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EVALUATION OF WASTEWATER CHARACTERISTICS IN BUDHA NALLAH DISCHARGE INTO RIVER SATLUJ IN LUDHIANA CITY

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Abstract

The most affected river from pollution point of view is river Satluj and most seriously affected zone of this river is near Ludhiana city (Punjab) where Budha Nallah (a tributary of river Satluj) caring city sewage and effluents from textile and electroplating industries finally is discharged into the river.

A study was made to assess the major pollutional parameters of the wastewater of Budha Nallah finally caring city discharges into river Satluj. A total of 36 sampling locations were identified covering a stretch of about 75 km from wastewater discharge point in Ludhiana to the point of confluence with river Beas. Eighteen physico-chemical parameters along with eight heavy metals were determined. The analytical data is indicative of the fact that river quality is deteriorated at location downstream of confluence with Budha Nallah as compared to upstream quality with respect to parameters DO, COD, BOD, TDS and heavy metals.

Key-Words: Physico-chemical parameters, water quality, SAR, SSP, DO, COD, BOD, etc.

Introduction

River plays an important role in human development and is important natural resource. Since the advent of earliest human civilization, man has been using the river environment for variety of applications and most of the earliest

population settlement occurred along the flood plains of rivers. Rivers provide drinking water, fertile land for agriculture and transportation. As a result of human proximity, rivers have been considerably affected by human activities ranging from agriculture and flood The municipal and industrial wastewaters discharge constitutes the constant pollution source, whereas, the surface run-off is a seasonal phenomenon. Seasonal variation in precipitation, surface run-off, interflow, groundwater flow and pumped in and outflows have a strong effect on river discharge and subsequently on the concentration of pollutants in river water [3, 4].

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control to the input of human and industrial wastes [1]. River is most vulnerable to pollution due to their easy accessibility for disposal of wastewaters. Both the natural processes (erosion, weathering of crystal materials), as well as the anthropogenic influences (urban, industrial and agricultural activities), together determine the quality of surface water in a region [2, 3]. River plays a major role in assimilation or carrying off the municipal and industrial wastewaters and run-off from agricultural land.
Since rivers constitute the main inland water resources for domestic, industrial and irrigation purposes, it is imperative to prevent and control the rivers pollution and to have reliable information on quality of water for effective management.

In Punjab State, Ludhiana (30056'-N; 75052'-E) as seen in Figure 1 (Location map) is a major industrial city with population of 14 lakhs (2001 census) situated on the bank of river Satluj. Budha Nallah, a non-perineal drain traverse across Ludhiana city (20 kms) from east to west and finally meeting the river Satluj in the outskirts of the city. Major industrial houses have set up their production units in Ludhiana comprising mainly textile, dyeing and electroplating industries. The process effluents from these polluting industrial units including the city's domestic sewage are finally discharged directly or indirectly into Budha Nallah

ultimately meeting river Satluj [5]. In addition there are number of cattle breeding and milking sheds in the city. As Budha Nallah carries industrial and domestic effluents finally discharging into river satluj, the water quality of the river has deteriorated. However, this river is a source of potable and irrigation water for villages located downstream in the southern districts of Punjab. The main objective of the study is to identify and analyze the harmful water quality parameters of Budha Nallah and river Satluj to assess its suitability for drinking and agricultural purpose.

