Assessment of Surface Water Quality for Drinking Purposes – A Case Study of Ashwani Khad, Shimla, Himachal Pradesh, India

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Abstract: *Shimla, the capital city of Himachal Pradesh has been bestowed with natural beauty and is endowed with an immense potential to be a place of tourist attraction. Shimla has been experiencing environmental degradation on many accounts. The major contributing factors towards this are population, crowded roads, heavy tourist inflow, excessive garbage, sanitation and sewage problems. Water scarcity is a major problem in Shimla almost all year round and is mainly due the high tourist influx. The water demand for the city is met by various surface water bodies one of which is Ashwani Khad. It is the third largest drinking water resource in the city. Unfortunately, Ashwani Khad is receiving treated sewage water from the Sewage Treatment Plant at Malyana. The treated sewage water from STP Malyana finds its way into the Ashwani Khad about 2 kilometers downstream. Thereafter, the water is collected around 3 kilometers downstream to be suppliedto the main city after treatment. The present study was carried out to study the pollution status of this surface water body since water from this Khad is being used for drinking purposes for a major part of the city. 26 surface water samples were collected during Post Monsoon Season (October 2012) from different sites along the length of the Ashwani Khad. Studies were carried out on these surface water samples and physico-chemical parameters like pH, EC, TDS, BOD, COD, hardness, alkalinity, nitrates, phosphates, sulphates and chlorides were evaluated in the laboratory. Raw and treated sewage water samples were also taken from the Sewage Treatment Plant (Malyana), which is discharging the treated effluent into the Ashwani Khad to know the effectiveness of the treatment plant and suggest suitable ameliorative measures for the proper treatment of sewage.*

Keywords: Sewage, Pollution, Ashwani Khad, Sewage Treatment Plant, Shimla

Introduction

Almost every state in India is under water stress. Even in places where there are adequate water resources, the water is getting increasingly polluted by human and industrial wastes and economic activities. The quality of surface water is a sensitive issue, especially if this surface water is used for drinking purposes. Almost 70% of the water in India has become polluted due to the discharge of domestic sewage and industrial effluents into natural water source, such as rivers, streams as well as lakes.[1] According to WHO estimate about 80% of water pollution in developing country, like India is carried by domestic waste. Industrial waste, sewage, municipal wastes are been continuously added to water bodies hence affect the physiochemical quality of water making them unfit for use of livestock and other organisms.[2] According to a report by Central Pollution Control Board (2005), disposal of about 29000MLD domestic sewage from cities and towns is the biggest source of pollution of water bodies in India.[3] Water quality monitoring facilitates evaluation of nature and extent of pollution and effectiveness of pollution control measures, water quality trends and prioritization of pollution control efforts. Both surface and ground water resources are contaminated by various sources like industrial effluents, agricultural discharge and municipal waste. Water contaminated by effluent from various sources is associated with heavy disease burden [4] and this could influence the current shorter life expectancy in the developing countries compared with developed nation (WHO, 2002). Due population explosion and rapid urbanization, people rely heavily on water sources of doubtful quality in the absence of better alternatives, or due to economic and technological constraints to adequately treat the available water before use. [5] The scarcity of clean of water and pollution of fresh water has therefore led to a situation in which one – fifth of the urban dwellers in

developing countries and three-quarter of their rural dwelling population do not have access to reasonably safe water supplies. [6] Sewage discharge is a major component of water pollution which is compounded in areas where waste water treatments are inefficient. The treated sewage water cannot be used for drinking purposes unless it has been given a tertiary treatment before being discharged into the surface water body which is being used for drinking purposes. Sewage treatment plants (STP's) should aim at making the municipal sewage suitable for disposal into the environment (surface and underground water bodies or land), to minimize the environmental and health impacts of the sewage, and to make the sewage fit for recycling and reuse. The present study was carried out to study the impact of treated sewage water discharge from Sewage Treatment Plant, Malyana, on the water quality of Ashwani Khad, which is a drinking water source for a major part of Shimla city.

