Water quality characteristics of Sahastradhara hill stream, Dehradun (Uttarakhand), India

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Abstract

Sahastradhara stream is a major tributary of river Song, 15 Km. far from Dehradun city in Uttarakhand. It has a great importance as a picnic tourist spot of the region, whereas there is not much industrial and agricultural pollution. Hill streams of the area are the cradle of nutrients especially calcium and magnesium in the form of ions. Anthropogenic factors mainly tourists activities and catchments runoff may influence the index of nutrients in stream water. Nutrients play a vital role into niche restoration maintenance, self-regulation and water quality. Location variation in nutrients concentration of the stream was studied with special reference to correlation with physico-chemical parameters of the stream water. Calcium and Magnesium were observed in higher range in Sahastradhara stream as comparison to other hill-streams. Calcium and Magnesium were found maximum 104.21 mg/l and 68 mg/l respectively in summer season.

Key words: Sahastradhara, Water quality monitoring, Aquatic pollution, physico-chemical parameters

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Introduction

The Himalayas are the cradle of a large number of streams and mighty rivers. Lesser Himalaya consists of a huge part of Uttaranchal. Dehradun, Hardwar & Rishikesh are the main religious and beautiful cities, which are situated in the foothills of Garhwal Himalaya. A hill-stream Sahastradhara, 15 Km. far from Dehradun city is the study site for the accounting of nutrients in natural water and fluctuations at the different locations

along with the stream. Adequate understanding of the Himalayan proglacial streams is extremely important for the development of a realistic program for utilizing the potential of water that exist in the form of snow and ice in the area (Malik and Bharti, 2005a).

Water quality characteristic of aquatic environment arise from a multitude of physical, biological and chemical interactions. The water bodies, lakes, rivers, dams and estuaries are continuously subject to a dynamic state of change with respect to the geological age and geochemical characteristics. This is demonstrated by continuous circulation, transformation and accumulation of energy and matter through the medium of living thing and their activities (Bharti, 2004; Bharti, 2012a; Bharti and Malik, 2005a).

The dynamic balance in the aquatic ecosystem is upset by human activities, resulting in pollution which meter, is manifested dramatically as fish kill, offensive taste, odour, colour and unchecked aquatic weeds. The over production of higher tropic levels biomass and the subsequent decay of dead plants could lead to oxygen depletion, death of aquatic organisms and development of anaerobic zone where bacteria action produce foul odours and bad tastes (Bharti, 2012b; Bharti, 2008; Bharti and Malik, 2005b).

Water quality includes all physical, chemical and biological factor that influence the beneficial use of water, Lotic habitats are those exiting in relatively fast running streams, springs, river and brooks. The lakes represent lentic habitats; marshes and swamps represent ponds and wetland. The above classification of fresh water environment is based on currents and ratio of the depth of surface area (Malik and Bharti, 2005b).

The biotic community in the streams and rivers is quite different from that in the ponds, lakes and other stagnant water bodies. The differences in the community are largely due to differences in the physical and chemical conditions of their environments. The physiological changes, adaptations and other characteristics are also entirely different (Malik and Bharti, 2007).

Previously, the adequate research work was also carried out on various aspects of Sahastradhara stream viz. nutrient dynamics (Malik and Bharti, 2005a), Plankton diversity (Malik and Bharti, 2005b), Primary productivity (Malik and Bharti, 2005c), aquatic ecology (Malik and Bharti, 2007), fish habitat (Bharti and Malik, 2005b), etc.

The present study reveals to characteristics the general water chemistry, influenced by tourist's activity & quarrying of the geologically sedimental environments and to determine the nature and degree of anthropogenic impacts on qualitative & quantitative variations occurred in nutrients in relation to physico-chemical parameters of stream water.

Materials and methods

Water samples were collected monthly from sampling site "Sahastradhara stream" from different sampling stations, Site-I, Site-II, Site-III, Site-IV, and Site-V in morning period 9:00 A. M. to 10:00 A. M.

The samples for nutrients and physico-chemical parameters were collected and analyzed by using rinsed borosil glassware, with the help of the procedure described by APHA (1995), Trivedi & Goel (1984).