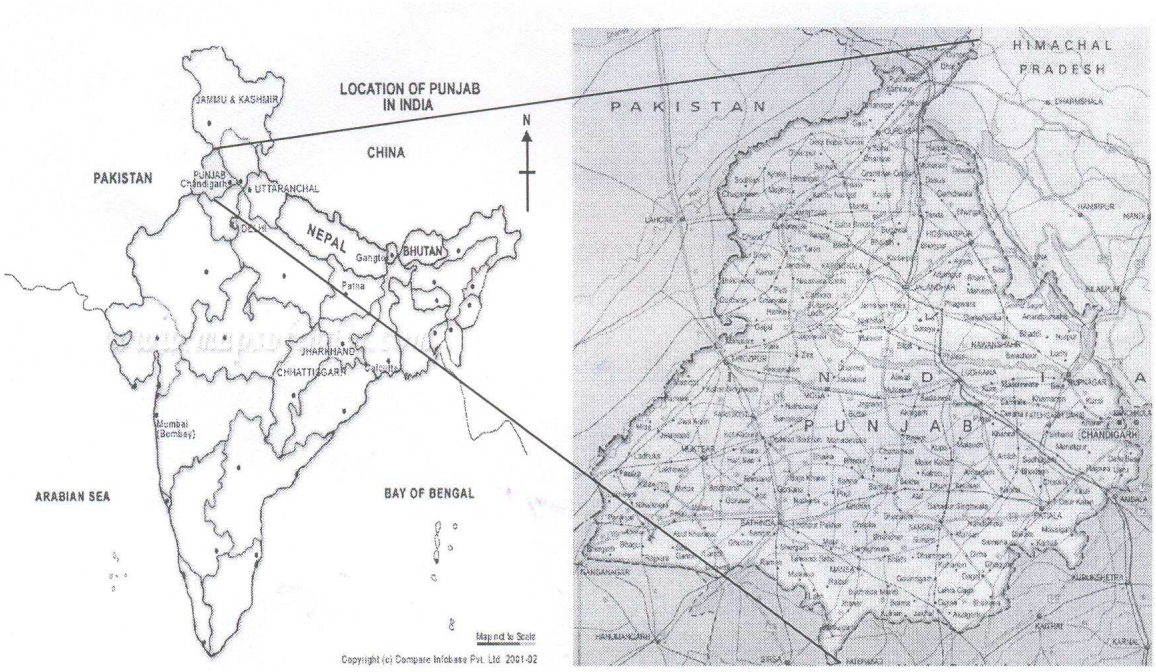

Figure 1: Location map

Materials and methods

Study Area

To assess the water quality of Budha Nallah and river Satluj, samples were collected along the course of the surface water body at various locations. The Budha Nallah was monitored from the location in Khassikalan on Tajpur road to 50 m upstream of confluence with Satlij covering a travel distance of around 40 – 45 kms and river Satluj is monitored from 50 m upstream of confluence with Budha Nallah to 15 – 20 kms down stream of river Satluj upto its confluence with river Beas. The river during its course receives pollution load from both the point and non-point sources. It receives agricultural run-offs from its vast catchments area directly or through its tributaries and wastewater drains. Other pollution sources are washing of clothes and animals in the river water and cremations ghats on the river banks.

Monitored parameters

The monitoring and sampling strategy were designed to cover a wide range of determinants at key sites, which represent the water quality of the river accounting for tributary and inputs from drains that have impact on downstream water quality.

Sampling, preservation and transportation of samples to the laboratory were as per Standard Methods [6]. Water temperature was measured on site using mercury thermometer. All other parameters were determined in laboratory following the standard protocols [6]. The samples were analyzed for 30 parameters which include pH, electrical conductivity (EC), total hardness (T-hard), calcium hardness, (Ca-Hard), total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonical nitrogen (NH4-N), nitrate nitrogen (NO3-N), chloride (Cl-), sulphate (SO42-), phosphate (PO43-), sodium (Na+),

potassium (K+), calcium (Ca2+), magnesium (Mg2+), including heavy metals.

