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WATER QUALITY MODELING AND MANAGEMENT OF SEER STREAM IN LOWER HIMALAYAS

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ABSTRACT

This paper deals with water quality status in Seer stream over a stretch of 5 km for variable, like biochemical oxygen demand (BOD) and dissolved Oxygen (DO) etc. One dimensional water quality model Stream – I was used in the study. The study shown that summer season is the most critical period when stream is having very less discharge. The various management options to treat wastewater of the stream have been discussed to maintain the water quality in the stream is within the prescribed standards.

KEYWORDS:* *Water quality management model, Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO).

INTRODUCTION

Water quality management is an organized effort to maintain, restore or improve the ambient water quality if the aquatic bodies, such that their most beneficiary use is not adversely affected, by exercising control over the waste loads and over the aquatic bodies themselves. Seer is one of the sub tributaries of river Satluj in Bilaspur District Himachal Pradesh (India). It lies at latitude of 31^0-26'-59" N and 76^0-43'-11" East longitude. The Bilaspur town falls in Shivalik Hills of lower Himalayan region, at an altitude of 600 m above means sea level. The town is located on Left Bank of Seer stream. It is small rain fed perennial stream taking its orgin from near Sarkaghat in Distt. Mandi and meandering over 20km in the district of Bilaspur. It ultimately joins Satuj river. It swells during rainy season but gets reduced to a narrow stream in the summer. The stream serves as 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 kitchen and baths flows in open drains and is being discharged into local Nallahs named as Ghumarwin Nallah-I and Ghumarwin Nallah-II. There has been a serious concern over the deterioration of water quality in steams of Himalayan region. Due to lack of literature in this region for water quality, the present study for monitoring, modeling and management of Seer stream was floated to evaluate the water quality profile of the stream and suggest water quality management for the region.

MATERIALS AND METHODS

Selection of a stream was necessary to apply concept of regional water quality management. After scrutinizing many streams, a sub-tributary of river Satluj was selected. The selected stretch is between abstraction point for water supply to Ghumarwin town on upstream and confluence of this stream with Satluj River, on downstream. The stretch was selected for the following reasons:

1. The stretch receives organic pollution from Ghumarwin town with a prospective increase in future.
2. The stretch in the past had shown occasionally poor quality of water.
3. It is compact drainage basin of 50 square kilometer.
4. The features encountered in this basin viz. seasonal rains, limited number of wet days, lean flow regime for the major part of the year, diverting the water to potable drinking water for domestic use and requiring a regional water quality management model are common with many sub basins in lower Himalayas.
5. The selected stretch has uniformity in all its reaches and sub- basins as to crop patterns, soil cover, rainfall pattern, ground water, climatology, physiology, river bed, etc.

MONITORING OF THE STREAM

Monitoring of water quality was carried out at 6 stations along the stretch of 5 km of Seer stream from weir for water supply to Ghumarwin town to the point of confluence of this stream with river Satluj. Station S1, was selected on upstream of Seer stream before the discharge of main town enter the stream; Station S2, was selected on Ghumarwin Nallah-I before it meet the Seer stream; Station S3, was selected on downstream of point where Ghumarwin Nallah-I meet Seer stream; S4, was selected on Ghumarwin Nallah-II before it meet the Seer stream; Station S5, was selected on downstream of point where Ghumarwin Nallah-II meet the stream; and S6, was selected at point 2Km D/S Ghumarwin town.. Keeping in view the fact that stream flow and concentration do not change rapidly, grab samples were selected at each point from the center of stream or Nallah at a 0.6 depth. Glass bottles with glass cap are used for collecting samples for DO and polyethylene containers are used for collecting sample for other analysis. Every container was first rinsed with phosphate free detergent and with cold tap water and then with distilled water three times. Samples are collected away from stream banks by wading into centre main current. The sample was collected free from bottom sediment.

The guidelines given by USEPA (1997) was followed for sampling. The sampling was repeated after 15 days and the present study is spread over a period of 6 months. All the physico-chemical parameters were determined following the Standard Methods (APHA, 1992).

RESULT AND DISCUSSION

Monitoring Results

The monitoring data at various stations during the study period are shown in tables 1 to 6. These have been discussed in detail below.

Station S1: At upstream of station S1, the water of stream is being lifted for drinking water supply of the town. The discharge at station S1 varies from 4 to 800 L/sec. Stream is having low BOD 2.0-5.0 mg/L; high Do5.4-11.0 mg/L (Figure 2). The concentration of other parameters that is chloride, hardness, alkalinity, conductivity are fairly constant (Table 1).

Station S2: Due to sufficient perennial flow in the Nallah the waste reaching the stream is diluted, having BOD 11.0-30.0 mg/LDO 5.0-7.6 mg/L and flow 26-202 L/sec (Figure 3). The concentrations of other parameters are almost constant (Table 2).

Station S3: The BOD in stream increases to 6.0-24.0 mg/L after the addition of wastewater from Ghumarwin Nallah - I. However DO is constantly high due to re-aeration (5.0-10.0) mg/L (Figure 4). The other parameters have also shown an increase (Table 3) but are fairly constant over a period of time.

Station S4: Station S4 is located on Ghumarwin Nallah - II, another source of wastewater from town to Seer stream. Due to very low flow of Nallah, dilution is not available to wastewater and high BOD (80-160) mg/L and low DO (0-6.2) are the characteristics of the wastewater (Figure 5). The others parameters also have high value (Table 4).

Station S5: The parameters of Seer stream have again shown an increase due to concentrated load from S4). The BOD and DO ranges from (8.0-5.0) mg/L and (4.0-8.0) mg/L, respectively (Figure 6).