General Description of the Study Area

Shimla, the capital of Himachal Pradesh is located at an average altitude of 2397.59 meters (7866.10 ft) above mean sea level. The town lies between North latitude $30^0$45'48'' to $30^0$43'0'' and East longitude $76^0$59'22'' to $78^0$18'40'' (Fig. 1). Shimla, being a hill station, records a maximum temperature of about 33^0 C during the month of June and about 16^0 C in the month of February. On the other hand, the minimum temperature of the town is around -3^0 C in February and around 15^0 C in August (Regional Meteorological Department, New Delhi). The average total annual rainfall is around 1650 mm and the humidity varies from 89% (Maximum) to 51% (Minimum). The drinking water supply to Shimla city is mainly fed by 7 major Water Sources. The total installed capacity of various water sources is 71.24 MLD and out of this installed capacity, on an average only 42.00 MLD water is being lifted to Shimla. The total ultimate demand of water is about 70.00 MLD. Ashwani Khad is the third largest water source of Shimla City with an installed capacity of 10.80 MLD. The Sewage of the city is collected by the underground sewer networks and then treated at 6 Sewage Treatment Plants (STP's) located at different parts of the city. Presently only 65% of the city is covered under the sewage network. The total installed capacity of all the STP's is 35.63 MLD. The Sewage Treatment Plant under study is the third largest treatment plant in the city with a capacity of 4.44 MLD. The sewage undergoes treatment upto the secondary level in the various STP's and the treated effluent is discharged into the adjoining *nallahs*. The treated effluent from the Sewage Treatment Plant Malyana finds its way into the drinking water source Ashwani Khad about 2 kms downstream. The treated water from this STP after mixing with the water of Ashwani Khad is collected and stored for further treatment, about 3 kms downstream of the confluence, to be used as a drinking supply for a major part of the city. The physico- chemical parameters of this surface water body were evaluated to find out its suitability for drinking purposes. The samples were taken along the Ashwani Khad during Post Monsoon (2012) season and the analysis of various physico-chemical parameters was done according to the procedures outlined in the Standard Methods for the Examination of Water and Wastewater(APHA,1998).[7]

