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Primary production efficiency in different environmental settings of Sahstradhara hill-stream, Dehradun.

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Abstract

An investigation was conducted on primary productivity and water quality of Sahastradhra hill-stream for evaluation of aquatic ecosystem status in different environmental settings along with the stream. The factors such as temperature, pH, carbon dioxide and plankton on which primary productivity depends were studied. It was pointed out that the Gross primary productivity showed a negative relationship with temperature, pH and carbon dioxide.

The present paper deals with the production efficiency of Sahastradhara hill stream, Dehradun and maximum production efficiency of Sahastradhara stream was found 66.66% at sampling site- III in the month of December 2003, while minimum production efficiency was recorded 20.79% at site- IV during May 2004.

Key words: *Production efficiency, Primary productivity, Photosynthesis, Hill-stream ecology.*

Introduction

The rate of production of organic matter per unit time is termed as productivity with the two levels; primary and secondary in producers and consumers respectively. the amount of new organic matter as plant tissue built up by photosynthesis is termed as primary production. Primary productivity is the rate at which the sun's radiation energy is stored by photosynthetic activity of producer organisms. The animal and plant communities inhabiting water bodies are considered as the direct manifestation of the productivity. It is well established that the primary productivity is controlled by several physico-chemical and biotic interactions (Pandey and Mishra,2000).

There are few successive steps of production process; Gross Primary Productivity (GPP) rate of photosynthesis and includes the organic matter used up in the respiration; Net primary productivity (NPP) the rate of storage of organic matter in plant tissues in excess of the respiratory utilization by the producer; Net community productivity (NCP) or community respiration (CR) the rate of organic matter not used by heterotrophs. Production effeciency depends upon net primary productivity. If NPP is relatively high, than production efficiency will be automatically high in the particular ecosystem.

Material and Methods

Five sampling site were selected for the measurement of primary production & efficiency in Sahastradhara river. We choose the *light & dark bottle method* of Gaarder & Gran for estimation of primary productivity. The water samples were collected monthly from five sampling stations of 'Sahastradhara stream' during December 2003 to May 2004 in morning period 9:00 hrs. to 10:00 hrs. The samples for plankton 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), Santhanam et. al (1989) and Bharti (2004).

Results and Discussion

It is well established that the primary productivity is controlled by several physico-chemical and biotic interactions. The biotic communities inhabiting water bodies are considered as the direct manifestation of the productivity. The maximum gross primary productivity of Sahastradhara stream was observed during winter season. Kar *et al*. (1978) recorded high productivity also in winter season.

Temperature plays a vital role in all physico-biochemical reactions and self-purification power of aquatic system. Temperature fluctuation measurement is useful to determine the trends of bio-chemical and biological activities. Temperature was recorded maximum (17.7ºC ± 0.4) in the month of May and minimum (13.1ºC±0.66) in January. The temperature of water decreases form September and increases from January onward. Badola and Singh (1981) observed similar trend in the river Alaknanda in the Garhwal region. Joshi and Kathait (1998) also reported similar trend in three Tributaries of river Ganga. The higher productivity in the present studies was concomitant with water temperature range from 14ºC to 18ºC. Singh and Swaroop (1980) observed positive correlation with productivity and water temperature. A positive correlation existed between gross primary productively and calcium in Cauvery (Lakshminarayan, 2001). Vashney *et al*. (1983) recorded a positive correlation was between gross primary productivity and dissolved oxygen while the negative correlation between gross primary productivity and temperature and free carbon dioxide. Sumithra (1971) reported a distinct correlation between productivity and alkalinity, we have also find the similar on individual values but there may be a standard error in correlations due to the mean value of parameters during the different months.

In this study it was recorded that the pH was always slightly alkaline. The pH of natural water was controlled in a greater extent by the interaction of hydroxyl ions, resulting form the dissociation of carbonic acid, and form hydroxyl ion arising from the hydrolysis of bicarbonate, was recorded highest (8.02 ± 0.1166) in December and lowest (7.4 ± 0.1414) in the month of April. The higher rate of photosynthesis decreases free carbon dioxide content and increases dissolved oxygen (Denham, 1938) while higher rate of decomposition increases free carbon dioxide. Similar observations were found in Sahastradhara stream during investigating period. Vashney *et al.* (1983) observed negative correlation between productivity and turbidity, total dissolved solids & suspended solids because these factors deceases the light penetration & further affects the rate of photosynthesis in aquatic ecosystem (Khanna, 1993), while negative correlation between GPP and pH, temperature & free carbon dioxide.