Results & Discussion

Sahastradhara stream is flowing through a valley of Dehradun mountain chain in foothills of Shivalik Himalaya, enriched with limestone and lignite rocks, which affect the water quality of stream according to the locations. The concentrations of major elements and related physico-chemical parameters from selected five sites are depicted in tables.

Sahastradhara stream has the spatio-temporal variations of water temperature, which plays a vital role in all physico-biochemical reactions and self-purification power of aquatic system (Badola & Singh, 1981). Higher value of temperature was found 18 °C in summer and minimum 12 °C in winter season. A direct relationship was established between the water temperature and free carbon dioxide (Hynes, 1970). Turbidity is striking characteristic of the physical status of the water bodies. Although in Sahastradhara stream water is clear because there is no more pollution, siltation was the main source of turbidity in tributaries. Detritus and other non-organic material being added to water mass due to rainfall and tourist activities (Camron, 1996). Maximum turbidity was recorded 7.0 JTU during rainy days and minimum 1.0 JTU in December. The maximum depth of photic zone provides the better biological production for all aquatic organisms.

Total solids were found in the range of 955 mg/l to 1535 mg/l towards summer season, due to the gradual increases in velocity of river which favoured effective sedimentation (Subramanian, 1979). Chemical oxygen demand represents chemically oxidizable organic matter load in water, while biochemical oxygen demand is only biodegradable materials. In the present study high values observed during summer months may be attributed maximum biological activities and high temperature, stimulate the growth of microorganisms (William et al., 1993).

The pH of natural water was controlled in a great extent by the interaction of hydroxyl ions arising from the hydrolysis of bicarbonate (Sharma, 1986). The pH of Sahastradhara stream was recorded slightly alkaline (7.2 - 8.1). Hardness is mainly due to percentage of calcium and magnesium salts of bicarbonates, carbonates, sulphates and chlorides, while the value of alkalinity occured due to presence of bicarbonates.

The highest concentration of hardness was analyzed 250 mg/l during warm months. A positive relationship between hardness and alkalinity was recorded in river Ganga at Rishikesh (Chopra and Patric, 1994).

Maximum chloride concentration was recorded (17.14 mg/l) in the month of May and minimum in December (11.36 mg/l). Chloride and hardness showed a positive relationship to one another (Chopra and Patric, 1994). Chloride was found in the form of chloride ion, and one of the major inorganic anion present in natural water.

Calcium and magnesium the dominant cations, and these represent the main weathering products, but significant hydro-chemical differences between the five sampling sites associated with the bedrock geology exist (Jenkins et al., 1995) Calcium is one of the essential nutrients, which plays an important role in biological system. Maximum calcium concentration was recorded (104.21 mg/l) in the month of May and minimum in January (77.154 mg/l). Calcium concentrations were found maximum about 7.5% of the total solids present in the stream water. Positive relationship between, calcium and temperature was also reported by Khanna and Singh (2000) in river Suswa, Dehradun. Magnesium is also an essential element but it is toxic at higher concentration. The amount of magnesium in Sahastradhara was found maximum (68.0 mg/l) in the month of April and minimum (45.0 mg/l) in December.

During the summer season nutrients concentration in hill-streams became more. Miller et al.(1997) described the nutrients availability in selected environmental settings of the Potomac River and Cameron, E. M. (1996) showed the similar type of fluctuation in Fraser river of British Columbia. Sodium is one of the most common cation have no adverse effect on human health at lower concentration. Bond, H.W. (1979) described similar nutrients concentration pattern in a stream draining a mountain ecosystem in Utah. Maximum sodium concentration in Sahastradhara was recorded (11.0 mg/l) in the month of May and minimum in January (6.0 mg/l).