Station S6: Station S6 is at distance of 1.5 km from station S5. The monitoring results show a considerable decay of BOD and regain of DO in the stretch. The ranges of BOD are from 3.5 - 8.0 mg/L, and Do from 6.6 to 9.5 mg/L (Figure 7). The other parameters do not show significant changes in their values (Table 6).

Stream Geometry: Seer stream has a steep slope which varies greatly on different reaches. The stream is having different velocity and X-section in different reaches. The stream comprises of falls and small ponds. Ghumarwin Nallah - I and Ghumarwin Nallah - II (wastewater source to stream) are also having steep slope. The Do available in the Nallah and stream beside high BOD is due to the steep slope causing high re-aeration.

DO-BOD MODELING

The study period is divided into 3 seasons, summer (May - June), rainy (August - September) and winter (December), the stream is divided into 3 reaches. The date of different seasons were applied to calibrate the model Stream – 1 separately and it is seen that to meet the monitored value, the model requires exceptionally high values of K1 (de-oxygenation constant) and K2 (re-aeration constant). The very high values of K2 are comparable except for couple readings, with the value of K2 calculated with O' Conner and Dobbis' empirical formula. It has been observed that the summer period is most critical as far as water quality of the Stream is concerned (BOD is 8.5 mg/L at S - 6). At present the wastewater generated in the town is discharged untreated into the stream through Ghumarwin Nallah - I (near S - 2) and Ghumarwin Nallah - II (near S - 4). The BOD in Ghumarwin Nallah - I is observed as 22.7 mg/L resulting in a BOD of 20 mg/L immediately downstream. It hardly reduces in the second reach before Ghumarwin Nallah - II discharges in to the stream with a BOD of 127.3mg/L. This results in a BOD of 45.7 mg/L immediately downstream. The stream travels about 1.5 km up to S - 6. The BOD reduces to 8.5 mg/L at S - 6. The DO, however, has been observed to be higher than 4mg/L throughout this stretch. Thus it is recommended that in order to meet the stream standards of BOD<5 mg/L and DO>4 mg/L, the following may be adopted: (A) Augmentation of stream flow before the Ghumarwin Nallah - I, (b) Checking the unauthorized and undue abstractions from the stream, and (c) Treatment of wastewater before discharging in the stream.

WATER QUALITY MANAGEMENT OF SEER STREAM

Keeping in view the above suggestions efforts has been made to generate 4 theoretical scenarios for water management of the stream.

Scenario 1: To maintain a stream standard of BOD of 5 mg/L through out the stream, taking the same concentration and flow of wastewater in Nallahs. The mass balance is applied at confluence points of Nallahs and stream. Total additional flow required to be added at Station S-1 is 0.37 m^3/sec, that is 370 L/sec water is required to be added, which is next to impossible, as in hilly terrain water can be made available through pumping from far distance at high cost. Since water is not available in summer the unauthorized abstraction shall also be limited. Therefore first two suggestions are not easy to implement.

Scenario 2: The second scenario is generated with Stream – 1 model assuming the model calibration to be true, an attempt was made to find the degree of treatment to be given to wastewater entering from Ghumarwin Nallah -I and primary treatment to wastewater from Ghumarwin Nallah -II, it can help in meeting the BOD standard of 5 mg/L at station S6. The primary treatment gives 30-35 % reduction in BOD in case of municipal wastewater. The Secondary treatment to wastewater from both the Nallahs can meet the future requirement of BOD standard of 5 mg/L. The treated effluents from conventional treatment plants show an overall BOD removal of more than 90%. The extended aeration process has BOD removal efficiency of 97-98% (Arceivala, 1999). This option can be used to maintain the stream environment in good condition.

Scenario 3: Land disposal of wastewater is another option which can be successfully used achieving primary, secondary and tertiary treatment in a single operation and is capable of giving return in the form of crops and recharge water. The quality limits for water use for irrigation are given in table 7. The average annual rainfall in the area varies from 1100mm to 2000mm per year and a major portion of it falls during monsoon months of July to September. Summer months are comparatively hot with maximum temperature reaching up to 40^0C. The rainfall pattern for the last five year for this region is given in table 8.

Enough agricultural and barren land is available on both banks of the stream and the quality of wastewater is suitable for irrigation use, the wastewater from Ghumarwin Nallah-I and Ghumarwin Nallah-II can be used for irrigation in summer and winter. The relative arid nature of the climate during summer and winter lack of plentiful fresh water resources as alternative to wastewater justifies its land application. Land disposal is preferable to direct disposal to the stream in order to avoid or minimize water pollution and related problems. The nearness of the wastewater to the farmland makes its use favourable. The government policy is in favour of recycling and reuse of wastewater to encourage farming and food production. Properly designed and operated, irrigation system can be convenient and low cost method comparable with tertiary treatment and capable of satisfying environmental criteria. The cost of wastewater disposal can be at least partly offset by the sale value of the treated effluent supplied to the farmers. The dilution flow is absent in the stream during summer and it is not possible to divert dilution water from other sub-basin as the area is hilly and transportation cost for water will be very high due to involved pumping.

The chances of salt built up are very little because due to heavy rains in monsoon excess salts will be leached out. During no irrigation period in monsoon enough dilution is available and water pollution is minimized. For irrigation, a biochemical oxygen demand of up to 100 mg/L is permissible and in this case of BOD in stream is in the range of 30-60 mg/L, no pretreatment is required.

Scenario 4: The other attractive alternative for wastewater treatment is Constructed Wetland. As there is enough wasteland available on both sides of stream a wetland system can be developed for the purpose of wastewater treatment of the stream. Since there are no industries in the vicinity of the town, the industrial pollution is negligible and hence this system is more suitable for the area. The constructed wetland system requires land 2 to 5 m^2/person. The native plant species that grow locally in the area can be used. The plants create oxidized microzones in an otherwise reduced substrate with anoxic and anaerobic zones in which microorganisms perform stabilizing organic matter and promoting nitrification and denitrification also. Good removal of TSS, BOD, COD can be achieved through constructed wetland. Reed beds show high tolerance to peak loading and relative stability over seasonal differences. However, pretreatment is highly recommended either in the form of aerated lagoon or conventional plant for wastewater from Ghumarwin Nallahs.