The maximum value of free carbon dioxide was observed (2.2 mg/l ±0.155) in May and minimum value in January (1.70 mg/l ± .066) free carbon dioxide and dissolved oxygen showed a negative relationship to one another. The highest rate of photosynthesis decreases free carbon-dioxide content and higher rate of decomposition increases free carbon dioxide.

The maximum net primary productivity was observed (0.335 ± .093) in the month of December and minimum (0.170 ± .04) in the month of May. The maximum gross primary productivity was observed (0.796 ± .123) in the month of January and minimum (0.569 ± .0379) in the month of May. The maximum net community respiration was observed (0.479 ± .0575) in the month of January and minimum (0.399 ± .0102) in the month of April. Net production efficiency shows the positive correlation with dissolved oxygen, while the negative correlation between net production efficiency and carbon dioxide. The maximum net production efficiency was observed (43.79%) in the month of December and minimum (29.88%) in the month of May. Similar trend was observed by Yeragi and Shaikh (2003) on the primary productivity of Tansa River. Kar *et al.* (1978) however, recorded low and high productivity in summer and winter respectively.

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Table-1: Primary productivity (mean values in mg/l) of Sahastradhara stream.

Parameters	Site-I	Site-II	Site-III	Site-IV	Site-V
N.P.P.	(0.200 - 0.355)	(0.200 – 0.255)	(0.140 – 0.500)	(0.105 – 0.320)	(0.200 – 0.330)
Mean	0.271±.069	0.220±.0215	0.336±.108	0.231±.086	0.265±.0522
G.P.P	(0.605 - 0.805)	(0.600 – 0.705)	(0.550 – 1.01)	(0.505 – 0.900)	(0.580 – 0.810)
Mean	0.6925±.074	0.640±.0776	0.716±.1344	0.729±.0975	0.676±.0826
C.R.	(0.405 - 0.450)	(0.400 – 0.450)	(0.390 – 0.480)	(0.400 – 0.580)	(0.380 – 0.480)
Mean	0.420±.0184	0.420±.0635	0.421±.0394	0.498±.156	0.411±.0375
NP.E (%)	(33.05 – 44.09)	(33.33 – 36.17)	(25.45 – 66.66)	(20.79 – 37.03)	(34.48 – 42.55)
Mean	38.77±4.7	34.29±1.101	44.15±15.56	30.485±6.445	38.87±3.069

Table- 2: Planktonic population (mean values) of Sahastradhara stream.

Planktonic diversity	Site-I	Site-II	Site-III	Site-IV	Site-V
Total plankton (n/l)	(700 - 1540)	(725 - 1525)	(693 - 1480)	(700 - 1490)	(730 - 1583)
Mean	1130.25±316.8	1133±316	1101.5±323.9	1063.75±346.9	1163.25±339.4
Phytoplankton (n/l)	(625 - 1380)	(635 - 1380)	(615 - 1345)	(635 - 1340)	(640 - 1410)
Mean	1018.25±286.1	1023.75±291.5	992.5±296.3	951.25±318.2	1037.5±259.5
Zooplankton (n/l)	(75 - 160)	(77 - 145)	(78 - 140)	(65 - 150)	(90 - 173)
Mean	112±31.61	109.25±27.09	109±28.6	112.5±31.72	125.75±36.66

Table-3: Physico-chemical parameters (mean values) of Sahastradhara stream.