Potassium is naturally occurring element, released by the clay minerals, weathering and leaching from growing vegetation and decomposition of organic matter (Berndtsson, 1990). Maximum potassium concentration was recorded (18.0 mg/l) in the month of April and minimum in December (14.0 mg/l). Pande and Mishra (2000) also observed similar results on Sahastradhara hill-stream Dehradun. Relationship between major ions and other physico-chemical parameters are given in the table-4 and percentages of major ions among the total dissolved solids are given in table-5, during the study period. These high concentrations confirm the location of the calcareous formation associated with the Central Himalaya thrust. Similarly, samples from stream draining the slope of Doon valley, exhibit high concentrations of Mg relative to K and Na. Again this can presumably be attributed to local geological features. In general, the

stream at site III with high Ca concentrations also exhibit relatively low K concentrations compared to the other sites.

Table- 1: Physical parameters of water quality of Sahastradhara stream

Parameters	Site- I	Site- II	Site- III	Site- IV	Site- V
Temperature (°C)	15.75±1.14	15.37±1.63	15.0±1.41	15.75±1.6	15.75±2.277
Velocity (m/s)	0.3±0.14	0.9±0.1	0.35±0.05	0.8±0.02	0.65±0.05
Turbidity (JTU)	2.75±1.47	3.25±1.30	4.5±1.15	3.75±1.48	4.75±1.48
Total solids (mg/l)	1218±183.2	1234.2±89.8	1277.25±122.6	1305.7±166.1	1290.75±146.1
TDS (mg/l)	1093.25±175	1094.25±120.5	1140.5±134.6	1189±158.01	1134.25±176.1
TSS (mg/l)	124.75±14.39	140.0±28.16	136.75±40.95	116.75±13.8	156.5±41.69

Table- 2: Chemical parameters of water quality of Sahastradhara stream

Parameters	Site- I	Site- II	Site- III	Site- IV	Site- V
pH	7.625±0.43	7.6±0.28	7.75±0.15	7.75±1.66	7.6±0.339
Free CO2 (mg/l)	1.6525±0.39	1.75±0.017	1.825±0.25	1.74±0.09	1.87±0.21
D O (mg/l)	8.41±1.62	8.46±1.18	8.65±0.95	7.55±0.87	7.49±1.36
BOD (mg/l)	1.875±0.162	1.98±0.23	2.25±0.18	2.0±0.14	2.05±0.15
COD (mg/l)	2.55±0.32	2.6±0.25	2.9±0.22	2.68±0.22	2.7±0.18
Hardness (mg/l)	196.25±8.2	200.0±15.41	222.5±19.2	200.0±18.71	198.75±21.02
Alkalinity (mg/l)	250.0±134.7	262.5±140.8	305±172.1	292.5±168.8	317.5±175.2

Table- 3: Major elements of Sahastradhara stream water

Parameters	Site-I	Site-II	Site-III	Site-IV	Site- V
Chloride *(mg/l)*	12.78±1.73	13.73±1.93	15.26±2.1	13.49±3.25	11.6±3.06
Calcium *(mg/l)*	84.67±3.58	85.67±4.28	91.68±10.13	89.18±8.26	88.43±6.19
Magnesium (*mg/l)*	48.66±3.09	57.33±3.29	64.66±2.36	55.33±2.49	51.0±5.29
Sodium *(mg/l)*	7.375±0.96	7.725±0.506	8.75±0.75	8.87±1.14	9.25±1.35
Potassium *(mg/l)*	15.13±0.74	15.75±0.901	16.62±0.65	16.5±0.79	17.0±1.35

Table- 4: Correlation between major elements and physico-chemical parameters of Sahastradhara stream water

Parameters	Chloride	Calcium	Magnesium	Sodium	Potassium
Temperature *(℃)*	-0.86097	-0.51833	-0.92056	-0.01186	-0.14275
Velocity *(m/s)*	-0.17595	-0.12077	0.007842	0.179873	0.225839
Turbidity *(JTU)*	0.012697	0.818834	0.400371	0.92284	0.959357
Total solids *(mg/l)*	-0.00448	0.788427	0.273292	0.949891	0.906666
T. D. S. *(mg/l)*	0.133154	0.71132	0.25802	0.764443	0.682478
T. S. S. *(mg/l)*	-0.35586	0.096981	0.004271	0.35689	0.46296
pH *(pH unit)*	0.681329	0.761113	0.623067	0.395679	0.345766
Free CO_2 *(mg/l)*	-0.03224	0.686443	0.396104	0.833271	0.90927
D.O. *(mg/l)*	0.679888	-0.12231	0.471533	-0.65112	-0.55633
B. O. D. *(mg/l)*	0.607899	0.912138	0.845587	0.615583	0.694262
C. O. D. *(mg/l)*	0.595229	0.954861	0.801927	0.654354	0.704159
Hardness *(mg/l)*	0.814816	0.795954	0.897315	0.312648	0.386789
Alkalinity *(mg/l)*	-0.04111	0.829565	0.331085	0.97707	0.985243

