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Short Research Article

Impact of Land Uses on Surface Water Quality and Associated Aquatic Insects at Parwanoo Area of Solan District of Himachal Pradesh, India

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Abstract

Study on water quality, its seasonal variation, type and diversity of aquatic insect fauna and quality of surface water during different seasons and under different land uses of Parwanoo area of Solan district of Himachal Pradesh was conducted during rainy, winter and summer seasons under different land uses. Samples of surface water from different sources under different land uses (agriculture, forest and urban) were collected and analysed for quality parameters viz. pH, temperature, electrical conductivity, total dissolved solids, biological oxygen demand(BOD), chemical oxygen demand(COD), Ca, Mg, NO_3, and Cl contents. The contents of all the elements were within permissible limits except Ca (>75 mg l^{-1}). Aquatic insects found in surface water were identified up to family level and Simpson Biodiversity, EPT and family biotic indices were calculated.

1. Introduction

Human population growth and land use changes have deteriorated water quality (Sliva and Williams 2001; Buck et al., 2004). The global transition from undisturbed areas to human dominated landscapes has strongly impacted on the physical features of lotic ecosystems (Allan, 2004; Vasanthavigar et al., 2010). Human disturbance alters water quality, habitat structure, hydrological regime, energy flow and biological interactions of aquatic ecosystem (Karr and Dudley, 1981; Karr, 1999). Certain nutrients are known to travel from agricultural and urban lands into rivers by means of runoff (Hynes, 1970; Smart et al., 1981) and influence the distribution and abundance of macro invertebrates depending on their tolerance and habitat requirements (Townsend et al., 1997). Water quality of the natural water bodies not only helps to ascertain the pollution control measures but also indicates its impact on aquatic ecosystem. Benthic macro invertebrates are good indicators of watershed health and fluctuations in aquatic insect communities give quick information on water quality (Singh, 1997).The terrestrial drainage basin and the stream channel, with its associated physical heterogeneity determine the spatial variation of the stream ecosystem (Schlosser, 1991). Biological measures provide an integrated, comprehensive assessment of the health of a water body over time (Karr, 1999). The aim of this study was to use physical, chemical and aquatic insect assemblage to assess changes in water quality under different land uses due to anthropogenic activities. The present study on impact of land uses on surface water quality and associated aquatic insects were under taken to know the quality of water status and the insect fauna associated with water bodies of Parwanoo area of Solan district of Himachal Pradesh.

2. Materials and Methods

Dharampur block of Solan district of Himachal Pradesh is situated between $30^0$54.079 N to $30^0$55.837 N and $076^0$49.473 E to $076^0$57.886 E at an altitude of 417 to 1478 meter above mean sea level. In this region, the winter season commences from October to March, summer season from April to June and rainy season from July to September. The Parwanoo area has rivers, *nalas*, *kuhls*, *bawries* and springs under different land use systems. The water samples have been drawn from different water sources falling under agriculture, forest and urban land uses.

2.1. Collection, preparation of water samples and analysis

Water samples (One litre) from different sources under different land uses (agriculture, forest and urban) were taken in transparent plastic bottles during summer, winter and rainy seasons and stored in the refrigerator at 4^{O}C for further analysis. Each sample was replicated thrice.

2.2. Water quality analysis

The water samples were analyzed for Physical, Chemical and Biological Parameters: pH was analyzed by EUTECH instrument pH-510 in laboratory, EC was measured with microprocessor based conductivity or TDS meter in the laboratory. TDS (Total Dissolved Solids) was measured by the instrument microprocessor based conductivity or TDS meter. Temperature was recorded with laboratory thermometer. Biological oxygen demand (BOD) with BOD-System Oxidirect. Chemical oxygen demand (COD) was determined with TR320 Spectroquant. Magnesium (Mg) was determined by Magnesium cell test. Calcium (Ca), Chloride (Cl) and Nitrate (NO_3) estimation was done photometrically by using Spectroquant pharo 300 of Merck made.

2.3. Collection, preservation and clearing of aquatic insect specimens

The collection of insect samples from different sources under different land uses were done as per method described by Subramanian and Sivaramakrishnan (2007) and preparation of slides in Hoyer's medium was done according to the method of Baker and Wharton (1952). All the aquatic insects found in surface water were identified up to family level by using the keys of Brues et al. (1954) and Dudgeon (2000).

