 ±1.41	5 ±1.41	2.5 ±0.71	1.5 ±2.12	1 ±0.00	0 ±0.00	1 ±0.00	0 ±0.00
	Genus – Monatractides												
n	*Monatractides garhwaliensis*	1 ±0.00	2.5 ±0.71	7 ±2.83	16 ±5.66	12.5 ±3.54	11 ±1.41	9.5 ±0.71	5.5 ±0.71	2 ±0.00	2 ±1.41	2 ±0.00	0 ±0.00
o	*Monatractides oxystomus*	0 ±0.00	1 ±0.00	0 ±0.00	5.5 ±2.12	2 ±0.00	4.5 ±3.54	1 ±0.00	0 ±0.00	0 ±0.00	1 ±0.00	0 ±0.00	0 ±0.00
p	*Monatractides kontschani*	0 ±0.00	1 ±0.00	1.5 ±0.71	6.5 ±0.71	3 ±1.41	0 ±0.00	0 ±0.00	3 ±1.41	1.5 ±0.71	1.5 ±0.71	0 ±0.00	0 ±0.00
	Total	**3**	**13.5**	**23.5**	**91**	**63**	**55.5**	**34.5**	**35**	**12.5**	**6.5**	**6**	**5.5**
4	**Family – Sperchontidae, Genus – Sperchon Kramer**												

q	*Sperchon garhwalensis*	1.5 ±0.71	3.5 ±2.12	5 ±1.41	14 ±2.83	11.5 ±2.12	9 ±1.41	6 ±1.41	8.5 ±0.71	6 ±2.83	1 ±0.00	0 ±0.00	1 ±1.41
r	*Sperchon indicus*	8 ±0.00	9.5 ±0.71	12 ±0.00	22.5 ±0.71	20 ±1.41	17.5 ±0.71	15 ±1.41	16 ±1.41	8 0.00	3.5 ±3.54	2 ±0.00	4 ±4.24
s	*Sperchon ootacamundis*	0 ±0.00	0 ±0.00	1 ±1.41	10 ±1.41	5 ±0.00	3.5 ±2.12	0 ±0.00	0 ±0.00	2.5 ±0.71	0 ±0.00	0 ±0.00	1 ±0.00
	Total	**9.5**	**13**	**18**	**46.5**	**36.5**	**30**	**21**	**24.5**	**16.5**	**4.5**	**2**	**6**
	Total no. of water mites	**22**	**43**	**62**	**188**	**128**	**113.5**	**79.5**	**68.5**	**32.5**	**16.5**	**9**	**13**

The correlation graph of the various physicochemical parameters with average water mite density in the downstream region of Song River during 2019-2020 are displayed in Figures 1 to 7.

Table 2: Average Family and season-wise density of water mites in the Upstream Zone of Song River during 2019-2020.

S. No.	Families	Autumn	Winter	Spring	Summer	Monsoon
	Feltriidae	4 ±1.41	8±3.54	0 ±0.00	2 ±1.41	1.50 ±0.71
	Hygrobatidae	42.50 ±0.71	99.50 ±3.54	33 ±1.41	7 ±1.41	1 ±1.41
	Torrenticolidae	40 ±1.41	209.50±9.19	69.50 ±3.54	19 ±4.24	11.50 ±3.54
	Sperchontidae	40.50 ±3.54	113 ±9.90	45.50 ±0.71	21 ±1.41	8 ±5.66
TOTAL		**127.00**	**429.50**	**148.00**	**49.00**	**22.00**

Table 3: Month-wise diversity indices of water mites in Spot-1 of Downstream Zone during 2019-2020.

Months→ / D. indices↓	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
Taxa S	8	14	15	19	15	17	15	10	13	11	5	6
Individual	21	37	64	188	119	104	80	65	33	12	7	7
Dominance	0.181	0.105	0.097	0.065	0.089	0.081	0.101	0.115	0.117	0.016	0.095	0.048
Simpson Index	0.819	0.895	0.903	0.935	0.911	0.919	0.899	0.885	0.883	0.985	0.905	0.952
Shannon-Weiner Index	1.599	2.144	2.278	2.724	2.427	2.497	2.285	2.094	2.054	1.953	1.264	1.391
Evenness	0.618	0.609	0.650	0.802	0.755	0.714	0.655	0.811	0.600	0.641	0.708	0.670
Margalef Index	2.299	3.600	3.666	3.437	2.929	3.445	3.195	2.156	3.432	4.024	2.056	2.569

Table 4: Month-wise diversity indices of water mites in Spot-2 of Downstream Zone during 2019-2020.