Figure (1) Location Plan of Sampling Station on Seer Stream

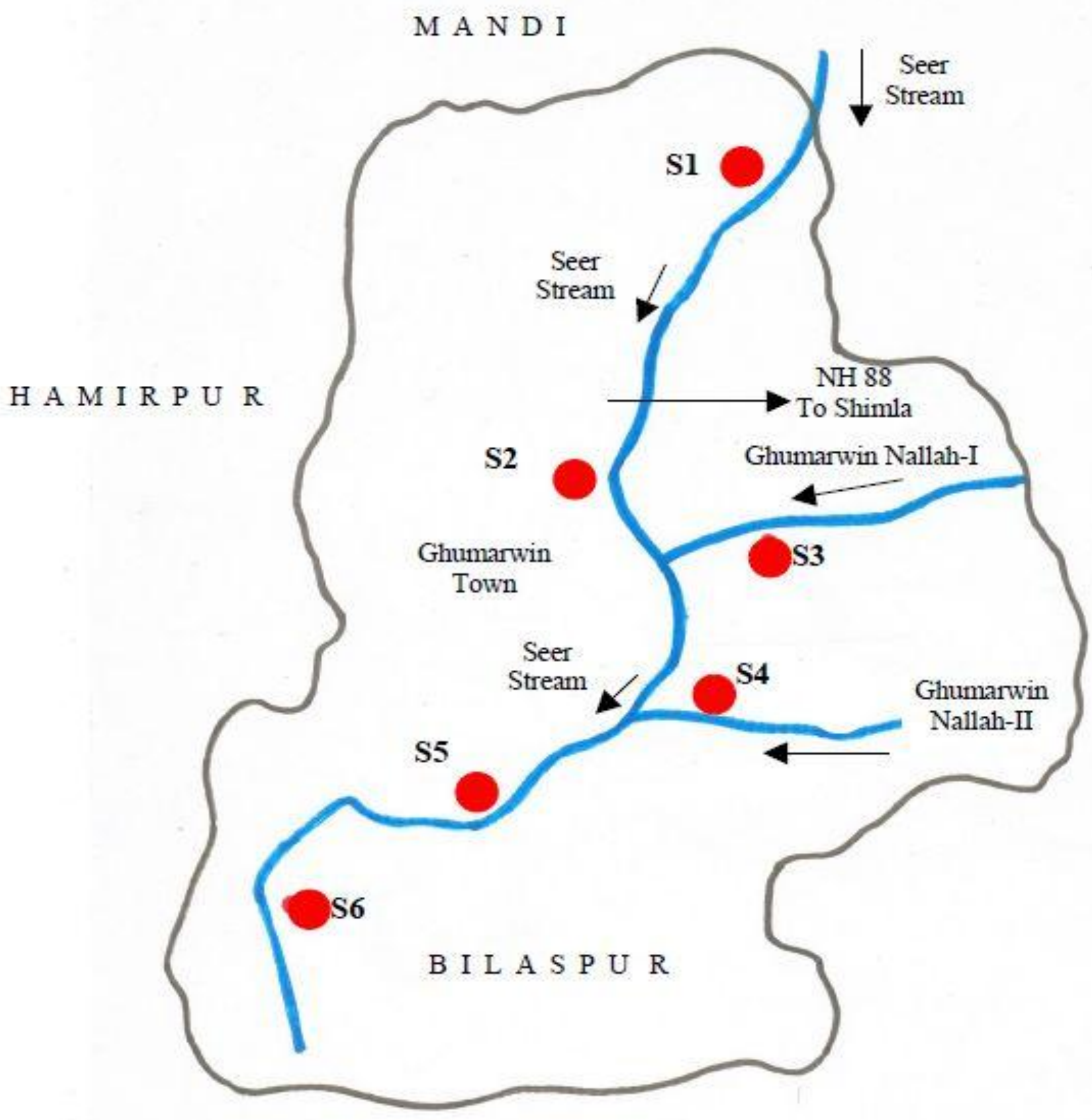

Figure (1)

Table 1: Observed data at Station S1

Date	Temp. C	pH	Conductivity, µ moh/cm	Turbidity NTU	Total alkalinity, mg/L	Total hardness mg/L	Chloride, mg/L	DO, mg/L	BOD, mg/L	Q-Obs., L/Sec.	Q-Adj., L/Sec.
30.05.2009	26	7.7	372	2.0	160	170	14.5	7.8	4.0	4	4
07.06.2009	26	7.8	380	4.0	165	175	21.3	7.5	5.0	4	4
13.06.2009	26	7.4	379	2.0	160	180	19.5	6.0	4.0	6	6
21.06.2009	26	7.4	396	2.0	210	160	14.2	5.4	4.0	20	20
29.06.2009	23	7.4	416	1.6	210	300	10.5	6.8	4.0	75	75
06.07.2009	21	7.6	392	2.0	210	280	14.2	7.5	6.0	140	141
11.07.2009	26	7.4	385	5.0	165	200	7.5	7.0	5.0	350	354
19.07.2009	21	7.6	401	4.0	185	220	10.5	7.2	4.0	450	450
01.08.2009	21	7.8	440	2.0	170	210	17.5	8.0	6.0	600	603
07.08.2009	23	7.9	552	4.0	180	150	10.5	7.0	5.0	690	690
18.08.2009	23	7.6	498	2.0	185	180	14.2	7.2	4.0	800	801
21.08.2009	23	7.6	485	1.8	190	185	14.2	7.4	3.0	720	720
31.08.2009	23	7.7	402	2.0	190	210	10.5	6.5	2.0	540	542
07.09.2009	26	7.9	352	2.0	168	140	14.5	7.5	2.0	520	520
15.09.2009	26	7.8	384	0.0	170	190	14.5	7.0	2.0	500	501
19.09.2009	23	7.7	390	3.2	180	180	14.0	6.8	4.0	430	431
23.09.2009	21	7.8	383	2.0	186	130	14.0	7.5	4.0	400	400
04.10.2009	21	7.9	358	2.0	190	205	12.0	7.6	4.0	210	212
13.10.2009	21	7.6	372	2.0	180	210	14.0	7.5	3.0	173	171
19.10.2009	19	7.7	375	3.0	166	170	18.0	7.1	3.0	150	152
25.10.2009	19	7.7	428	1.2	170	170	15.4	7.0	2.0	150	150
01.11.2009	17	7.7	370	4.0	180	160	12.5	7.5	2.0	150	152