Simpson's diversity index (D), Biotic index and EPT index was calculated by using the formula of Kirsch (1999), Mandaville (1999) and NCDEHNR (1997), respectively.

Data were subjected to two-way ANOVA test with the land use and seasons as factors as per the formula of Cochran and Cox (1964).

3. Results and Discussion

It is evident from Table 1 that the highest pH (8.29) of surface water was in summer season and while it was higher in urban land use (7.97). The maximum pH during summer season may be due to decreased volume of water by evaporation and minimum in winter season may be due to short day length and decrease in evaporation rate. Sharma and Capoor (2010) also reported similar results. The EC of surface water under urban land use was 0.61 dS m^{-1}. Higher values of conductivity under urban land use may be due to increase in pollution load by addition of nutrients, agricultural runoff, industrial effluents, and organic matter in water. The present findings are in confirmation with the findings of Sharpley and Menzel (1987) who reported that the conductance of water increases under urban land use which might be due to addition of nutrients from soaps and detergents of the bathing places.

Temperature of surface water was higher under urban (22.67^{0}C) and lower under forest land use (20.38^{0}C). In summer season temperature was higher (29.13^{0}C) as compared to winter (12.02^{0}C) and rainy season. The lower water temperature recorded during winter season may be due to dry spell as well as scarce rainfall, cold weather and low atmospheric temperature. Higher temperature during summer season may be due to longer photoperiod, bright sunshine, dry wind and other weather conditions. The present findings are in confirmation with the findings of Welch (1952) who reported that the water temperature was higher during summer season and relatively lower in rainy and winter seasons. The total dissolved solid (TDS) (379.56 mg l^{-1}) recorded during rainy season was statistically at par with summer season (243.33 mg l^{-1}).Total dissolved solids was higher (360.78 mg l^{-1}) in urban land use

Table 1: Physico-chemical properties of surface water of Parwanoo area under different land uses and seasons

Season	Land uses				
	Agri-culture	Forestry	Urban	Mean	CD (p=0.05)
Temperature (^{0}C)					
Rainy	24.00	23.17	25.00	24.06	-
Winter	12.03	11.67	12.37	12.02	-
Summer	30.47	26.30	30.63	29.13	-
Mean	22.17	20.38	22.67	21.74	-
pH					
Rainy	7.76	7.60	7.81	7.72	L=NS
Winter	7.62	7.57	7.64	7.61	S=0.34
Summer	8.26	8.15	8.46	8.29	L X
Mean	7.88	7.77	7.97	7.87	S=NS
EC (dS m^{-1})					
Rainy	0.38	0.35	0.66	0.46	L=0.10
Winter	0.29	0.25	0.44	0.32	S=0.10
Summer	0.44	0.35	0.72	0.50	L x
Mean	0.37	0.31	0.61	0.43	S=NS
TDS (mg l^{-1})					
Rainy	406.33	217.33	515.00	379.56	L=NS
Winter	138.33	111.67	256.67	168.89	S=166.11
Summer	234.00	185.33	310.67	243.33	L x
Mean	259.56	171.44	360.78	263.93	S=NS
NO_3 (mg l^{-1})					
Rainy	3.43	1.20	1.93	2.19	L=0.79
Winter	1.20	0.43	0.80	0.81	S=0.79
Summer	1.83	0.85	1.58	1.42	L x
Mean	2.15	0.83	1.44	1.47	S=NS

as compared to agriculture and forest land use which may be due to urban runoff. This pattern of fluctuations in TDS is in conformity with those of Shaikh and Mandre (2009) who reported maximum TDS in rainy season which may be due to addition of solids from surface run off. Maximum nitrate (NO_3) content (2.15 mg l^{-1}) of surface water recorded under agriculture land use and minimum under forest land use (0.83 mg l^{-1}). Maximum NO_3 (2.19mg l^{-1}) of surface water was during rainy season and minimum during winter season (0.81 mg l^{-1}). The increased nitrate value in agriculture land use may be due to runoff, land drainage and input of fertilizers from adjacent agricultural fields and oxidation of ammonia. The leachate of crop nutrients and nitrate fertilizers from agricultural lands may be responsible for higher content of NO_3 under agriculture land use. These results corroborate the findings of Simeonov et al. (2003).