Table- 5: Percentage of different major elements (%) among the total dissolved solids at different location of Sahastradhara stream at Dehradun

Variable	Site-I	Site-II	Site-III	Site-IV	Site-V
Total dissolved solids	100%	100%	100%	100%	100%
Chloride	1.0492%	1.1125%	1.1948%	1.0331%	0.8987%
Calcium	6.951%	6.941%	7.178%	6.830%	6.851%
Magnesium	3.995%	4.645%	5.062%	4.238%	3.951%
Sodium	0.6055%	0.6263%	0.6852%	0.6793%	0.7166%
Potassium	1.242%	1.276%	1.301%	1.264%	1.317%

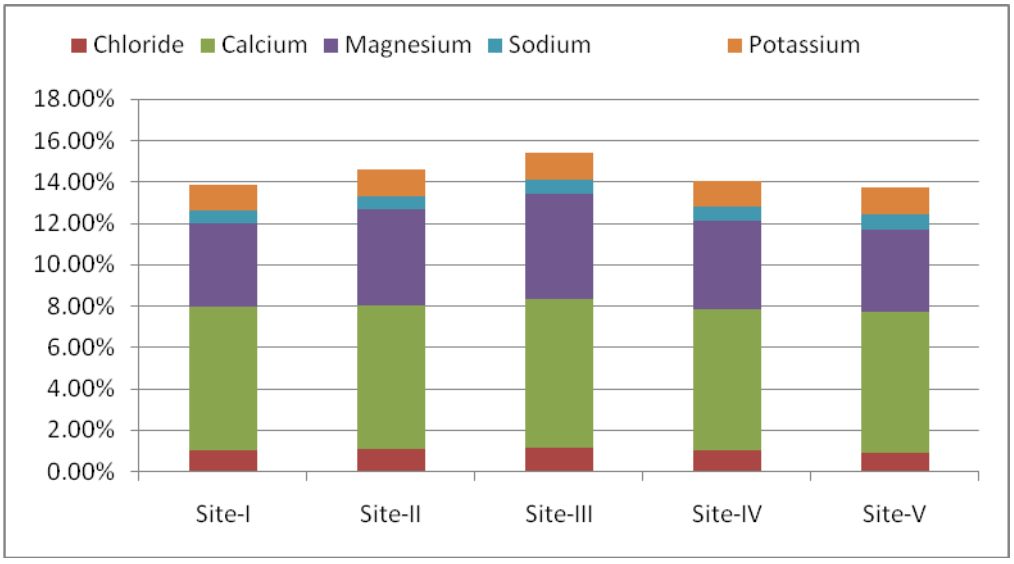

Fig.-1: Percent composition of major elements among total dissolved solids in Sahastradhara water

