Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 10	No. 2	pp. 297-301	2011

Original Research Paper

Presence of Algae and Dissolved Oxygen Production in Seer Stream

D. K. Gautam and M. R. Sharma*
Govt. Polytechnic, Hamirpur-177 030, H. P., India
*MIT College of Engineering and Management, Bani-174 304, District Hamirpur, H. P., India

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 15-11-2010
Accepted: 30-12-2010

Key Words:
Filamentous attached algae
Dissolved oxygen production
Seer stream
Water quality model

ABSTRACT

Seer is the stream in outer Himalayas, which is a sub-tributary of River Satluj. It is getting polluted due to wastewater of Ghumarwin town in District Bilaspur in Himachal Pradesh. The pollution impact is severest in the low flow months of summer. Steep slopes, pools, riffles, shallow depth and small waterfalls are the main characteristics of the stream. The stream bed consists of stones and cobbles. All the stones in the stream bed are heavily coated with a greenish layer of algae. Greenish filamentous attached algae also grow in abundance in the stream. Some aquatic plants have also been observed in the stream. The paper describes the quantification of oxygen production due to the presence of attached algae in the stream.

INTRODUCTION

Himalayas are the cradle of a large number of streams and mighty rivers, which ensure all the year round availability of water. Seer is one of the sub tributaries of river Satluj Himachal Pradesh, India. It lies at latitude of 31°25'59' North and 76°43'11' East longitude. The Ghumarwin town is located on left bank of the Seer stream. It is a small rainfed perennial stream taking its origin from near Sarkaghat in District Mandi and meandering over 20 km in the district of Bilaspur. It finally joins River Satluj. It swells during rainy season but gets reduced to a narrow stream in summer. The stream serves as a drinking water source for the region. For want of proper sewerage system, the night soil from the houses is being treated through septic tanks. The water from kitchens and baths flows in open drains and is being discharged into local nallahs named as Ghumarwin nallah-I and Ghumarwin nallah-II. The wastewater of the town is polluting the stream (Sharma et al. 2002).

Water quality models have gained wide acceptance as valuable tools to support the effective management of pollution-impacted streams and lakes. The credibility of the model is accomplished through model calibration and verification. The verified model can be used to forecast the water quality, when any control measure is implemented.

During the water quality modelling of Seer stream, it was observed that the water quality model stream-1 assumes very high values of deoxygenation coefficient (K_1) and reaeration coefficient (K_2). The paper describes the quantification of oxygen production due to the presence of attached algae in the stream. Thus, there is a need to modify the existing water quality models to predict the water quality of hilly streams.

Stream geometry: Seer stream has a steep slope which varies greatly on different reaches. The stream has different velocities and cross-section in different reaches. The stream comprises of small waterfalls and tiny pools. Steep slopes, pools, rimes and small waterfalls thus characterize the stream. The stream bed consists of stones and cobbles. All the stones in the stream bed are heavily coated with a greenish layer of algae. There are also plentiful greenish filamentous attached algae in the stream.

MATERIALS AND METHODS

To assess the contribution of solar energy to dissolved oxygen (DO), a section of Seer stream, 500m in length i.e., Reach-1 (Fig. 1) was selected and DO was monitored for one year, round the clock and diurnal variation in DO was observed.

Since the entire bed of Reach-1 is covered with attached algae it has been assumed that the bed of stream is covered with a uniform, thin layer of algae growing on stones and rocks and the entire bed is contributing to the oxygen production. An attempt has been made to correlate diurnal DO variation with solar energy and algal growth.

Algal growth converts solar energy to chemical energy in the organic form. It has been assumed that 6% of the visible light energy will get converted to algal growth in the Seer stream. This is parallel to the assumption universally made for oxidation pond design. The chemical energy contained in an algal cell has been found taking average of 6000 calories per gramme of algae, on ash free basis.

