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Sediment Characterization of Lower sections of a Central Himalayan river, Tawi, Jammu (J&K), India

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Abstract

Information on sediment quality and characterization is an important requirement for water resources development and management. This paper presents the results of a study that was conducted to assess the sediment physico- chemistry of river Tawi during a period of twelve months. Sediments were analyzed according to the standard methodology for sediment particle size (sand, silt and clay), sediment texture, pH, EC, TOC and TOM. Analysis of Variance (ANOVA) and Pearson correlation coefficient were used to analyze the data. Sand was found to be the major contributor to the sediment texture. The values of TOC and TOM do not exceeded the acceptable limits but tend to be increasing gradually. Therefore, environmental surveillance of these parts of the river is strongly recommended.

Keywords: Sediment characterization, sediment texture, TOC, TOM, river Tawi.

Introduction

Sediments play an outstanding role in Limnological studies as they can both reflect and affect what is occurring in the overlying waters. They are highly dynamic and active in character primarily due to various biogeochemical reactions and transformations occurring within the water body. Sediments in our rivers provide a natural buffer system and an important habitat for aquatic organisms[1]. Because of their variable physical and chemical properties, they not only act as source and sink of nutrients in an aquatic system, but also provide a record of river's pollution history[2- 4]. Sediments act as site for decomposition of organic matter carried by bacteria which promotes biological changes and affect the water quality by re suspension and nutrient release[5]. Sediments can be either organic or inorganic, carried by water, wind and ice or other naturally occurring agents to lakes, streams and rivers. Sediment texture specifically refers to the proportions of sand, silt and clay below 2000 micrometers (2mm) in diameter in a mass of sediment[6] (table 1). Sediments comprise many shapes and sizes ranging from silt, sand, small pebbles to boulders. Sand is coarse and gritty, silt is smooth and clay is sticky and plastic when wet[7]. Unfortunately, overpopulation, local soil erosion and extensive urbanization adds organic matter to the river bed which on decomposition releases TOC in the sediments that adversely effects physico- chemical and biological properties of the sediments[8], eventually deteriorating the productivity of the overlying waters[9- 10].

The above discussed factors have been deteriorating River Tawi in Jammu region. Many works have been carried out on the different aspects of this water body such as physico-chemistry, plankton and bacterial aspects, benthos, fish and fisheries. But there has been no information on the sediment quality of river Tawi, despite of various human activities going on and within it. The study was necessary to assess the sediment fractions and some physico-chemical parameters of this aquatic system. So, the present study was carried out on the sediments of river Tawi in order to assess the moisture content, particle size, sediment texture, pH, EC, TOC and TOM and TN. The study of sediments will be a useful tool for future researchers for actual assessment of environmental pollution of this aquatic system.

Material and Methods

Study area: River Tawi, (figure 1) a major River in Jammu region is the left bank tributary of river Chenab originating from the lapse of Kali Kundi glacier in Bhaderwah, flows through some parts of Doda district, Udhampur reaches Jammu from where it finally merges into Chenab in Pakistan. It is an open and bare river lacking any proper macrophytic growth and vegetation. This aquatic body receives effluents discharges from the water front communities, dredging company, manual, dredging, sewages and garbage disposal etc. Thus, it is essential in this context to study the sediments of the water body as these act as ultimate sink for wastes.

Sampling stations: Four sampling stations were selected along the longitudinal profile of River Tawi, viz; S1, S2, S3 and S4. Station1 (S1) (near Sainik School, Nagrota), water was comparatively clean with the bottom composed of stones andboulders. Station 2(S2) (Circular Road) was about 6 kilometers from st.1, and receives organic load in the form of religious wastes, crematorium etc. Station 3(S3) (Gujjar Nagar) at a distance of about 4 kilometers from station 2 and 10 kilometers from station 1. It receives heavy pollution load and organic matter in the form of sewage and garbage. Station 4(S4) (near Satwari) is the revival zone of the river which is located at a distance of about 6 kilometers from station 3 which is again a clean water zone with the bottom of stones and gravels.