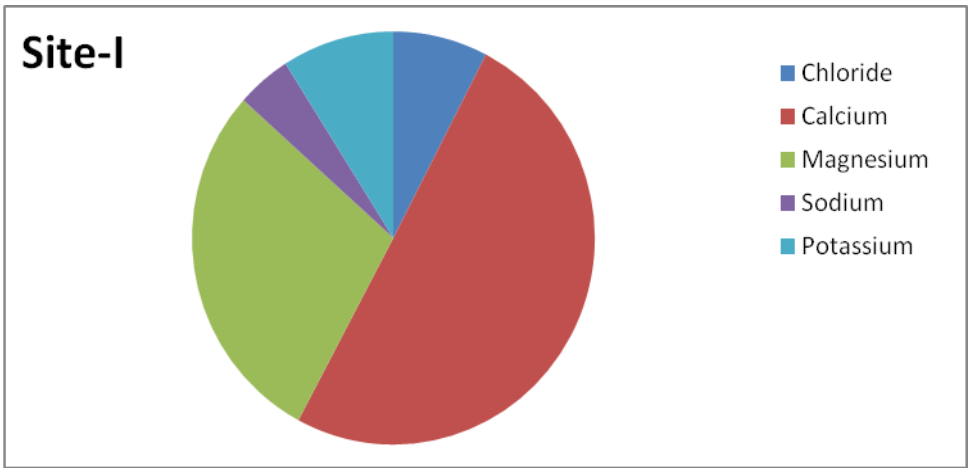

Fig.-2: Percent composition of major elements among total dissolved solids at Sahastradhara site-I

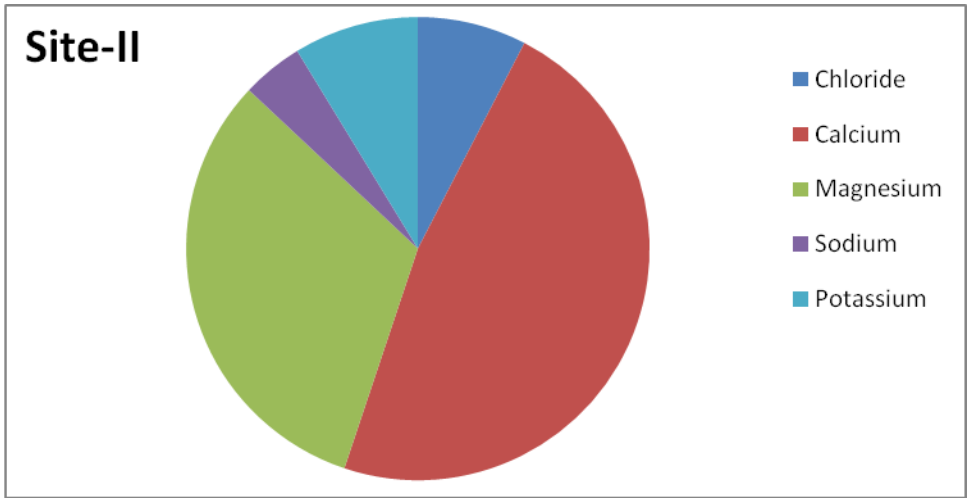

Fig.-3: Percent composition of major elements among total dissolved solids at Sahastradhara site-II

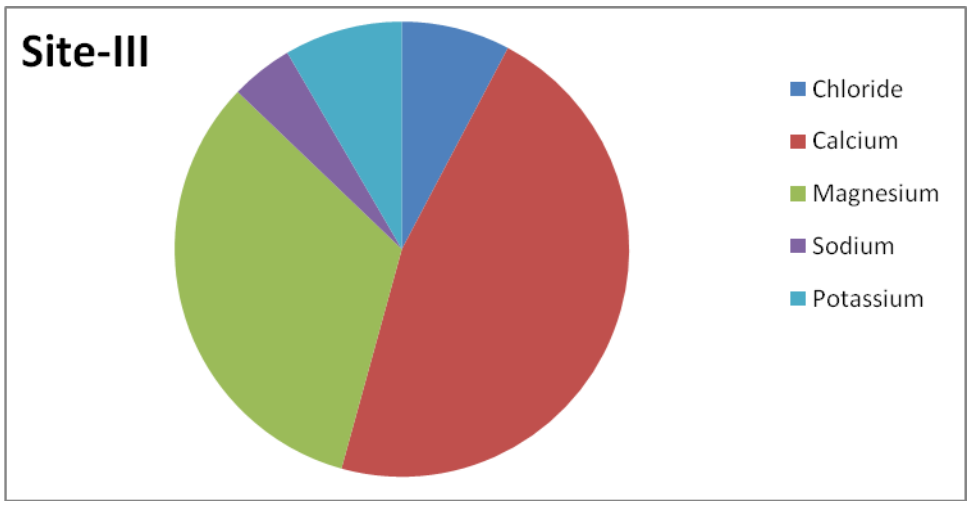

Fig.-4: Percent composition of major elements among total dissolved solids at Sahastradhara site-III