08.11.2009	17	7.7	347	2.0	176	180	28.4	8.5	2.0	120	122
15.11.2009	15	7.2	352	2.0	170	140	20.0	8.7	3.0	90	92
26.11.2009	12	7.1	365	1.2	160	170	18.0	9.5	2.0	73	72
01.12.2009	13	7.0	360	0.8	195	200	11.2	10.0	2.0	70	70
12.12.2009	10	7.1	365	2.0	185	170	18.0	11.0	2.0	70	71

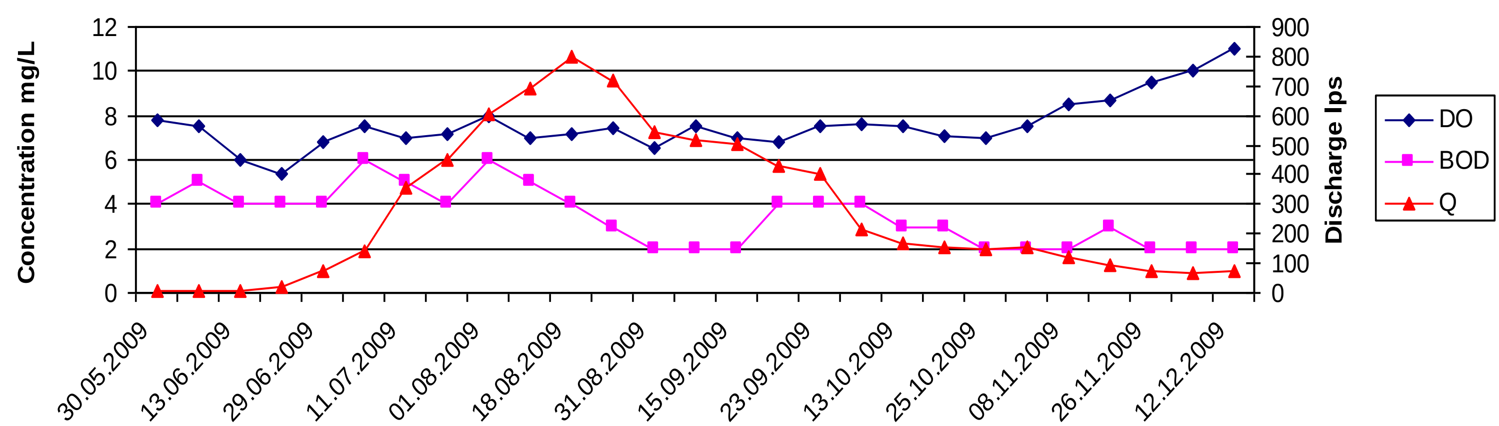

Fig 2 Observed Data at Location S-1 Seer Stream

Table 2: Observed data at Station S2

Date	Temp. C	pH	Conductivity, µ moh/cm	Total alkalinity, mg/L	Total hardness mg/L	Chloride, mg/L	DO, mg/L	BOD, mg/L	Q-Obs., L/Sec.	Q-Adj., L/Sec.
30.05.2009	25	7.5	615	260	260	28.4	6.7	22	30	31
07.06.2009	25	7.7	670	240	246	28.4	6.7	23	26	26
13.06.2009	25	7.4	613	265	260	32.4	6	23	30	29
21.06.2009	25	7.3	646	260	240	35.7	5	24	35	36
29.06.2009	22	7.6	662	260	380	35.5	5.2	30	60	60
06.07.2009	20	7.6	636	265	270	14.2	6.2	18	90	91
11.07.2009	25	7.5	547	220	280	21.3	5.8	22	140	142

19.07.2009	20	7.4	561	225	260	24.5	6	22	180	180
01.08.2009	20	7.5	562	210	240	21.5	5.8	22	200	202
07.08.2009	22	7.8	962	220	250	17.5	6.5	20	180	180
18.08.2009	22	7.7	742	270	250	17.5	6.1	20	200	101
21.08.2009	22	7.7	750	188	240	17.5	6.2	20	80	80
31.08.2009	22	8.0	457	195	230	14.2	6.5	18	86	88
07.09.2009	25	7.9	400	188	180	14.2	7.5	18	90	90
15.09.2009	25	8.0	524	280	210	31.5	5.6	24	88	89
19.09.2009	22	7.9	534	248	230	25.9	6.4	22	80	81
23.09.2009	20	7.8	373	272	162	14	6.8	14	76	75
04.10.2009	20	7.5	562	215	240	21.5	6	21	72	73
13.10.2009	20	7.6	524	210	230	14.2	6.5	18	72	71
19.10.2009	18	7.8	540	210	240	35.5	7.1	24	65	66
25.10.2009	18	7.9	576	240	280	36.4	7	22	65	65
01.11.2009	16	7.2	670	220	280	56	7.6	30	54	55
08.11.2009	16	7.7	472	244	300	36.4	7.4	22	60	61
15.11.2009	14	7.5	480	220	270	21.5	7.6	20	54	56
26.11.2009	11	7.2	510	215	280	14.2	7.4	18	50	60
01.12.2009	12	7.1	530	210	300	21.5	7.5	14	60	51
12.12.2009	9	7.0	523	220	270	32	7.6	13.7	50	56