Parameters	Site- I	Site- II	Site- III	Site- IV	Site- V
Temperature °C Mean	(14 - 18) 15.75±1.14	(13 – 17.5) 15.37±1.63	(13 - 17) 15.0±1.41	(13.5 - 18) 15.75±1.6	(12 - 18) 15.75±2.277
Velocity (m/s) Mean	(0.3 – 0.4) 0.3±0.14	(0.28 – 0.32) 0.9±0.1	(0.8 – 1.0) 0.35±0.05	(0.78 – 0.82) 0.8±0.02	(0.6 – 0.7) 0.65±0.05
Turbidity (JTU) Mean	(1 – 5) 2.75±1.47	(2.0 – 5.0) 3.25±1.30	(3 - 6) 4.5±1.15	(2 - 6) 3.75±1.48	(3 - 7) 4.75±1.48
Total solids (mg/l) Mean	(955 - 1427) 1218±183.24	(1090 - 1332) 1234.2±89.8	(1115 - 1443) 1277.25±122.6	(1135 - 1520) 1305.7±166.1	(1148 - 1535) 1290.75±146.1
TDS (mg/l) Mean	(840 - 1278) 1093.25±174.9	(895 - 1217) 1094.25±120.5	(1010 - 1322) 1140.5±134.6	(1039 - 1380) 1189±158.01	(965 - 1420) 1134.25±176.1
TSS (mg/l) Mean	(113 - 149) 124.75±14.39	(119 - 195) 140.0±28.16	(105 - 207) 136.75±40.95	(105 - 140) 116.75±13.8	(115 - 211) 156.5±41.69
pH Mean	(7.2 – 8.1) 7.625±0.43	(7.3 – 8.1) 7.6±0.28	(7.5 – 7.9) 7.75±0.15	(7.6 – 8.0) 7.75±1.66	(7.2 – 8.1) 7.6±0.339
Free CO2 (mg/l) Mean	(1.40 – 1.69) 1.6525±0.39	(1.62 – 1.92) 1.75±.017	(1.62 – 2.20) 1.825±0.25	(1.65 – 1.85) 1.74±0.09	(1.62 – 2.20) 1.87±0.21
D. O. (mg/l) Mean	(7.04 – 11.08) 8.41±1.62	(6.84 – 10.07) 8.46±1.18	(7.04 – 9.47) 8.65±0.95	(6.04 – 9.06) 7.55±0.87	(6.04 – 9.47) 7.49±1.36
BOD (mg/l) Mean	(1.60 – 2.0) 1.875±0.162	(1.7 – 2.2) 1.98±0.23	(2.0 – 2.5) 2.25±.18	(1.8 – 2.2) 2.0±0.14	(1.9 – 2.3) 2.05±0.15
COD (mg/l) Mean	(2.1 – 3.0) 2.55±0.32	(2.2 – 2.9) 2.6±0.25	(2.6 – 3.2) 2.9±0.22	(2.4 – 3.0) 2.68±0.22	(2.4 – 2.9) 2.7±0.18
Hardness (mg/l) Mean	(190 - 210) 196.25±8.2	(185 - 220) 200.0±15.41	(200 - 250) 222.5±19.2	(180 - 230) 200.0±18.71	(185 - 235) 198.75±21.02
Alkalinity (mg/l) Mean	(150 - 480) 250.0±134.7	(140 - 500) 262.5±140.8	(170 - 600) 305±172.1	(130 - 570) 292.5±168.8	(120 - 540) 317.5±175.2

Table- 4 :Correlation (=CORREL) between Primary productivity (mean values) and Physico-chemical parameters (mean values) of Sahastradhara stream.

Parameters	Net primary productivity	Gross primary productivity	Community respiration	Net production efficiency
Temperature °C	-0.59945	0.006189	0.311429	-0.57232
Velocity (m/s)	-0.82147	-0.40554	0.387568	-0.78591
Turbidity (JTU)	0.459379	0.237629	-0.09751	0.389256
Total solids (mg/l)	0.086601	0.565255	0.544701	-0.16675
TDS (mg/l)	0.01787	0.761621	0.801179	-0.33031
TSS (mg/l)	0.165469	-0.58282	-0.73453	0.444083
pH	0.409892	0.87509	0.647625	0.023325
Free CO_2(mg/l)	0.335796	-0.03623	-0.24934	0.360837
D O (mg/l)	0.43596	-0.20694	-0.47748	0.522691
BOD (mg/l)	0.715985	0.330189	-0.11921	0.583037
COD (mg/l)	0.757185	0.484589	-0.01968	0.572202
Hardness (mg/l)	0.811178	0.38677	-0.13668	0.659382
Alkalinity (mg/l)	0.380434	0.349649	0.067672	0.259953