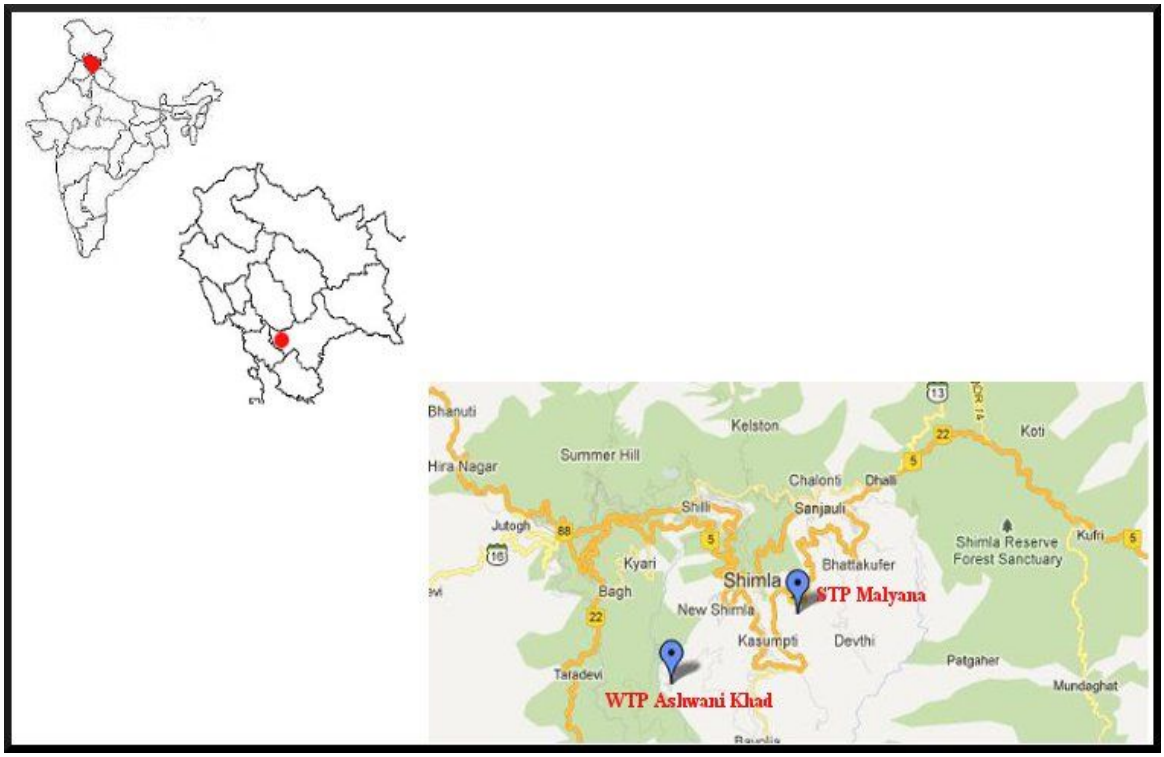

Fig. 1: Location map of Study Area

Materials and Methods

26 surface water samples were collected at a distance of 100 meters intervals along the Ashwani Khad. Raw and treated water samples were also taken from the inlet and outlet of Sewage Treatment Plant, respectively. The samples were stored in clean plastic bottles with screw caps. Prior to sample collection, all the plastic bottles were thoroughly washed and sun-dried and before sample collection the plastic

Results and Discussions

In the present study 26 water samples were taken from various sites along the Ashwani Khad in the Post Monsoon Season (2012). (Fig. 2) The parameters like pH, electrical conductivity, total

bottles were rinsed twice with the same collected water samples. The bottles were then labeled and the co-ordinates of the sampling sites were duly noted. Parameters like pH, EC and TDS were analyzed on the spot using potable water and soil analysis kit. For the analysis of other parameters, the bottles were taken to the laboratory and stored at 4^{o}C. For the assessment of BOD and COD samples were collected in glass bottles and taken to the laboratory within 24 hours.

dissolved solids, hardness, alkalinity, nitrates, phosphates, sulphates, chlorides etc, were evaluated in the laboratory and based on these results the water quality has been assessed . The results showing the values of various parameters are given in Table 1 and Table 2.