Biological oxygen demand (BOD) of surface water of urban land use was 3.17 mg l^{-1} which was lowest under forest land use (1.70 mg l^{-1}) while BOD of surface water recorded during rainy season was 3.44 mg l^{-1} which differed statistically from summer season (2.68 mg l^{-1}) and winter season (1.08 mg l^{-1}) as indicated in Table 2 Similar to present findings Prasanna and Ranjan (2010) also reported decrease in BOD during winter season which may be due to higher solubility of oxygen at lower temperature. The maximum chemical oxygen demand (COD) (15.29 mg l^{-1}) of surface water was recorded under urban land use as compared to agriculture (12.02 mg l^{-1}) and forest land use (9.10 mg l^{-1}). Maximum COD (13.60 mg l^{-1}) of surface water recorded during rainy season was followed by summer season (12.10 mg l^{-1}) and winter season (10.62 mg l^{-1}). Similarly, Kaushik and Saksena (1999) reported heavy load of organic , inorganic pollution that require more oxygen to oxidize under increased thermal conditions. The calcium (Ca) content varied between 108.00 to 61.98 mg l^{-1} with maximum under urban (108 mg l^{-1}) and minimum in forest land use (61.68 mg l^{-1}). Calcium content was maximum during summer (89.56mg l^{-1}) and minimum during rainy season (74.83 mg l^{-1}). The calcium is one of the most abundant substances of natural water being present in high quantities in the rocks. The present findings are in confirmation with the finding of Hackley et al. (1996) who also recorded that landfill leachates were enriched in Ca^{2+}, Mg^{2+}, Na^{+}, Cl^{-} and other anions and cations.

Magnesium (Mg) content in surface water differed non-significantly under different land uses during different seasons. Chloride content (32.40 mg l^{-1}) of surface water of urban and agriculture land use (30.11 mg l^{-1}) were at par with each other and differed from forest land use (21.04 mg l^{-1}). Chloride content (32.36 mg l^{-1}) of surface water during summer season differed statistically from rest of seasons. The higher content of chlorides under urban land use may be due to city sewage and domestic waste, man and animals excreta which contain higher quantity of chloride. The lowest values in rainy season can be attributed due to the increase dilution by rain water. The results corroborate the findings of Reddy et al. (2009).

A total number of 118 individuals m^{-2} of aquatic insects under 6 families and 5 orders were recorded (Table 3). Out of which 39 individuals m^{-2} of aquatic insects was under agriculture land use. Maximum number (6 individuals of m^{-2} each Batidae: Ephemeroptera and Hydropsychidae: Trichoptera) of aquatic insects were found during winter season, followed by Cordullidae (4 individuals) of Odonata and Leuctridae (3 individuals m^{-2}) of Plecoptera while during rainy and winter season only one individual of family Gerridae of Hemiptera was observed. Maximum number (48 individuals m^{-2}) of aquatic insects were recorded under forest land use. Highest number (8 individuals m^{-2}) of aquatic insects of Hydropsychidae family of Trichoptera followed by Baetidae of Ephemeroptera, Leuctridae of Plecoptera (both 6 individuals

Table 2: Chemical properties of surface water of Parwanoo area under different land uses and seasons

Season	Land uses				
	Agri-culture	For-estry	Urban	Mean	CD (p=0.05)
	BOD (mg l^{-1})				
Rainy	3.33	3.00	4.00	3.44	L=0.73
Winter	1.00	0.90	1.33	1.08	S=0.73
Summer	2.67	1.20	4.17	2.68	L X
Mean	2.33	1.70	3.17	2.40	S=NS
	COD (mg l^{-1})				
Rainy	13.67	9.73	17.40	13.60	L=1.00
Winter	10.67	8.20	13.00	10.62	S=1.00
Summer	11.73	9.10	15.47	12.10	L X
Mean	12.02	9.01	15.29	12.11	S=NS
	Ca (mg l^{-1})				
Rainy	65.17	63.27	96.07	74.83	L=20.74
Winter	86.17	63.00	102.93	84.03	S=NS
Summer	84.00	59.67	125.00	89.56	L x
Mean	78.44	61.98	108.00	62.64	S=NS
	Mg (mg l^{-1})				
Rainy	6.60	5.37	7.40	6.46	L=NS
Winter	6.63	5.63	6.70	6.32	S=NS
Summer	13.33	8.27	13.67	11.76	L x
Mean	8.86	6.42	9.26	11.12	S=NS
	Cl (mg l^{-1})				
Rainy	22.33	18.00	28.20	22.84	L=2.74
Winter	31.33	19.40	34.33	28.36	S=2.74
Summer	33.67	25.73	37.67	32.36	L x
Mean	29.11	21.04	33.40	27.85	S=NS