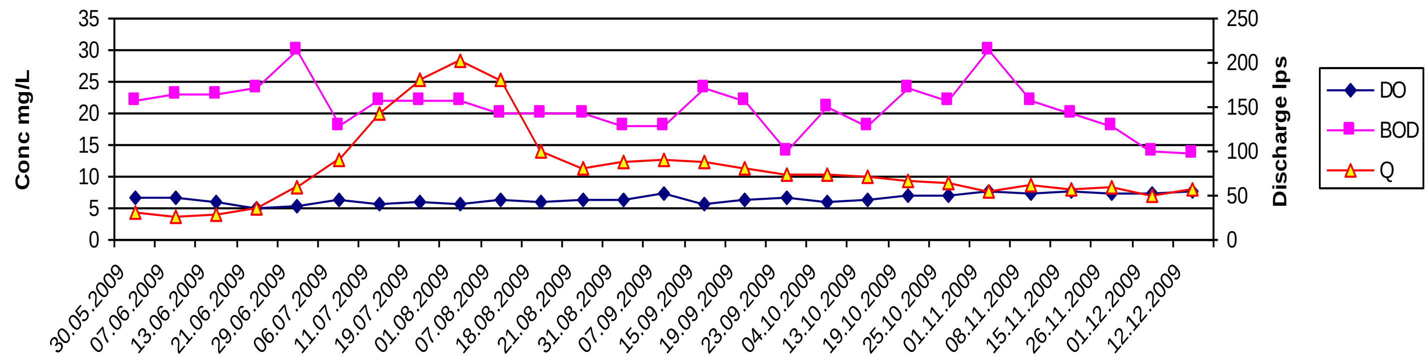

Fig 3 Observed Data at Location S-2 Seer Stream

Table 3: Observed data at Station S3

Date	Temp. C	pH	Conductivity, µ moh/cm	Turbidity NTU	Total hardness mg/L	Chloride, mg/L	DO, mg/L	BOD, mg/L	Q-Obs., L/Sec.	Q-Adj., L/Sec.
30.05.2009	25	7.65	481	4	240	28.4	6.9	20	35	35
07.06.2009	25	7.68	492	2.6	230	21.5	7.4	20	30	30
13.06.2009	25	7.52	516	2	220	28.4	5.5	20	35	35
21.06.2009	25	7.34	629	6	220	36	5	16.4	56	56
29.06.2009	22	7.47	524	7.2	320	21.3	6	11	135	135
06.07.2009	20	7.81	378	3	260	14.2	7.2	12	232	232
11.07.2009	25	7.55	473	2	260	13.5	6.2	9	498	496
19.07.2009	20	7.83	496	4.8	240	13.4	7	8	630	630
01.08.2009	20	8.05	480	4	215	15.2	7.4	5.8	805	805
07.08.2009	22	7.85	463	4.5	200	10.5	7	6	870	870
18.08.2009	22	7.9	485	3	190	10.5	7.1	6.5	903	902
21.08.2009	22	7.88	470	2.5	190	24.5	7	7	800	800
31.08.2009	22	7.82	401	1.5	220	10.5	7	6.5	630	630

07.09.2009	25	7.92	333	3	150	14.2	6.8	5.5	610	610
15.09.2009	25	8.08	384	1	200	12.5	6.9	5	590	590
19.09.2009	22	8.04	438	5.2	210	18.9	7.6	6	512	512
23.09.2009	20	7.97	405	2.4	130	19.6	7.5	6	475	475
04.10.2009	20	7.82	401	2.5	230	18.6	7.4	8	285	285
13.10.2009	20	7.88	470	3	210	18.6	7.4	9	242	242
19.10.2009	18	8	440	2	190	18.6	7	8	218	218
25.10.2009	18	8.13	432	2.4	180	14.7	7	8	215	215
01.11.2009	16	7.9	430	2	210	32.7	7.9	8.5	210	207
08.11.2009	16	7.83	384	2	276	25.2	8	8	185	183
15.11.2009	14	7.5	360	2.8	210	20.5	8	9	150	148
26.11.2009	11	7.4	418	4	220	18.2	8	9.5	120	121
01.12.2009	12	7.33	410	4	230	12.5	9	7	130	130
12.12.2009	9	7.24	420	6	260	28	10	7	123	122