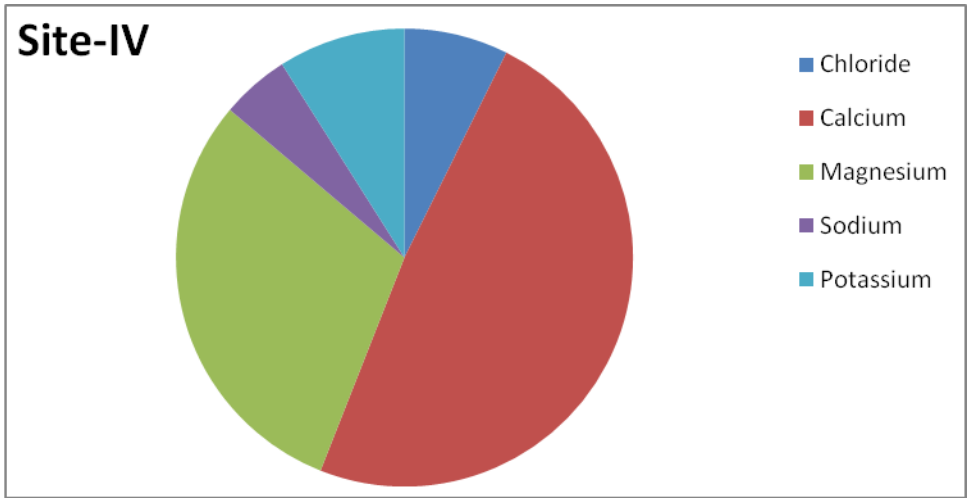

Fig.-5: Percent composition of major elements among total dissolved solids at Sahastradhara site-IV

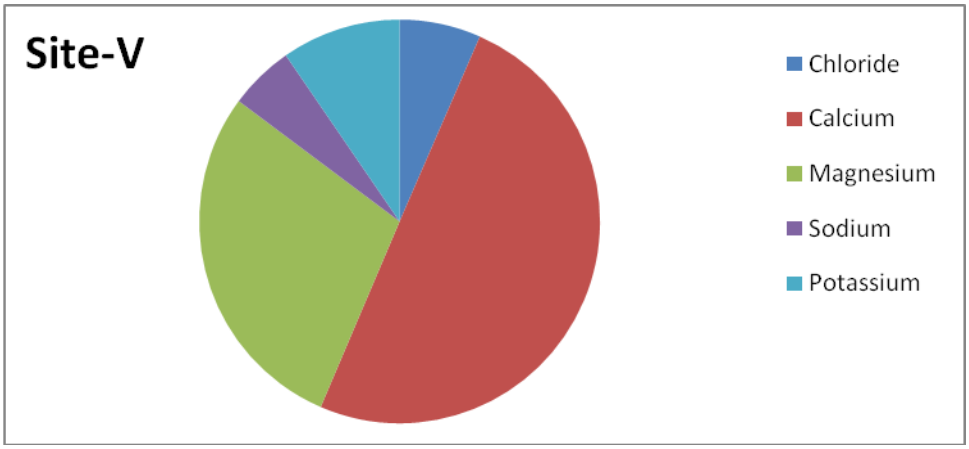

Fig.-6: Percent composition of major elements among total dissolved solids at Sahastradhara site-V

Conclusion

The present results conclude that significant differences in stream water nutrient concentrations exist among different environmental settings within the five subunits. The environmental setting with the highest potential by more soluble nutrients, fluctuations in nutrient concentrations were the land use and carbonate bedrock that was predominated in the Doon valley especially, at main tourist spot & sulphur springs site III.. Ca and Mg are the dominant cations in this alkaline tributary of river Song. Rock weathering is the most important mechanism controlling the water chemistry. The high concentrations of alkali earth metals, high alkalinity and the high (Ca+Mg)/(Na+K) ratio indicate that the water chemistry of the stream is controlled largely by carbonate weathering and partially by run-off process & tourists activities. The spatial variations in TDS are attributed to climatic and lithological control over the ionic concentrations.

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