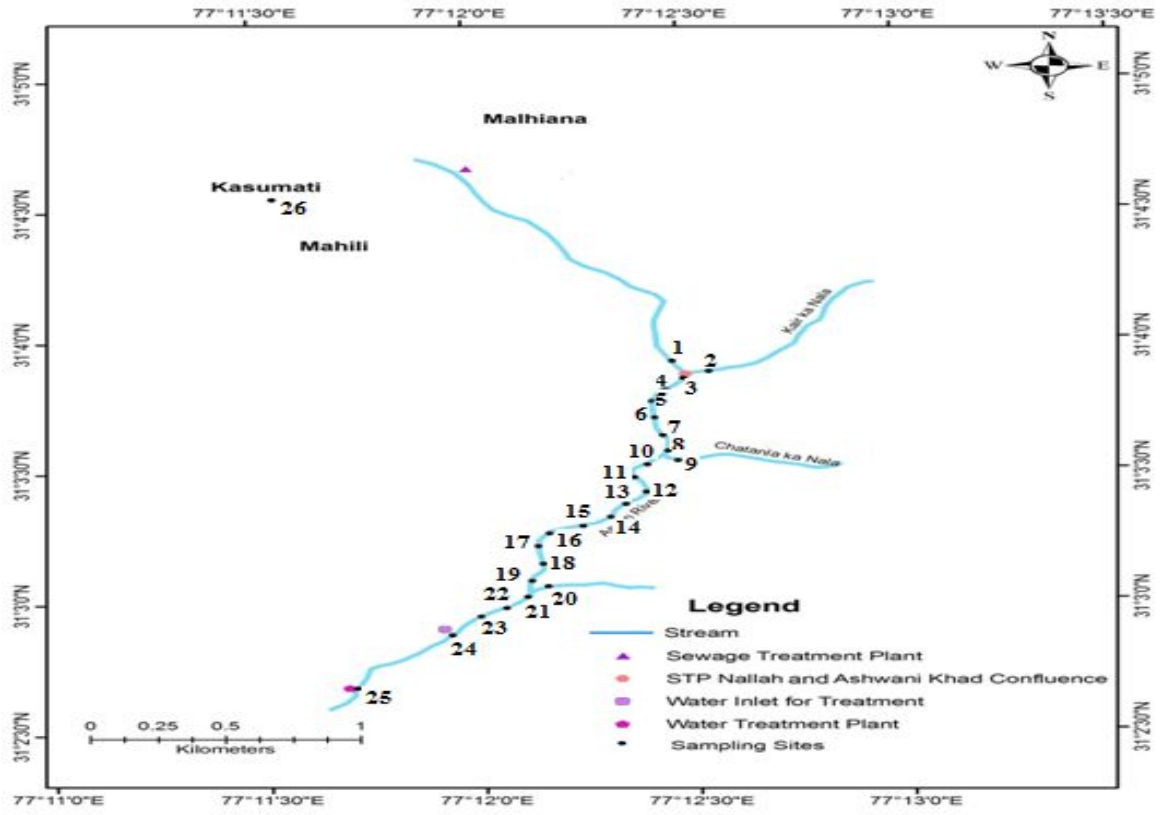

Fig. 2: Location Map Showing the Sampling Sites in the Study Area

pH

pH is the hydrogen ion activity and a measure of acidity and alkalinity in aquatic bodies. In general waters having pH between 6.5 and 8.5 are categorized as suitable, whereas waters with pH 7.0 to 8.0 are highly suitable (ideal) for all purposes. The pH values of all the samples range between the values 7.44 to 8.2 with a mean value of 7.87 indicating slightly alkaline nature.

Electrical conductivity (EC)

Electrical conductivity of water is also an important parameter for determining the water quality. It is a measurement of water's capacity for carrying electrical current and is directly related to the concentration of ionized substance in the water. The values of EC varied between 312 µS/cm to 1140 µS/cm with a mean value of 646.88 µS/cm.

Total Dissolved Solids (TDS)

Total dissolved salt concentrations is the primary indicator of the total mineral content in water and are related to problems such as excessive hardness. TDS concentrations in the study area ranged between 157 mg/l to 570 mg/l with a mean value of 323.46 mg/lt. The value of TDS is higher than the desirable level in one of the samples.

Total Hardness (TH)

It results from the presence of divalent metallic cations of which calcium and magnesium are the most abundant. The values of Total Hardness ranged from 78 mg/l to 178mg/l. the mean value of Total Hardness is 116.8 mg/l.

Total Alkalinity

Alkalinity usually is due to the presence of carbonates, bicarbonates and hydroxide ions. Alkalinity, itself is not detrimental to human body, but is generally associated with high pH values. The values of alkalinity in the study area varied from 42 mg/l to 120 mg/l with a mean value of 69.3 mg/l.

Calcium (Ca)

The Calcium content in the water samples was within the permissible limits. According to the BIS standards the desirable limit for calcium is 75 mg/l. The calcium content in the water samples was between 19.34 mg/l to 41.21 mg/l with the average value of 30.24 mg/l.

Magnesium (Mg)
The magnesium content ranged between 7.81 mg/l to 19.52 mg/l. the average value of magnesium is 10.9 mg/l. The BIS desirable limit however is 30 mg/l showing that the magnesium levels in the water samples are within the permissible limits.

Chloride (Cl)
Chloride in drinking water is not generally harmful to human beings until high concentration is present. The Chloride concentration ranged between 13.92 mg/l to 52.68 mg/l indicating that the values are within the permissible limits. The mean value of Chlorides in the water samples was found to be 25.99 mg/l.

Nitrates (NO_3)
Excess of nitrates consumed by humans particularly infants is likely to cause health hazards and may lead to Methaemoglobinemia (Blue baby) disease. The values of nitrates in the water samples range between 0.12 mg/l to 13.3 mg/l with a mean value of 2.89 mg/l. The values are well within the permissible limits prescribed by BIS.

Sulphates (SO_4)
Sulphates are common in natural waters, but levels can be increased from industrial contamination with sulphuric acid, bisulphate and aluminum sulphate used in water purification plants. The values of sulphates ranged between 19.5 mg/l to 25.3mg/l. the average value of sulphates was 22.48 mg/l.

Phosphates (PO_4)
Phosphates come from fertilizers, pesticides, industry and cleaning compounds. Natural sources include phosphate containing rocks and solid or liquid wastes. The values of phosphates was found to be between 0.19 mg/l to 0.68 mg/l with a mean value of 0.39 mg/l.

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand(COD):
The BOD and COD for the raw and treated sewage at the Sewage Treatment Plant, Malyana was carried out. The BOD value was calculated to be 660.3 mg/l for the raw sewage and 21.1mg/l for the treated sewage. The value of COD was calculated as 1360.1 mg/l for the raw sewage and 167.2 mg/l for the treated sewage. These values clearly indicate that the levels of BOD and COD are above the permissible limits if the effluent from the treatment plant is to be disposed off into water bodies used for drinking purposes.