The light energy received on a surface has been stated as g calories per cm^2 per day (langleys/day). Typical values for latitudes from 12° to 34° North have been taken from standard tables. These ideal values have been adjusted for cloudiness and elevation. The maximum values relate to clear sky condition, while minimum values occur when the sky is cloudy, depending on the 'sky clearance factor' for the area. The sky clearance factor (SKF) values for the Indian cities have been taken from standard tables (Bajwa 1993). Since the SKF values for all the months and the site under study were not available, they have been assumed very close to the values given for Roorkee city which is situated at about the same latitude and has similar weather conditions as Bilaspur (Ghumarwin). The possible day light hours for a particular month have been taken from standard table (Michael 1992). These values have been compared with the local almanac available for the region. The average visible radiation received has been estimated as follows:

Average Radiation = Mill radiation + (Max. radiation – Min. radiation) × sky clearance factor correction for elevation above mean sea level = Visible radiation at sea level {1 + 0.003EL}, where EL is elevation in 100m.

Applying this empirical formula average algal production in g per m^2 per day have been found for Reach-1 of the Seer stream (Fig. 1) i.e., 500m in length and oxygen production has been calculated by multiplying the algal production by a factor of 1.3. The oxygen consumed for algal respiration at the rate of 10% of oxygen produced has been deducted from it. Average discharge of the stream in the stretch has been observed. The volume of the water passing that stretch has been calculated for the entire day light time.

Fig. 1: LOcation plan of sampling stations for diurnal dissolved oxygen measurement in Seer stream.

Average oxygen produced has been found out by multiplying the net oxygen produced with surface area of the reach. The value of oxygen available has been found out by dividing the average oxygen produced for the entire day light period by volume of water passing the bed area of stream during day light hours. This has been compared with the observed value of DO variation at site. The percentage deviation from the calculated values has been found out.

Keeping in view the fact that stream flow and concentration do not change rapidly, grab samples for dissolved oxygen were collected at two stations from the centre of stream at 0.6 m depth. The guidelines given by U.S.EPA in 'A Methods Manual for Volunteer Stream Monitoring' were followed for sampling. All the samples were analysed following standard methods (APHA 1992).

RESULTS AND DISCUSSION

During the study, it has been observed that the bed of Seer stream is heavily coated with attached algae. In addition to it filamentous algae are also present in the stream water. The presence of rooted and attached macropytes has also been noticed in Seer stream as well as in Ghumarwin nallah-I. As a result of presence of attached algae in the water the diurnal variability of DO in the stream is high. The net effect of photosynthesis and respiration contributes to the average DO resources of the stream.

Seer is a shallow stream and light can reach up to the bottom, the plants (algae and macropytes) would tend to make up most of the plant biomass. Heavy algal growths have been observed at the bed of stream growing on stones and rocks. Filamentous algae are also common at unpolluted and slightly polluted sites in the stream. Table 1 gives the month-wise diurnal dissolved oxygen variation in Seer stream at Reach-1. Table 2 gives the month-wise calculation of oxygen production in Seer stream at Reach-1, i.e., from RD 0 to 500m.

The sample calculations for the month of January are given below:

1. Visible Solar Radiation for the month of January,
   Maximum = 124
   Minimum = 62
2. Sky Clearance Factor (S.K.F.) = 60%
3. Average Radiation = Min. Rad. + (Max. Radiation – Min Radiation) × S.K.F.
   = 63 + (126-63) 0.60 = 99.2
4. Applying correction for elevation for 600m above mean sea level = Visible Radiation at sea level [1+ 0.003 EL], where, EL is elevation in 100m= 99.2 [1+ 0.003 × 7] = 101.28

Table 1: Diurnal variation (2-hourly) in dissolved oxygen (mg/L) in Seer stream.