Months→ / D. indices↓	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
Taxa S	8	16	14	19	16	18	15	11	12	11	7	8
Individual	23	49	60	188	137	123	79	72	32	21	11	19
Dominance	0.182	0.086	0.098	0.065	0.078	0.071	0.089	0.116	0.099	0.105	0.073	0.158
Simpson Index	0.818	0.914	0.902	0.935	0.922	0.929	0.911	0.884	0.901	0.895	0.927	0.842
Shannon-Weiner Index	1.612	2.330	2.246	2.730	2.536	2.600	2.378	2.154	2.091	1.915	1.621	1.651
Evenness	0.627	0.642	0.675	0.807	0.789	0.748	0.719	0.784	0.675	0.617	0.723	0.652
Margalef	2.233	3.854	3.175	3.437	3.049	3.533	3.204	2.338	3.174	3.285	2.502	2.377

The maximum value of water temperature was noted during August (23.80 ±0.04ºC) while the minimum value (12.50±0.03 ºC) was noted in winter (January). The maximum value of pH was recorded as 8.30±0.00 in February whereas the minimum was 7.30±0.14 during monsoon (August). Highest Stream velocity value of 0.21±0.01 m/sec was obtained in June and the lowest value 0.87±0.04 m/sec was noted in July. Dissolved oxygen concentration and alkalinity were highest as 9.75±0.07 mg/l and 71.40±0.14 mg/l in January and February respectively whereas the lowest values were noted 7.25±0.07 mg/l and 63.70±0.14 mg/l in August. The maximum value for Total Hardness was found as 93.60±0.42 mg/l in June whereas minimum value as 80.60±0.14 mg/l in February. Free CO_2 concentration was nil throughout the year in both the spots during the study period while the maximum and minimum values of conductivity were found to be 109.45±0.49 µS/cm and 67.85±0.07 µS/cm during April and June respectively. The Taxa index for both spots was highest (19 each) in December and lowest (5 and 7) in July. The Simpson index was maximum as 0.985 in June and minimum as 0.819 in September at Spot-1. It was highest (0.935) in December and lowest (0.818) in September. Shannon-Weiner Index ranged from 1.264 (July) -2.724 (December) at Spot-1 and from 1.612 (September) -2.730 (December) for Spot-2. A high evenness value was reported in April as 0.811 while lowest was 0.600 in May. Whereas, maximum evenness was in December (0.807) for Spot-1 and minimum evenness was noted in June (0.617). The Margalef index that shows species richness of the system ranged from 2.056 (July) - 4.024 (June) in Spot-1 and from 2.223 (September) – 3.854 (October) in Spot-2.

Table 5: Average physicochemical parameters recorded from the Downstream Zone of Song River (Sep 2019 to Aug 2020).

