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Assessment of surface water quality and associated aquatic insect fauna under different land uses of Barotiwala area, Solan, Himachal Pradesh

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ABSTRACT

The present investigations were carried out to assess the quality of surface water of Barotiwala area of district Solan, HP during the year 2011-2012. Studies were conducted on seasonal (rainy, winter and summer) variation in water quality under different land uses (agriculture, forest and urban). Samples of surface water from various sources under different land uses 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). Diversity of aquatic insect fauna associated with surface water during different seasons under different land uses was also studied. Aquatic insects found in surface water were identified up to family level and Simpson's Biodiversity, EPT and family biotic indices were calculated.

Keywords: Water quality; land use; aquatic insects

INTRODUCTION

Water a major constituent of all living organisms is essential for survival. Rapid increase in human population, increasing anthropogenic activities, land use changes, discharge of sewage and municipal waste into water bodies etc have deteriorated water quality (Meitei et al 2004, Nriagu 1979, Mohapatra and Singh 1999). The terrestrial drainage basin and the stream channel with its associated physical heterogeneity determine the spatial variation of the stream ecosystem (Schlosser 1991). Discharge of sewage, domestic waste, industrial effluents and agrochemicals resulted in variety of changes in the hydrology and water quality (Mahadev and Gholami 2010) and it creates difficulties for macro-invertes to survive in high polluted water bodies. Problems arising out of water quality deterioration are as severe as those related to water availability. According to Rao and Mamatha (2004) about 70 per cent of India's surface water resources are already contaminated. Benthic macro-invertebrates are good indicators of watershed health and fluctuations in aquatic insect communities give quick information on water quality (Singh 1997). Biological measures provide an integrated and comprehensive assessment of the health of a water body over time (Karr 1999). The aim of this study was to use physical, chemical and biological measures to assess changes in water quality under different land uses due to anthropogenic activities. The present study on assessment of surface water quality and associated aquatic insects under different land uses was undertaken to know the quality of water status and the insect fauna associated with water bodies of Barotiwala area of Solan district of Himachal Pradesh.

MATERIAL 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 meters amsl. In this region the winter commences from October to March, summer from April to June and rainy season from July to September. The Parwanoo area has rivers, Nalas, Kuhls, Bawaries and springs under different land use systems.

Collection of water samples: Water samples (one litre) from various sources under different land uses were collected in transparent plastic bottles during different seasons and stored in the refrigerator at $4^{o}C$ for further analysis. Each sample was replicated thrice.

Water quality analysis: The water samples were analyzed for physical, chemical and biological parameters under laboratory conditions. pH was analyzed by EUTECH instrument pH-510, EC with microprocessor based conductivity/TDS meter, TDS (total dissolved solids) with microprocessor based conductivity/TDS meter, temperature with laboratory thermometer, biological oxygen demand (BOD) with BOD-System Oxidirect and chemical oxygen demand (COD) with TR320 Spectroquant. Magnesium (Mg) was determined by magnesium cell test whereas calcium (Ca), chloride (Cl) and nitrate (NO_3) were determined photometrically using Spectroquant pharo 300 of Merck made.

Collection, preservation and clearing of aquatic insects: The collection of insects from various sources under different land uses were done as per method described by Subramanian and Sivaramakrishnan (2007). The slides were prepared in Hoyer's medium according to the method of Baker and Wharton (1952). The insects were identified up to family level by using the keys of Brues et al (1954).

Simpson's diversity index , Biotic index and EPT index were calculated according the formula of Kirsch (1999), Mandaville (1999) and Anon (1997). Data were subjected to two-way ANOVA test with the land use and seasons as factors as per the formula of Chochran and Cox (1964).

RESULTS and DISCUSSION

It is evident from Table 1 that the highest pH (8.24) of surface water was in summer season and under urban land use (8.03). The maximum pH during summer might be due to decreased volume of water by evaporation and minimum in winter 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 0.44 dS/m. Higher values of conductivity under urban land use might 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 (24.55^{0}C) and lower under forest land use (21.43^{0}C). In summer season temperature was higher (32.57^{0}C) as compared to winter (11.58^{0}C) and rainy season. The lower water temperature recorded during winter might be due to dry spell as well as scarce rainfall, cold weather and low atmospheric temperature. Higher temperature during summer could 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. Total dissolved solids were higher (414.78 mg/l) in urban land use as compared to agriculture and forest land use. This pattern of fluctuations in TDS is in conformity with the results of Shaikh and Mandre (2009) who reported maximum TDS in rainy season which could be due to addition of solids from surface runoff. Maximum nitrate (NO_3) content (2.70 mg/l) of surface water was recorded under urban land use and minimum under forest land use (1.03 mg/l). Maximum NO_3 (3.29 mg/l) of surface water was recorded during rainy and minimum during winter season (1.14 mg/l). The increased nitrate value in agriculture land use might 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 might be responsible for higher content of NO_3 under agriculture land use. These results corroborate the findings of Simeonov et al (2003).