Date	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.0	22.0	24.00	2.00	4.00	Mean	Max	Min	Max vari-aiton
Jan. 09	8.9	9.4	11.1	1.9	11.0	10.8	10.6	10.4	9.8	8.8	8.8	8.8	10.0	11.9	8.8	3.1
Feb. 09	7.7	8.9	10.6	11.6	11.1	9.6	9.4	9.4	7.7	7.7	7.7	7.7	9.1	11.6	7.7	3.9
Mar. 09	7.1	8.3	10.1	11.0	106	9.1	8.9	8.7	7.1	7.1	7.1	7.1	8.5	11.0	7.1	3.9
Apr. 09	6.8	7.3	7.8	8.9	9.9	8.7	7.3	6.4	6.4	6.4	6.4	6.4	7.4	9.8	6.4	5.0
May 09	5.2	6.5	7.3	8.2	8.8	10.8	9.2	7.7	6.2	5.2	5.2	5.2	7.1	10.7	5.2	5.6
Jun. 09	5.3	7.1	7.8	9.2	9.8	8.9	7.5	5.3	5.3	5.3	5.3	5.3	6.8	9.8	5.3	4.5
Jul. 09	5.1	5.3	7.0	7.0	6.5	6.5	5.9	5.6	5.4	5.3	5.3	5.3	5.9	7.0	5.1	1.9
Aug. 09	5.4	6.2	7.6	7.6	7.2	6.8	6.4	5.9	5.4	5.4	5.4	5.4	6.2	7.6	5.4	2.2
Sep. 09	6.0	75	9.0	9.3	9.0	8.0	7.6	6.0	6.0	6.0	6.0	6.6	7.2	9.3	6.0	3.3
Oct. 09	6.3	7.5	8.5	8.8	7.5	6.3	6.0	6.0	6.0	6.0	6.0	6.0	6.7	8.8	6.0	2.8
Nov. 09	8.0	U	9.5	10.5	16	8.4	8.3	7.9	7.9	7.9	7.9	7.9	8.6	10.5	7.9	2.6
Dec. 09	8.5	9.2	10.2	10.8	10.8	9.5	8.6	8.5	8.5	8.5	8.5	8.5	9.2	10.8	8.5	2.3

Table 2: Solar radiation and algal production/oxygen production in Seer stream in Reach-1.

S. No.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Jan	126	63	60	100.8	102.95	102.95	10.30	13.38	0.33	13.05	10.30	76	2818080	534	6968403	2.5	3.1
2	Feb	169	87	60	138.2	139.11	139.11	13.91	18.08	0.45	17.63	11.00	77	3049200	528	930e847	3.1	3.9
3	Mar	212	126	60	177.6	181.40	181.40	18.41	23.58	0.69	22.99	11.90	60	2510400	428	9840524	3.8	3.9
4	Apr	258	146	10	224.40	229.20	229.20	22.	29.80	0.74	29.06	12.80	30	1382400	314	912:1812	6.6	3.5
5	May	290	181	60	286.2	27$.93	273.93	21.39	35.61	0.89	34.72	13.60	10	485600	176	6110888	12.5	5.8
6	Jun	296	186	66	25c<.50	255.85	255.85	25.	33.26	0.83	32.43	14.00	30	1512000	232	7523626	5.0	4.5
7	Jul	289	178	65	250.16	255.50	255.50	25.55	33.21	0.83	32.38	13.81	350	17400600	982	318001198	1.8	1.9
8	Aug	269	183	66	231.90	236.88	236.88	23.69	30.79	0.17	30.02	13.15	500	23870000	1350	40529011	1.1	2.2
9	Sep	226	140	50	208.80	213.26	213.26	21.33	27.22	0.69	27.03	12.25	250	11025000	900	24327893	2.2	3.3
10	Oct	185	104	90	176.90	180.68	180.68	18.07	23.49	0.59	22.90	11.15	200	8028000	850	19486069	2.4	2.8
11	Nov	138	80	85	1290.30	132.06	132.0$	13.21	17.17	0.43	18.74	10.50	123	4649400	615	10294497	2.2	2.6
12	Dec	114	60	85	105.90	108.16	108.16	10.82	14.06	0.35	13.71	10.10	85	3090600	543	7444359	2.4	2.3