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Water Temperature(ºC)	23.18 ±0.03	20.20 ±0.01	16.85 ±0.01	13.25 ±0.04	12.50 ±0.03	15.00 ±0.04	17.00 ±0.00	19.00 ±0.03	20.00 ±0.04	21.10 ±0.01	22.74 ±0.06	23.80 ±0.04
pH	7.65 ±0.21	7.80 ±0.14	7.85 ±0.07	8.05 ±0.07	8.25 ±0.07	8.30 ±0.00	8.05 ±0.07	7.85 ±0.07	7.70 ±0.14	7.45 ±0.07	7.40 ±0.28	7.30 ±0.14
Stream Velocity (m/sec)	0.49 ±0.01	0.47 ±0.01	0.44 ±0.01	0.41 ±0.01	0.39 ±0.02	0.23 ±0.04	0.22 ±0.00	0.29 ±0.01	0.23 ±0.01	0.21 ±0.01	0.87 ±0.04	0.84 ±0.05
Dissolved Oxygen (mg/l)	7.75 ±0.21	8.25 ±0.07	8.75 ±0.07	9.30 ±0.14	9.75 ±0.07	9.50 ±0.14	9.05 ±0.07	9.00 ±0.14	8.85 ±0.07	8.15 ±0.07	7.35 ±0.21	7.25 ±0.07
Total Alkalinity (mg/l)	65.65 ±0.21	67.00 ±0.28	68.40 ±0.42	69.85 ±0.07	68.40 ±0.28	71.40 ±0.14	71.05 ±0.07	68.35 ±0.35	67.45 ±0.07	64.80 ±0.14	66.35 ±0.21	63.7 ±0.14
Total Hardness (mg/l)	84.70 ±0.14	85.20 ±0.14	82.40 ±0.42	84.60 ±0.28	82.60 ±0.14	80.60 ±0.14	84.55 ±0.49	91.30 ±0.14	92.80 ±0.14	93.60 ±0.42	83.40 ±0.28	81.15 ±0.07
Free CO_2 (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Conductance (µS/cm)	73.85 ±0.07	78.50 ±0.14	76.45 ±0.35	90.15 ±0.07	96.45 ±0.21	101.7 ±0.28	105.5 ±0.14	109.45 ±0.49	107.40 ±0.14	67.85 ±0.07	70.60 ±0.14	68.55 ±0.21

Table-3 and 4 represented the several diversity indices of the water mites at Spot-1 and Spot-2

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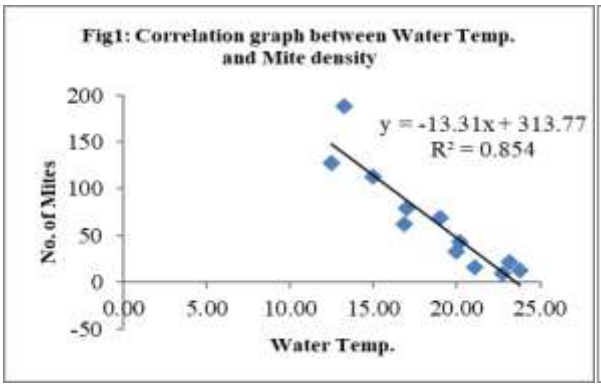