Sediment sample collection and laboratory analysis: River bed sediments were collected using Ekman's dredge once a month from March, 2011 to February, 2012. Sediments were collected at each sampling station and stored in well labeled zip lock polyethylene bags and kept in an ice-chest box before transferring to the laboratory.

Samples were analyzed for moisture content prior to drying. Sediment samples were then air dried at room temperature in the laboratory. The dried samples were further crushed to fine texture using 2.0 mm mesh sized sieve for the estimation of physico-chemical parameters. Physico-chemical parameters were determined according to standard methods: Moisture content: by oven drying method[11], pH: by digital pH meter[12], electrical conductivity (EC): by using conductivity meter[13], particle size: by Bouyoucous hydrometer[14], Texture: by textural triangle software[15], total organic carbon (TOC) and total organic matter (TOM): by Walkley and Black rapid titration method[16], total nitrogen (TN): by Kheldahl's method[17].

Data analysis: Analysis of variance (2- way ANOVA) and Pearson correlation coefficient were used to analyze the data using SAS (2003) and Microsoft excel (2007) packages.

Results and Discussion

Sediment particle size: The calculated range, mean and standard deviation of all the parameters are presented (table2). Across all the stations, the sand component was found to in highest proportion over silt and clay. Percentage sand content ranged from 84.60 % (St.1) to 61.89 % (St.3). Maximum percentage of silt content ranged from 23.32% (St.3) to 10.42% (St.1). Highest value for clay was recorded as 11.79 % (St.3) and lowest of it was recorded as 4.94% (St. 4). Texture was observed to be Loamy sand at station 1and 4; while it was observed sandy loam at station 2 and 3. Sediments depend on the parent material available and deposits of materials[18]. At station 1and 4, sediments were mainly of loamy sand nature with sand as the major component which may be due topographical features of the concerned area, due to the weathering of rocks and frequent dredging of sediments[19- 21]. At station 2 and 3 sediments were of sandy loam nature with silt and clay in high proportion compared to the sand. High concentration of silt and clay was due to the deposition and decomposition of organic matter as these sites received through sewage and garbage of the city[22]. Station with the highest percentage of clay also had the highest percentage of silt[22]. Variations in the sand, silt and clay content in the bottom sediments at different stations are also strengthened by 2- way ANOVA (table 4) which recorded highly significant values for all components of bottom sediments among stations of the river Tawi. Sand exhibited significant negative correlation with clay (r= -0.997) and silt (r= -0.999). But silt and clay shared significant positive correlation with each other (r= 0.994)[22,8] (table 5).

Figure 1(a).

Figure 1(b).

Figure 1(c).

Figure 1(d).

Figure-1
Whole map of study area (a) Station 1(a) (Sainik School, Nagrota) 1(b) Station 2(Circular road) 1(c) Station 3(Gujjar Nagar) 1(d) Station 4(Satwari)

Table-1
Size limits of sediment particle size in the United State department of Agriculture (USDA) and International Soil Science Society (ISSS) Schemes

USDA Scheme		ISSS Scheme	
Name of the Particle Size	**Diameter Range(µm)**	**Name of the Particle Size**	**Diameter Range(µm)**
Very Coarse sand	2000- 1000		
Coarse sand	1000-500	Coarse sand	2000- 200
Medium sand	500- 250		
Fine sand	250- 100	Fine sand	200- 20
Very fine sand	100- 50		
Silt	50- 2	Silt	20- 2
Clay	<2	Clay	<2
Coarse Fragments			
Gravels	2000- 75000µm (2-75mm)		
Cobbles	75000- 25400µm (75-254mm)		
Stones	>254000µm (>254mm)		

Table-2
Sediment particle size in river Tawi (from March2011 to February, 2012)

Parameters	St.1	St.2	St. 3	St. 4	Range	Mean+ S.D
Sand %	84.60	68.21	61.89	84.59	61.89-84.60	74.82±10.02
Silt %	10.42	21.34	23.32	10.47	21.34-10.47	16.38±5.98
Clay %	4.98	10.45	11.79	4.94	4.94- 11.79	8.04±3.11
Textural class	Loamy sand	Sandy loam	Sandy loam	Loamy sand		