A-Month; B-Maximum; C-Minimum; D-Sky clearance factor; E-Average radiation; F-Correction for elevation for 600m; G-Average algal production in kg/ha/day; H-Average algal production in g/sq.m/day; I-Average oxygen produced in g/sq.m/day; J-Oxygen consumed for algal respiratory at the rate of 0.025; K-Net oxygen available in mg/sq.m/day; L-Average day light hours during the month at Ghumarwin; M-Average discharge in l.p.s. during the month in Reach-1; N-Volume of water passing bed area during the day light hrs of stream in Reach-1; O-Surface area of the Reach producing algal oxygen; P-Average oxygen produced and available for mass transfer in Reach-1 of the stream; Q-Calculated value of oxygen in mg/L; R-Observed value of oxygen in mg/L

5. Average algal production in kg/ha-day = {99.2 × 108 × 0.06} × (1/6000) × (1/103) = 102.75 kg/bs-day
6. Average algal production in g/m^2-day = 102.75 × 1000 × (1/10000) = 10.20 g/sq.m
7. Average oxygen production at the rate of 1.3 times the algal production = 10.20 × 1.3 = 13.26 g/sq.m
8. Oxygen consumed for algal respiration = 0.025 × 13.26 = 0.3315 g/sq.m
9. Net oxygen available in g/sq.m per day = 13.26 – 0.33 = 12.93 g/sq.m
10. Average day light hours during the month of January at Ghumarwin = 1030 hrs.
11. Average discharge in litre per second during the month at Reach-1 = 75.02 l.p.s.
12. Volume of water passing the bed area of stream during the day light hours at Reach-1 = 2807000 litres
13. Surface area of the Reach-1 contributing to algae/oxygen production = 530 sq.m
14. Average oxygen produced in mg and available for mass trawler in Reach-1 of stream = (net oxygen available in g/sq.m) × 1000 × (surface area of Reach-1) = 12.93 × 1000 × 530 = 685290 mg
15. Calculated value of oxygen available in mg and available for mass transfer in Reach-1 of stream) (net oxygen available in g/sq.m × 1000 × surface area of Reach-1) = 685290 + 2807000 = 2.49 mg/L
16. Observed value of DO variation in mg/L at Reach-1 in stream = 2.9 mg/L

Table 3: Seasonal average of diurnal DO variation in Seer stream at un-polluted site.

Sr. No.	Season	Month	Observed value of diurnal variation of DO in the stream in mg/L	Remarks
1	Winter	October	2.7	Observed values have been taken from Table 2
2	Winter	November	2.8	
3	Winter	December	2.4	
4	Winter	January	3.0	
5	Winter	February	3.8	
	Min. value of the season		2.4	
1	Summer	March	3.9	
2	Summer	April	3.4	
3	Summer	May	5.7	
4	Summer	June	4.6	
	Min. value of the season		3.4	
1	Monsoon	July	1.8	
2	Monsoon	August	2.3	
3	Monsoon	September	3.4	
	Min. value of the season		1.8	

Table 4: Maximum dissolved oxygen at various temperatures at sea level and at a height of 600m above mean sea level i.e., mean level of Seer stream.

Temperature in Degrees Celsius	DO at sea level (mg/L)	D.O. at a height of 600m above mean sea level (mg/L)	Temperature in Degree celsius	D.O. at sea level (mg/L)	D.O. at a height of 600m above mean sea level(mg/L)
0	14.60	13.42	23	8.56	7.87
1	14.19	13.04	24	8.40	7.72
2	13.81	12.70	25	8.24	1.58
3	13.44	12.36	26	8.09	7.43
4	13.09	12.04	27	7.95	7.31
5	12.75	n.73	28	7.81	7.18
6	12.43	11.43	29	7.67	7.05
7	12.12	11.14	30	7.54	6.93
8	11.83	10.88	31	7.41	6.81
9	11.55	10.62	32	7.28	6.69
10	11.27	1036	33	7.16	6.58
11	11.01	10.12	34	7.05	6.48
12	10.76	9.26	35	6.93	6.37
13	10.52	9.67	36	6.82	6.27
14	10.29	9.46	37	6.71	6.17
15	10.07	9.26	38	6.61	6.07
16	9.85	9.06	39	6.51	5.99
17	9.65	8.87	40	6.41	5.89
18	9.45	8.69	41	6.31	5.80
19	9.26	8.51	42	6.22	5.72
20	9.07	8.34	43	6.13	5.64
21	8.90	8.18	44	6.04	5.55
22	8.72	8.02	45	5.95	5.47

Source: Volunteer Stream Monitoring-A Methods Manual, (1997) EPA 841-B-97-033, p.140
Note: *Saturation Concentration of DO at 'p' Atmospheric pressure = Saturation concentration of DO at 1 atm {1-0.1148 × elevation (km)}
Where, elevation is elevation above mean sea level.