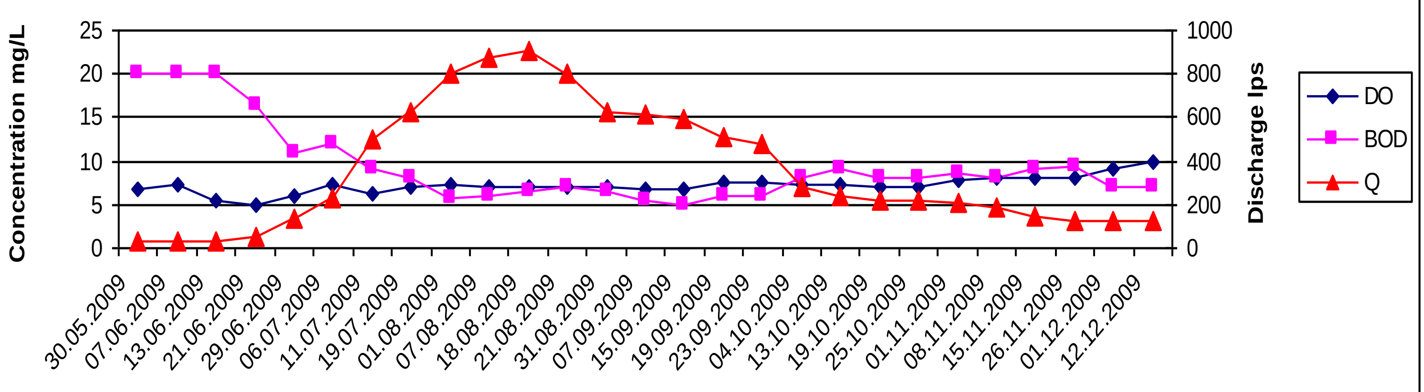

Fig 4 Observed Data at Location S-3 Seer Stream

Table 4: Observed data at Station S4

Date	Temp. C	pH	Conductivity, µ moh/cm	Turbidity NTU	Total alkalinity, mg/L	Total hardness mg/L	Chloride, mg/L	DO, mg/L	BOD, mg/L	Q-Obs., L/Sec.	Q-Adj., L/Sec.
30.05.2009	25	7.6	1113	80	410	320	96	4	150	12	12
07.06.2009	25	7.6	1083	46	380	290	84	0	130	10	11
13.06.2009	25	7.3	1088	40	420	360	66	0	102	12	12
21.06.2009	25	7.4	1112	10	450	340	120	4	128	15	15
29.06.2009	22	7.4	1065	24	385	460	82	1	118	28	28
06.07.2009	20	7.6	1028	6	265	250	29.5	0	80	20	21
11.07.2009	25	7.6	994	8	315	440	70	5.5	120	30	31
19.07.2009	20	6.8	705	8	238	300	45	4	92	40	43
01.08.2009	20	6.7	806	20	245	280	48	1.2	95	50	50
07.08.2009	22	7.9	631	24	310	300	28.4	3	82	30	31
18.08.2009	22	7.7	600	20	330	320	60	3.8	110	20	21
21.08.2009	22	7.7	610	25	330	340	72	0.2	125	24	26
31.08.2009	22	7.9	658	8	260	300	42.5	0	90	10	11
07.09.2009	25	8.0	702	40	210	280	90	1	130	20	20
15.09.2009	25	7.9	783	14	294	260	55	4.3	98	10	11
19.09.2009	22	7.9	868	58	363	270	65.8	4	100	20	19
23.09.2009	20	7.9	791	32	346	182	60.2	6.2	102	24	25
04.10.2009	20	7.9	780	14	290	270	52	4	92	24	25
13.10.2009	20	7.9	790	18	296	270	42.5	3	110	20	21
19.10.2009	18	7.5	770	18	240	280	50	3.2	90	24	24
25.10.2009	18	7.5	840	30.4	355	340	78.1	4.3	130	26	26
01.11.2009	16	7.7	1088	32	370	360	63	3.2	120	20	21

08.11.2009	16	7.7	860	146	225	330	91	3	130	18	18
15.11.2009	14	7.5	780	52	320	340	68	2.5	120	20	21
26.11.2009	11	7.4	770	40	420	360	70	3	120	20	20
01.12.2009	12	7.4	860	46	310	320	72	2.8	160	18	18
12.12.2009	9	7.2	952	80	360	300	90	3	120	20	20