Table-3
Physical and chemical parameters of sediments in river Tawi (from March2011 to February, 2012)

Parameters	St.1	St.2	St. 3	St. 4	Range	Mean+ S.D
Ph	7.7	7.8	7.7	7.7	7.7-7.8	0.037±3.43
E.C (µs)	0.23	0.24	0.24	0.14	0.14-0.24	0.212±0.04
Moisture %	4.26	5.29	5.56	4.26	4.26-5.56	4.842±0.59
TOC %	0.22	0.33	0.35	0.24	0.22-0.35	0.285±0.05
TOM %	0.38	0.57	0.61	0.42	0.38-0.61	0.495±0.09
TN %	0.019	0.0285	0.0305	0.00105	0.001-0.03	0.019±0.01

Table-4
Values of Analysis of Variance (ANOVA) for stations

Parameters	Value
Sand	*10.99
Silt	*20.05
Clay	*6.61
TOC	*91.77

*Values are significant at 5%

Table-5
Pearson's correlation coefficient of Sediment Texture and TOC

Parameters	Sand	Silt	Clay	TOC
Sand	-			
Silt	- 0.999*	-		
Clay	-0.997*	0.994*	-	
TOC	-0.987*	0.983*		-

*Values are significant at 5%

Sediment physico-chemical parameters: The results of the physical and chemical parameters of sediments of river Tawi have been tabulated (table 3). The pH value of the sediments represented alkaline conditions and fluctuate between 7.7 to 7.8 which may be attributed to the land drainage pollution arising from commercial and anthropogenic activities like disposal of industrial wastes andwashing of vehicles etc[23,24]. EC of sediments is strongly affected with particle size and soil texture. Sands have low EC and clays and silts have high EC[23,25]. EC of the sediments, on an average, was observed to be low. High EC of 0.24µs/cm was recorded (St. 2 and 3) and low EC was recorded as 0.14µs/cm (St.4). EC content of sediments of station 2 and 3 was more as they had sandy loam type of sediments (more clay and silt as compared to sand). Contrarily, station 1 and 4 had low EC having more percentage of sand. High percentage of moisture content recorded was 5.56% (St.3) and it was recorded as low 4.26% (St.4). Moisture content is the quantity of water contained in soils or sediments. Sandy loam sediments (St.2 and 3) have high moisture content while Loamy sand (St.1 and 4) have low moisture content which may be attributed to the fact that moisture content depends on the particle size, organic matter and bulk density[26]. Also, the clayey soils have more organic matter and thus retain more water than sandy soils[27, 28].

The TOC percentage ranged from 0.35% (St.3) to 0.22% (St.1).TOM and TN followed TOC and found to be ranged from 0.61 % (St.3) to 0.38 % (St.1); whereas TN ranged from 0.03 % (St.3) to 0.01% (St.1 and 4) (table 3). TOC also showed significant value for 2-way ANOVA which inferred that stations showed greater variation in TOC (table 4). Total organic carbon and total organic matter were high (St. 3); which could be attributed to the fact that this station received heavy organic matter in form of municipal wastes, agricultural wastes, sewage, human and cattle excreta. As TOC is directly proportional to TOM thus, the deposition and decomposition of organic matter released organic carbon in water which ultimately gets accumulated in the sediments[8,10,21]. Total organic carbon shared significant positive correlation with silt (r=0.983) and clay (r = 0.991)[8,21] but significant negative correlation with sand (r = -0.987)[10]. TOC also shared significant positive correlation with moisture content (table 5). Particle size distributions and TOC percentage of all the stations has also been graphically represented (figure 2).