It is evident from Table 2 that biological oxygen demand (BOD) of surface water of urban land use was 16.61

Table 1. Summary of physico-chemical properties of surface water samples of Barotiwala, Solan

Season	Land use			Mean
	Agriculture	Forest	Sub-urban	
		Temperature (^oC)		
Rainy	25.50	26.83	29.50	27.28
Winter	11.08	10.90	11.58	11.19
Summer	27.70	27.17	32.57	29.14
Mean	21.43	21.63	24.55	
		P^H		
Rainy	7.67	7.67	7.81	7.72
Winter	7.64	7.50	7.81	7.65
Summer	8.13	7.82	8.47	8.24
Mean	7.81	7.76	8.03	
CD $_{0.05}$: L= 0.16, S= 0.16, L x S= 0.28				
		Ec (dS/m)		
Rainy	0.34	0.30	0.56	0.40
Winter	0.36	0.23	0.44	0.34
Summer	0.36	0.29	0.67	0.44
Mean	0.36	0.27	0.44	
CD $_{0.05}$: L= 0.40, S= 0.34, L x S= 0.44				
		TDS (mg/l)		
Rainy	475.67	251.00	647.67	458.11
Winter	223.00	158.33	246.00	209.11
Summer	267.67	199.67	350.67	272.67
Mean	322.11	203.00	414.78	
CD $_{0.05}$: L= 76.27, S= 76.27, L x S= NS				
		NO_3 (mg/l)		
Rainy	3.10	2.27	4.50	3.29
Winter	1.30	0.38	1.74	1.14
Summer	1.83	0.43	1.87	1.38
Mean	2.08	1.03	2.70	
CD $_{0.05}$: L= 0.89, S= 0.89, L x S= NS				

mg/l which was lowest under forest land use (3.65 mg/l) while BOD of surface water recorded during rainy season was 18.54 mg/l which differed statistically from summer (8.03 mg/l) and winter season (1.57mg/l). Similar to present findings Prasanna and Ranjan (2010) also reported decrease in BOD during winter season which might be due to higher solubility of oxygen at lower temperature. The maximum chemical oxygen demand (COD) (78.44 mg/l) of surface water was recorded under urban land use as compared to agriculture (20.48 mg/l) and forest land use (11.11 mg/l). Maximum COD (49.22 mg/l) of surface water recorded during rainy season was followed by summer (35.92 mg/l) and winter season (24.89 mg/l). Similarly Kaushik and Saksena (1999) reported heavy load of organic and inorganic pollution that requires more oxygen to oxidize under increased thermal conditions. The calcium (Ca) content varied between 81.10 to 46.77 mg/l with maximum under urban (81.10 mg/l) and minimum in forest land use (46.77 mg/). Calcium content was maximum during summer (95.00 mg/l) and minimum during rainy season (59.43 mg/l). The calcium is one of the most abundant substances of natural water being present in high quantities in the rocks. Maximum magnesium content recorded under urban land use (17.09 mg/l) varied significantly from rest of the land uses. 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. Chloride content (38.92 mg/l) of surface water of urban, agriculture (35.02 mg/l) and forest land use (26.12 mg/l) differed significantly. Chloride content (37.06 mg/l) of surface water during summer differed statistically from rainy season (37.06 mg/l). The higher content of chlorides under urban land use might 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 85 individuals/m^2 of aquatic insects under 6 families and 5 orders were recorded (Table 3) out of which 28 individuals/m^2 of aquatic insects were under agriculture land use. Maximum number ie six individuals/m^2 belonging to Batidae family of order Ephemeroptera were found during winter season followed by family Hydropsychidae (4 individuals/m^2) of order Trichoptera and family Leuctridae (3 individuals/m^2) of order Plecoptera while only one individual/m^2 of family Gerridae of order Hemiptera was observed during summer season. Maximum number ie thirty six individuals/m^2 of aquatic insects was recorded under forest land use. Highest number of six individuals/m^2 belonged to family Baetidae of order Ephemeroptera followed by family Hydropsychidae of order Trichoptera and

Table 2. Summary statistics of the analytical results of chemical properties of surface water samples of Barotiwala, Solan