17. Percent deviation from the calculated value = (0.6/2.49) × 100 = 24%

It can be observed from Table 3 that with the exception of values for the month of April, May and September, the observed values of oxygen variation range from 90% to 130% of the calculated values. For the month of April and May the observed values are only 52% and 44% of the calculated values respectively. It is due to the reason that oxygen level during day in the month of April and May reaches a peak value of 9.8 and 10.7 mg/L respectively, which is much higher than the saturation values of oxygen (Table 4) at that particular temperature. Since the stream is flowing the dissolved oxygen may be escaping to the atmosphere.

In general, values of average daily aerial production rate range from about 0.3 to 3g $O_2m^{-2}d^{-1}$ for moderately productive streams. Highly productive systems can range from 3 to 20 g oxygen per square meter per day (Chapra 1997). Thus, it can be concluded that the algal biomass is major contributor of oxygen in the stream and must be taken into account during water quality modelling of the stream.

CONCLUSION

The streams in hilly regions of outer Himalayas are generally small having shallow depth with steep and variable slopes. The stream beds of these rivulets are covered with attached algae. The floating algae are generally insignificant due to swift and shallow nature of streams. These streams have high diurnal as well as seasonal variation in DO levels. Though QUAL-2e water quality model takes into account the effect of floating algae in rivers but the effect of attached algae has not been considered in any of the known models (Athens 1987). Since the effect of attached algae on DO levels in shallow streams is quite significant, there is need to modify the models to take into account the presence of periphyton and benthic algae.

ACKNOWLEDGEMENT

The authors are grateful to Er. Raj Kumar Mukul, Executive Engineer, Er. Satish Sharma Assistant Engineer, I & PH Division, Ghumarwin, Er. Pankaj Thakur, Lecturer of Computer Engg., and Sh. Amit Kumar Choudhary of Govt. Polytechnic College, Hamirpur for their help during the research work.

REFERENCES

APHA 1992. Standard Methods for the Examination of Water and Wastewater. 18th Edition, American Public Health Association, Washington, DC.

Arceivala, S. 1981. Wastewater Treatment and Disposal. Mercel Dekker, New York.

Bajwa, G.S. 1993. Practicla Handbook on Public Health Engineering. Deep Pubishers, Shimla.

Chapra, S.C. 1997. Surface Water Quality Modeling. McGraw Hill, N. Y.

Michael, A.M. 1992. Irrigation, Theory and Practice. Vikas Publishing House, New Delhi.

Oswakdm, W.J. 1972. Complete waste treatment in ponds. In: Proceedings of 6th International Water Pollution Research Conference, Pergamon Press, London.

Qual-2E UNCAS 1997. Documentation and User Model. U.S.EPA, Athens, 1987.

Sharma, M.R., Gupta, A.B. and Bassin, J.K. 2002. Waste quality management of Seer stream in Lower Himalayas. Indian Journal of Environmental Protection, 9: 1014-1025.

Sharma, Moti Ram, Bassin, J.K. and Gupta, A.B. 2003. Pollutional profile of Seer stream in Lower Himalayas. Pollution Research, 22(2): 237-240.

Sharma, M.R. and Gupta, A.B. 2004. Prevention and control of pollution in streams of outer Himlayas - A case study. 36th Annual Convention of IWWA, Ahmedabad, January 9-13, p.77-85.

U.S.EPA 1997. Volunteer Stream Monitoring: A Methods Manual. Office of Water, 4503F, EPA 841-B-91-003.