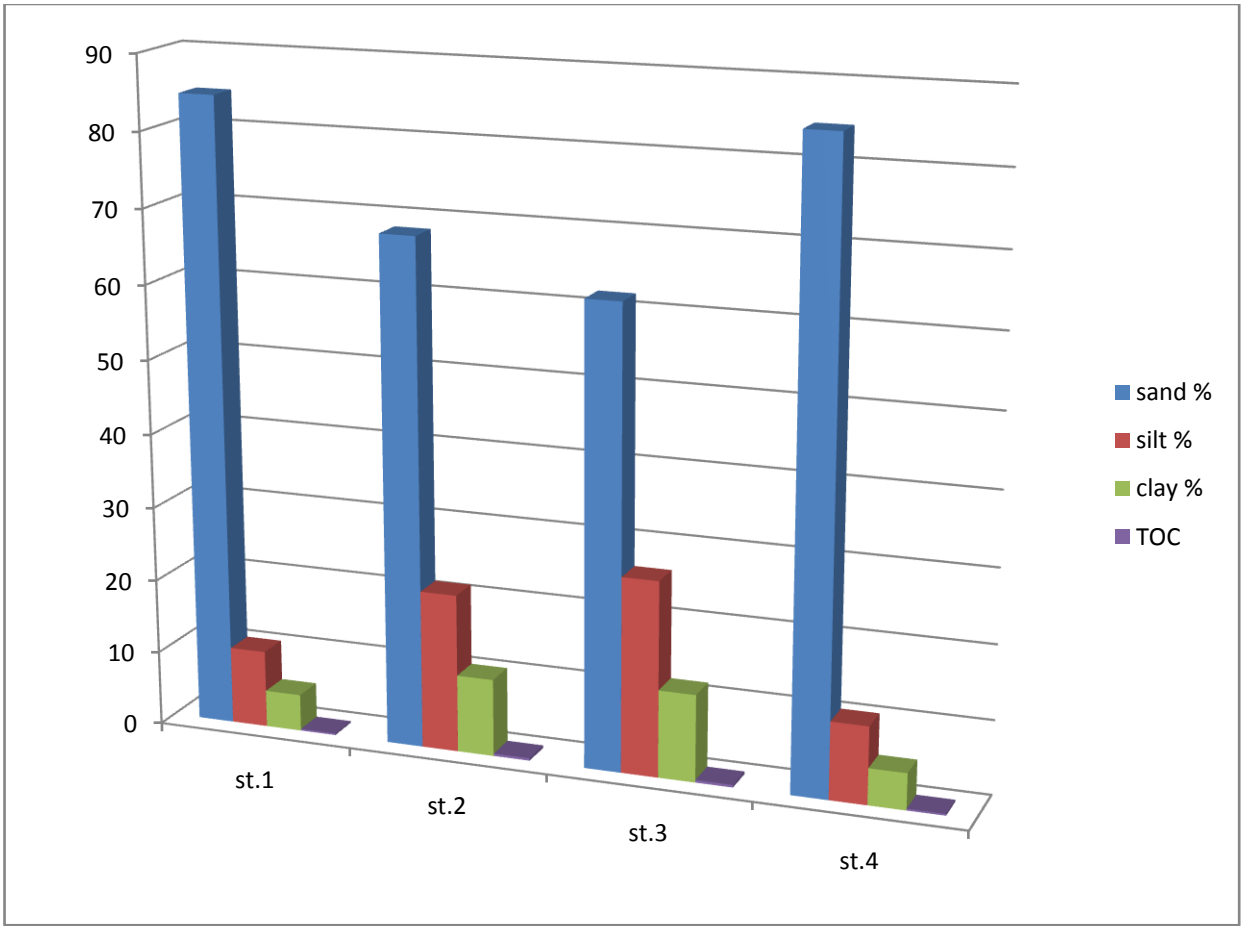

Figure-2
Graphical representation of particle size distribution and TOC on all the four stations

Conclusion

The results of the study indicated that the sediments of the river Tawi were having sand as the major contributor followed by silt and clay. Percentages of TOC, TOM and TN indicated the effect of incorporation of the effluents on the natural sediments of the river Tawi. However, the concentration and dispersal pattern of these parameters were moderate and comparatively lower than the average value. It is therefore strongly recommended that strict measures should be taken against the disposal of wastes on the river sites so that the natural nature of the sediments should be conserved andpreserved.

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