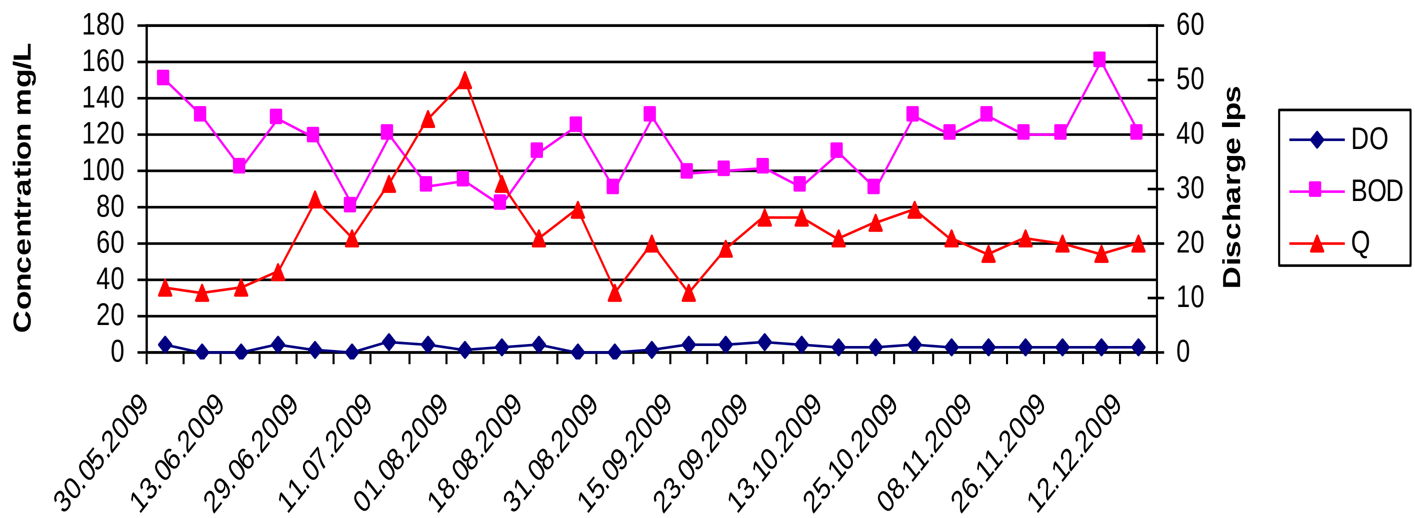

Fig 5 Observed Data at Location S-4 Seer Stream

Table 5: Observed data at Station S5

Date	Temp. C	pH	Conductivity, µ moh/cm	Turbidity NTU	Total alkalinity, mg/L	Total hardness mg/L	Chloride, mg/L	DO, mg/L	BOD, mg/L	Q-Obs., L/Sec.	Q-Adj., L/Sec.
30.05.2009	25.0	7.6	668.0	10.0	262.0	280.0	45.0	6.5	50.0	48.0	47.0
07.06.2009	25.0	7.9	495.0	12.0	210.0	260.0	35.5	6.0	46.0	42.0	41.0
13.06.2009	25.0	7.3	730.0	12.0	290.0	280.0	42.6	4.5	41.0	48.0	47.0

21.06.2009	25.0	7.3	692.0	2.0	340.0	290.0	63.9	4.0	41.0	71.0	71.0
29.06.2009	22.0	7.5	609.0	6.0	260.0	380.0	28.4	6.6	30.0	163.0	163.0
06.07.2009	20.0	7.8	603.0	4.0	170.0	180.0	13.8	4.5	16.0	254.0	253.0
11.07.2009	25.0	7.7	564.0	2.8	270.0	260.0	16.0	6.5	14.0	528.0	527.0
19.07.2009	20.0	7.9	499.0	6.0	216.0	240.0	17.5	6.0	14.0	680.0	673.0
01.08.2009	20.0	7.7	510.0	8.0	215.0	25.0	18.5	6.2	10.0	855.0	855.0
07.08.2009	22.0	7.8	471.0	6.0	220.0	200.0	14.2	6.5	8.0	905.0	901.0
18.08.2009	22.0	7.9	498.0	12.0	210.0	200.0	13.4	5.4	8.8	925.0	923.0
21.08.2009	22.0	7.9	505.0	14.0	235.0	210.0	16.3	5.2	10.2	832.0	826.0
31.08.2009	22.0	8.0	478.0	4.0	210.0	240.0	14.5	6.5	7.6	642.0	641.0
07.09.2009	25.0	7.9	438.0	15.0	150.0	20.0	17.0	6.2	9.0	630.0	630.0
15.09.2009	25.0	8.1	432.0	1.2	150.0	200.0	14.2	7.8	6.8	604.0	601.0
19.09.2009	22.0	8.0	459.0	2.8	207.0	210.0	20.4	6.8	9.3	530.0	531.0
23.09.2009	20.0	8.0	411.0	4.4	238.0	140.0	20.4	7.5	10.5	500.0	500.0
04.10.2009	20.0	8.0	470.0	2.8	207.0	220.0	19.6	7.4	12.4	310.0	310.0
13.10.2009	20.0	7.9	478.0	4.0	210.0	200.0	14.2	7.5	16.5	265.0	263.0
19.10.2009	18.0	7.9	420.0	6.0	200.0	210.0	22.4	7.0	16.0	241.0	242.0
25.10.2009	18.0	7.9	428.0	4.4	185.0	210.0	27.5	6.4	10.0	240.0	241.0
01.11.2009	16.0	7.9	470.0	8.0	240.0	220.0	36.0	7.1	17.4	230.0	228.0
08.11.2009	16.0	7.9	396.0	4.0	200.0	260.0	26.6	7.2	17.0	202.0	201.0
15.11.2009	14.0	7.6	462.0	12.0	210.0	260.0	26.4	6.9	21.0	171.0	169.0
26.11.2009	11.0	7.5	470.0	14.0	235.0	260.0	25.8	7.2	26.0	142.0	141.0
01.12.2009	12.0	7.4	422.0	8.0	190.0	240.0	26.0	7.5	23.0	148.0	148.0
12.12.2009	9.0	7.3	543.0	25.0	250.0	270.0	30.0	8.0	23.0	142.0	142.0