Table 3: Effect of land uses on diversity of aquatic insects m^{-2} of surface water of Parwanoo area during different seasons

A	B	C	D	E	F	G
Agri-culture	Trichoptera	Hydropsychidae	2	6	4	39
	Odonata	Cordullidae	0	4	0	
	Ephemeroptera	Batidae	2	6	4	
	Plecoptera	Leuctridae	2	3	4	
	Hemiptera	Gerridae	1	1	0	
		Notonectidae	0	0	0	
Forest	Trichoptera	Hydropsychidae	3	8	2	48
	Odonata	Cordullidae	0	4	3	
	Ephemeroptera	Batidae	3	6	5	
	Plecoptera	Leuctridae	3	6	3	
	Hemiptera	Gerridae	0	1	0	
		Notonectidae	0	1	0	
Urban	Trichoptera	Hydropsychidae	2	4	3	31
	Odonata	Cordullidae	0	3	0	
	Ephemeroptera	Batidae	3	4	3	
	Plecoptera	Leuctridae	1	3	3	
	Hemiptera	Gerridae	0	1	0	
		Notonectidae	0	1	0	
		Total	22	62	34	118

A: Land Use; B: Order; C: Family; D: Rainy; E: Winter; F: Summer; G: Total

m^{-2}), Cordullidae (4 ind.ividuals m^{-2}) of Odanata and Gerridae and Notonectidae of Hemiptera (both 1 individuals m^{-2}) were recorded during winter season. The lowest number (31 individuals m^{-2}) of aquatic insects were recorded under urban land use. Maximum number (4 individuals) of aquatic insects of Hydropsychidae of Trichoptera and Batidae (4 individuals m^{-2}) of Ephemeroptera followed by Leuctridae (3 individuals m^{-2}) of Plecoptera, Cordullidae (3 individuals m^{-2}) of Odanata , Gerridae and Notonectidae (both 1 individual m^{-2}) of Hemiptera were recorded under urban land use during winter season. The low number of individuals under urban land use may be due to the discharge of industrial effluents and anthropogenic activities like addition of domestic wastes, sewage and industrial discharge which may lead to reduction in species. Similar results were reported by Wahizatul et al. (2006). Foreman et al. (2008) reported that the human activities add nitrogen and phosphorus to the water, which lead to algal blooms and low dissolved oxygen in slow-moving streams which caused reduction in aquatic insects.

During winter season 62 individuals m^{-2} of aquatic insects were recorded followed by summer season (34 individuals m^{-2}) and rainy season (22 individuals m^{-2}). Similar to present findings Sharma et al. (2008) also reported highest number of aquatic insects during winter season. Data contained in Table 4 reveal that the Simpson's Diversity Index (D), EPT index and family biotic index was 0.90, 32.67 and 2.49, respectively. Simpson's Diversity Index indicated high diversity of aquatic insects in surface water. The EPT index as well as family biotic index was within rating limits. The present findings support the findings of Armitage et al. (1983) who reported the biological indices provided better information about the environmental conditions under which they lived than a consideration of the individual taxa alone.

Table 4: Aquatic insect diversity Index

Sl. No.	Name of Index	Index value
1.	Simpson's Diversity Index	0.90
2.	EPT index	32.67
3.	Family biotic index	2.49

4. Conclusion

All the quality parameters and contents of nitrate and chloride except Ca in surface water under different land uses were within permissible limits. Simpson diversity index indicated high diversity of aquatic insects in surface water. The EPT as well as family biotic indices were within permissible rating limits.

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6. Further Research

There is a need to conduct further research on prediction of water pollution under different land uses, effect of climate change on water resources and accumulation of heavy metals in aquatic insects in mountainous streams of Himachal Pradesh.

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