Table 1: Statistics of Surface Water Samples of Ashwani Khad

S.No.	Parameter	Minimum	Maximum	Average
1	pH	7.44	8.2	7.87
2	Electrical Conductivity	312	1140	646.88
3	Total Dissolved Solids	157	570	323.46
4	Total Hardness	78	178	116.8
5	Total Alkalinity	42	120	69.3
6	Calcium	19.34	41.21	30.24
7	Magnesium	7.81	19.52	10.9
8	Chloride	13.92	52.68	25.99
9	Nitrate	0.12	13.3	2.89
10	Sulphate	19.5	25.3	22.48
11	Phosphate	0.19	0.68	0.39

Table 2: Statistics of Surface Water Samples of Ashwani Khad

Sample No.	pH	EC	TDS	TH	TA	Ca	Mg	Cl	NO3	SO4	PO4
1	7.29	390	195	100	42	27.7	8.3	13.92	0	22.5	0.54
2	8.2	1140	570	178	120	41.21	19.52	52.68	1.8	19.5	0.19
3	7.98	900	450	162	104	37.84	17.57	39.76	1.9	21.6	0.38
4	7.95	798	399	156	90	34.48	18.06	34.79	5.9	21.1	0.37
5	7.92	794	397	158	86	34.48	18.54	32.8	3.2	21.3	0.35
6	7.93	778	389	128	82	34.48	11.22	31.8	2.5	21.5	0.35
7	7.92	766	383	122	82	33.64	10.25	31.8	4.6	21.6	0.33
8	7.93	758	379	120	80	33.64	9.76	31.8	3.2	21.6	0.34
9	7.93	756	378	130	78	33.64	12.2	31.8	1.3	21.7	0.33
10	7.93	776	388	120	78	33.64	9.76	30.81	4.6	21.6	0.31
11	7.86	624	312	116	72	30.28	10.74	27.83	3.2	22.2	0.33
12	7.89	626	313	114	68	30.28	10.25	24.85	1.3	22.8	0.32
13	7.89	622	311	112	68	30.28	9.76	24.85	2.5	21.5	0.33
14	7.93	618	309	112	66	29.44	10.25	23.86	1.3	22.9	0.33
15	7.9	618	309	110	62	29.44	9.76	23.86	1.3	21.1	0.32
16	7.9	608	304	106	62	28.59	8.74	23.86	10	23.2	0.31
17	7.92	564	282	104	60	28.59	8.74	22.86	13.3	23.8	0.31
18	7.94	592	296	104	60	28.59	8.74	22.86	2.5	23.7	0.33
19	7.94	582	291	104	60	27.75	9.27	22.86	2.5	24.1	0.33
20	7.91	578	289	102	58	27.75	8.74	21.87	0	24.2	0.33
21	7.92	574	287	102	58	26.91	9.27	21.87	1.3	24.4	0.34
22	7.91	570	285	102	58	26.91	9.27	21.87	1.9	24.2	0.35
23	7.44	322	161	78	44	19.34	7.81	8.95	0	25.3	0.12
24	7.51	312	157	84	48	21.87	7.81	7.95	0	25.2	0.11
25	7.92	560	275	105	58	27.75	9.76	25.87	1.7	24.2	0.45
26	7.93	556	270	108	58	27.75	9.27	23.76	1.6	24.2	0.41

EC- Electrical Conductivity (µS/cm); TDS- Total Dissolved Solids (mg/l); TH- Total Hardness (mg/l); TA- Total Alkalinity (mg/l) Ca- Calcium (mg/l); Mg- Magnesium (mg/l); CL- Chloride (mg/l); NO_3- Nitrate (mg/l); SO_4- Sulphate (mg/l); PO_4- Phosphate (mg/l).

Conclusions

The study of physical and chemical characteristics of the surface water samples of Ashwani Khad provides a considerable insight into the quality of water which is directly related to health since this water is being used for drinking purposes. The values of EC and TDS were above the permissible levels in some water samples. The high values of BOD and COD clearly indicate that the treatment plant is not working effectively. Also the technology being used for water treatment is of a secondary level which needs to be upgraded to tertiary level.

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