Season	Land use			Mean
	Agriculture	Forest	Sub-urban	
		BOD (mg/l)		
Rainy	14.00	8.28	33.33	18.54
Winter	1.47	1.07	2.17	1.57
Summer	8.17	1.60	14.33	8.03
Mean	7.88	3.65	16.61	
$CD_{0.05}$: L= 5.65, S= 5.65, L x S= NS				
		COD (mg/l)		
Rainy	28.00	12.33	107.33	49.22
Winter	15.67	10.00	49.00	24.89
Summer	17.77	11.00	79.00	35.92
Mean	20.48	11.11	78.44	
$CD_{0.05}$: L= 28.37, S= NS, L x S= NS				
		Ca (mg/l)		
Rainy	32.23	32.12	59.43	41.29
Winter	68.60	53.43	88.87	70.30
Summer	79.33	54.67	95.00	76.33
Mean	60.06	46.77	81.10	
$CD_{0.05}$: L= 7.92, S= 7.92, L x S= NS				
		Mg (mg/l)		
Rainy	8.37	3.57	15.37	9.10
Winter	10.37	4.03	16.03	10.14
Summer	11.00	4.47	19.87	11.78
Mean	9.91	4.02	17.09	
$CD_{0.05}$: L= 7.16, S= NS, L x S= NS				
		Cl (mg/l)		
Rainy	27.93	25.67	29.43	27.68
Winter	36.00	32.67	37.33	35.33
Summer	41.13	20.03	50.00	37.06
Mean	35.02	26.12	38.92	
$CD_{0.05}$: L= 3.11, S= 3.11, L x S= NS				

Table 3. Effect of land use on distribution and abundance of aquatic insects (individual/m^2) of surface water at Barotiwala during three seasons

Land use	Order	Family	Rainy season	Winter season	Summer season	Total
Agriculture	Trichoptera	Hydropsychidae	3	4	2	28
	Odonata	Cordullidae	0	0	1	
	Ephemeroptera	Batidae	2	5	2	
	Plecoptera	Leuctridae	2	3	3	
	Hemiptera	Gerridae	0	0	1	
		Notonectidae	0	0	0	
Forest	Trichoptera	Hydropsychidae	3	4	2	36
	Odonata	Cordullidae	0	0	0	
	Ephemeroptera	Batidae	3	6	2	
	Plecoptera	Leuctridae	3	4	2	
	Hemiptera	Gerridae	0	0	7	
		Notonectidae	0	0	0	
Urban	Trichoptera	Hydropsychidae	0	3	2	21
	Odonata	Cordullidae	0	0	1	
	Ephemeroptera	Batidae	2	3	2	
	Plecoptera	Leuctridae	2	3	2	
	Hemiptera	Gerridae	0	0	1	
		Notonectidae	0	0	0	
Total			20	35	30	85

family Leuctridae of order Plecoptera (both 4 individuals/m^2). No aquatic insects belonging to other families viz Cordullidae order Odanata, Gerridae and Notonectidae of order Hemiptera during the winter season were found. The lowest number (21 individuals/m^2) of aquatic insects were recorded under urban land use. The families Hydropsychidae of order Trichoptera, family Batidae of order Ephemeroptera and Leuctridae of order Plecoptera recorded equal number ie three individuals m^2 whereas no insect specimens belonging to other families viz Cordullidae of order Odanata , Gerridae and Notonectidae of order Hemiptera were recorded during winter season. During this season thirty five individuals/m^2 of aquatic insects were recorded followed by summer (30 individuals/m^2) and rainy season (20 individuals/m^2).

The low number of individuals under urban land use might be due to the discharge of industrial effluents and

Table 4. Biological indices

Index	Value
Simpson's Diversity Index	0.88
EPT index	27.33
FBI	2.73

anthropogenic activities like addition of domestic wastes and sewage and industrial discharge which might lead to reduction in species. Similar results were reported by Wahizatul et al (2006). Foreman et al (2008) reported that the human activities add addition of nitrogen and phosphorus to the water which lead to algal blooms and low dissolved oxygen in slow-moving streams cause reduction in aquatic insects. During winter season 35 individuals/m^2 of aquatic insects were recorded followed by summer (30 individuals/m^2) and rainy season (20 individuals/m^2). Similar to present findings Sharma et al (2008) also reported highest number of aquatic insects during winter season. The Simpson's Diversity Index, EPT index and family biotic index were 0.88, 27.33 and 2.73 respectively (Table 4). Simpson's Diversity Index indicated high diversity of aquatic insects in surface water. The EPT as well as family biotic index were within rating limits. The present findings support the findings of Armitage et al (1983) who reported that the biological indices provided better information about the environmental conditions in which they live.

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