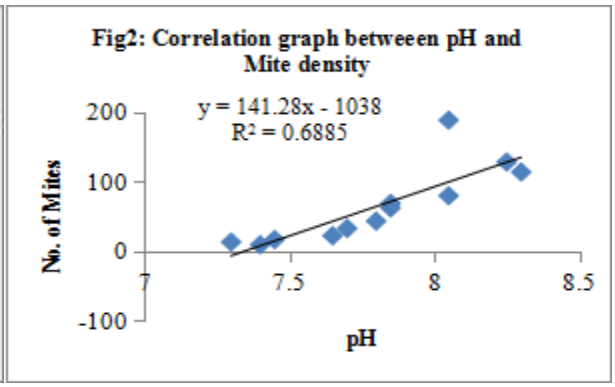

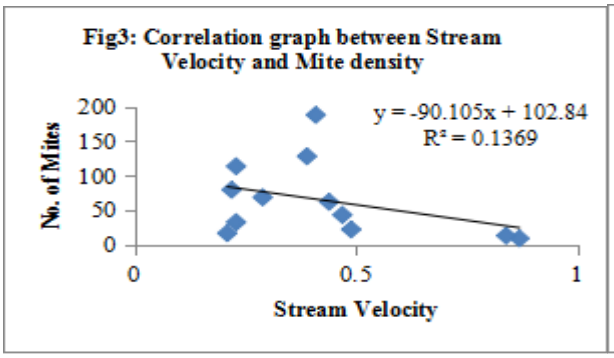

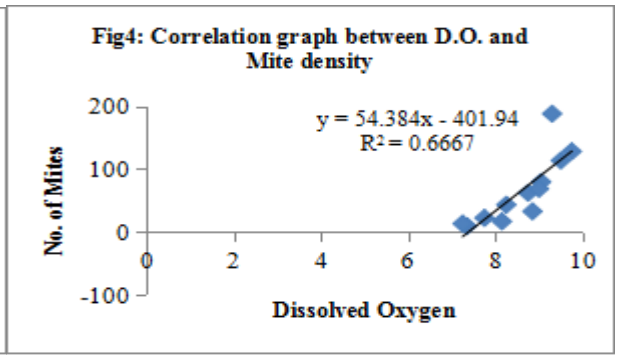

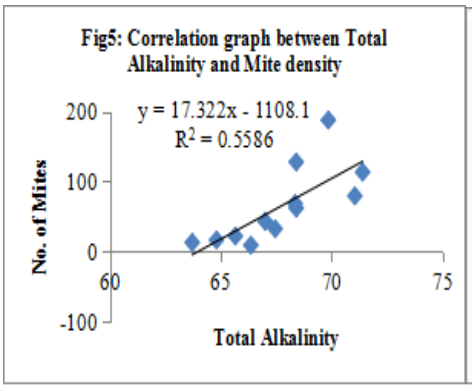

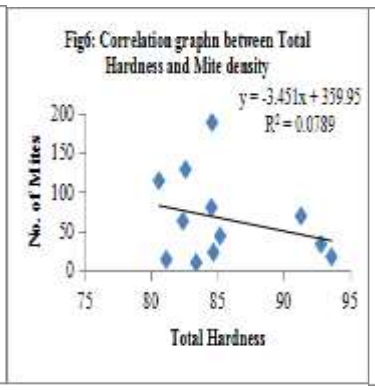

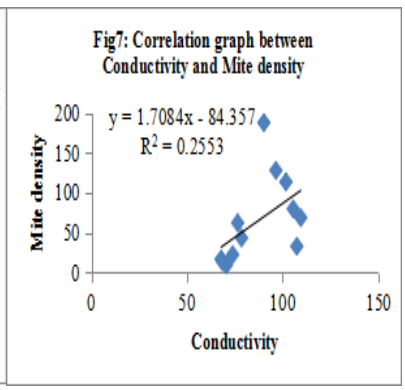

Discussion

A total of 19 species were found in the downstream zone of the River. The number of individuals and diversity were found maximum during winter in the month of December whereas the minimum value was obtained in July (Monsoon) for both spots. Similar findings were reported by Bahuguna et al. (2019) in the Randi gad stream and Negi et al. (2021) in the Khankra gad stream.

It is witnessed that the density and diversity of water mites of the river were controlled by various abiotic components directly or indirectly. The physical and chemical parameters directly affect the abundance, diversity and composition of water mites (Zawal et al. (2017). Schwoerbel (1959) and Smit and Van der Hammen (1992, 2000) mentioned that the species composition of water mites can be affected by pH, Oxygen concentration, conductivity, nutrient concentration, water

vegetation and other physicochemical parameters of the water bodies. During the study, it was detected that water mite density decreases with raising water temperature while it increases with the increase in pH values. The numbers lessen with the increase in the Velocity of the stream and increases with the increase in the values of dissolved oxygen (DO) concentration, Total Alkalinity, and Conductivity. A slight decrease in the number of water mites was obtained with increase in Total Hardness as well. Due to no traces of free CO_2, its relation with water mite density could not be inferred. Therefore, the pH, Dissolved Oxygen, Total Alkalinity and Conductivity showed a positive correlation with the number of water mites which may indicate their favorable concentration in the region. And, a negative correlation of water mite density with Water Temperature, Stream Velocity and Total Hardness was found. The assessment of water quality is a good tool to monitor the present status of any aquatic ecosystem and helps in promoting awareness and planning strategy for its management. Water mites may be used as the bio-indicator of aquatic ecosystems as their density, diversity, abundance and composition are affected by the changes in the physical and chemical parameters of water. The present study provides an understanding of assemblages of water mite communities in the downstream region of the river and the effects of varying ecological parameters on them. It indicated the fine status of water mites and water quality of the downstream area of the river ecosystem which could be enhanced by sustainable management of anthropogenic activities. Proper and sustainable management strategies are required in order to maintain its biotic and abiotic factors in the future.

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