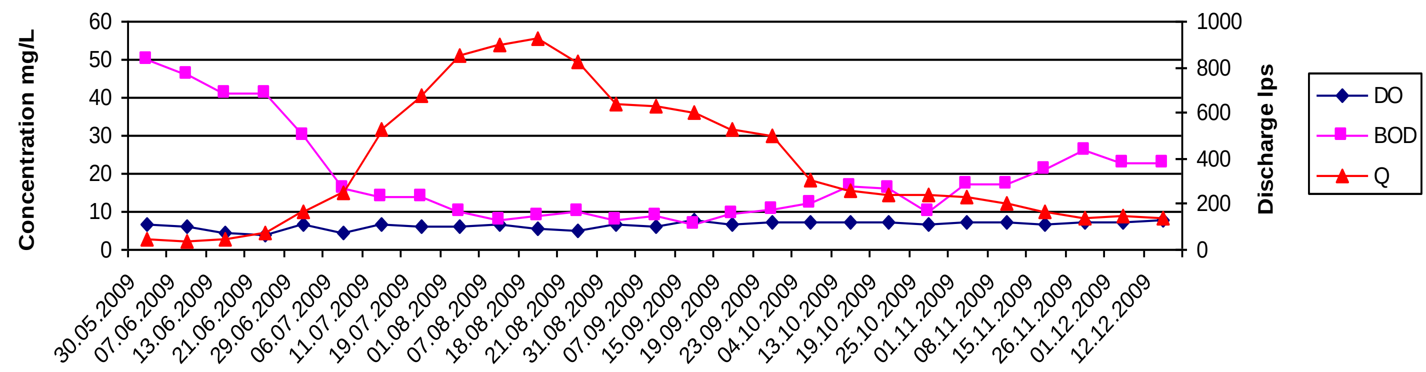

Fig 6 Observed Data at Location S-5 Seer Stream

Table 6: Observed data at Station S6

Date	Temp. C	pH	Conductivity, µ moh/cm	Turbidity NTU	Alkalinity	Hardness	Chloride	DO	BOD	Q-Obs., L/Sec.
08.05.2009	25	7.8	494	2	205	230	25	7.5	8.5	60
20.05.2009	25	7.7	492	2	208	235	24	7.8	5.5	50
10.06.2009	25	7.8	496	2	210	236	20	7	5.0	60
29.06.2009	25	7.7	489	4	200	240	14	6.6	5.0	200
07.07.2009	25	7.7	470	2	195	220	24	7	3.5	300
27.07.2009	22	7.7	490	2	210	230	13	6.9	4.5	900
13.08.2009	22	7.7	491	2	190	200	22	6.7	4.5	1000
27.08.2009	22	7.8	452	2.6	220	236	18	6.8	4.0	1000
15.09.2009	20	7.7	442	4.4	216	230	12	6.9	4.0	620
03.10.2009	19	7.7	439	4	210	230	12	7.5	3.5	325
24.10.2009	17	7.7	436	4	200	220	11	8	4.5	255
01.11.2009	15	7.4	498	4	180	280	42	7.5	4.5	245
20.11.2009	13	7.4	466	4	190	285	43	9	4.0	180
12.12.2009	09	7.4	473	4	210	290	30	10.5	9.5	160

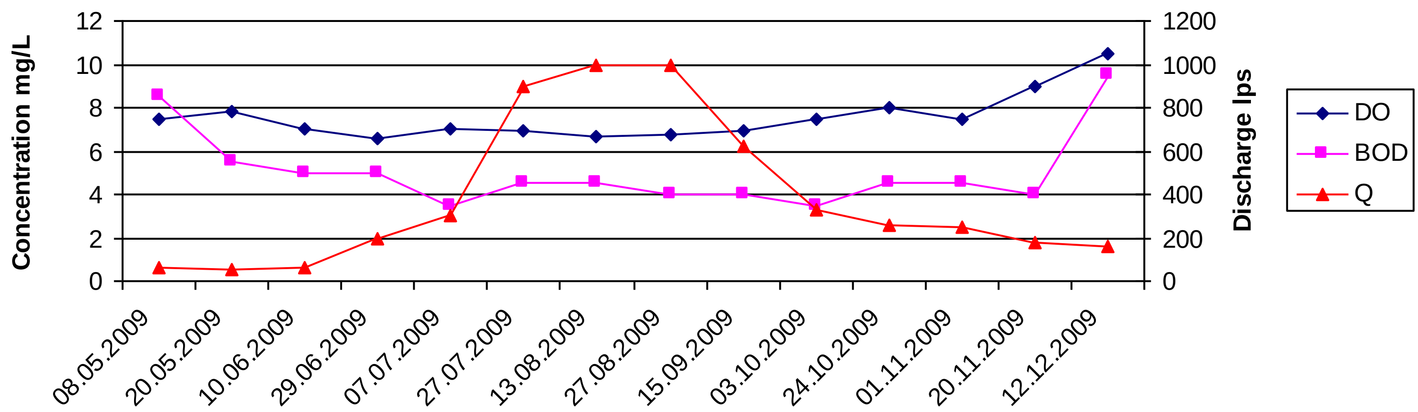

Fig 7 Observed Data at Location S-6 Seer Stream

Table 7: Quality limits for water use for irrigation in U.S.A. and India

Item	California		India
	Agriculture	Parks	
Total dissolved salt, mg/L	2100	1500	2100
Electrical conductivity, µ moh/com	-	-	3000 to 20^{0}C
Chlorides, mg/L	355	250	600
Sulphates, mg/L	-	250	1000
Boron, mg/L	2.0	2.0	2.0
Percent sodium	-	-	60
Sodium absorption ratio, meq/L	10	8	-
Residual sodium carbonate, meq/L	2.5	-	-
Source : Arceivala (1999)			

Table 8: Annual Rainfall in mm in respect of Bilaspur district (Himachal Pradesh)

Year	Rainfall (mm)
2001	1162.90
2002	1049.80
2003	1264.20
2004	1072.20
2005	910.80
2006	1319.30
2007	1293.20
2008	1798.40
Source:	Metrological Deptt office Berthin Distt. Bilaspur Himachal Pradesh.

CONCLUSION

On the basis of present study the following conclusions can be drawn.

1. The Seer stream is having variable flow, with almost negligible flow during summer.
2. The stream is heavily polluted below the point where Ghumarwin Nallah-I Meets the stream.
3. The monitoring results on six stations indicate that, Seer stream is having the conservative parameters as per standards except few exceptions. The DO is reasonably high, except in Ghumarwin Nallah – I which is having very high BOD due to less dilution. The BOD in Seer stream is within standard of 5 mg/L before the town wastewater enters the stream. Summer season is the most critical period when stream is having

very less discharge. The entire stretches of stream have high BOD especially after Ghumarwin Nallah - I meet the stream.

4. The augmentation of flow or restriction of abstraction is not practical solution to maintain stream water quality within prescribed standards. Secondary treatment to Ghumarwin Nallah - I wastewater and primary treatment to Ghumarwin Nallah – II wastewater can help meet the standard of BOD presently, however as pollution load is increasing continuously secondary treatment to wastewater from both nallahs is required for maintaining BOD standard of 5 mg/L.
5. Since there is shortage of water in the area during winter and summer season and enough agricultural land is available, the wastewater can be used for irrigation.
6. The still other option is Constructed Wetlands which can be used to treat wastewater as lot of wasteland is available.

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