Sodium Adsorption Ratio (SAR)

SAR is an important parameter for determination of suitability of irrigation water. This index quantifies the proportion of sodium (Na+) to calcium (Ca++) and magnesium (Mg++) ions in a sample. Sodium hazard of irrigation water can be well understood by knowing SAR [7]. Irrigation water with SAR values less than 6 are classified as 'fit', between 6 and 10 are classified as 'marginally fit' and SAR values greater than 10 are classified as 'unfit' for any crop [8, 9]. Lower the ionic strength of sodium, greater the sodium hazard; and conversely, if calcium and magnesium are predominant, the hazard is low. Consequently the SAR values of each water sample were calculated by Richard equation [10] given below:

$SAR = (Na+) / \sqrt{[(Ca2+) + (Mg2+)] / 2}$

Where all concentrations are in milliequivalents per litre (meq/l) defined as

meq / l = ([C] x |Charge|) / MW

[C] - concentration in mg/l

|Charge| - oxidation state

MW - atomic or molecular weight

There is a significant relationship between SAR values of irrigation water and the extent of sodium absorption by the soil. If the water used for irrigation is high in sodium and low in calcium, the cation – exchange complex may become saturated with sodium. This can destroy the soil structure owing to dispersion of clay particles [7].

Soluble Sodium Percentage (SSP)

SSP determines the ratio of sodium in total cations including sodium, potassium, calcium and magnesium in meq/l. The SSP is calculated by Todd equation [9] given below:

Na % = (Na x 100) / (Na + K + Ca + Mg)

The SSP values are divided into three categories as 'good' (20 – 40 Na %), 'permissible' (40 – 60 Na %) and 'doubtful' (60 – 80 Na %) according to Wilcox [7].

Results and discussions

Budha Nallah

The water quality of Budha Nallah and its major outfalls at different locations points are presented in Tables 1 and 2. Throughout all the sampling stations the values of DO, BOD and COD are found to be in the range Nil, 65 – 366 mg/l and 152 – 3880 mg/l respectively. SAR and SSP values of Budha Nallah and its major outfalls are shown in Figures 2 and 3. From figure it is clearly seen that the water is 'marginally fit' to 'unfit' with respect to SAR whereas SSP values are in the range of 'permissible' to 'doubtful' for irrigation purpose.

River Satluj

The water quality of river Satluj at different location points are presented in Table 3. The COD and BOD variations with respect to distance are presented in Figure 4 from wastewater discharge point in Ludhiana to the confluence point with river Beas.

At station R-1 (STP Bhattian discharge upstream) in Table 3, the average values of DO, BOD and COD are found to be 6.6 mg/l, < 5 mg/l and 12 mg/l respectively. Water at this station may therefore be considered less polluted and is suitable for most of beneficial uses such as drinking with conventional treatment followed by disinfection, fish culture, irrigation and industrial cooling. Beyond station R-2, on the downstream side the river gets gradually polluted due to the discharge of wastewater through Budha Nallah.

Table 1: Characteristics of Budha Nallah water samples at various locations

Parameters	BN 1	BN 2	BN 3	BN 4	BN 5	BN 6	BN 7	BN 8	BN 9	BN 10	BN 11
pH	7.2	7.3	7.2	7.3	7.3	7.3	7.2	7.2	7.3	7.3	7.4
Conductivity	2460	2320	2270	2160	1660	1820	1870	1590	1700	1615	2300
TDS	1750	1608	1546	1480	1148	1258	1288	1090	1166	1106	1560
SS	172	234	440	304	130	138	128	212	237	144	352
DO	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
COD	344	392	744	544	424	472	416	632	718	520	809
BOD	88	103	200	123	116	128	110	182	196	118	213
Tatal Hardness	788	750	712	697	608	631	623	566	592	688	702
Calcium	205	189	154	162	131	146	144	129	144	159	163
Magnesium	66	67	79	70	67	64	64	58	55	69	71
Sodium	342	318	309	276	201	231	246	189	209	156	319

Potassium	17	16	16	15	14	16	17	14	15	13	16
Chloride	526	489	475	425	309	355	379	291	321	240	490
Sulphate	60	61	37	59	19	16	19	22	28	30	42
Ammonical Nitrogen	5.6	BDL	BDL	5.6	BDL	BDL	BDL	BDL	BDL	BDL	5.6
Nitrate	2.0	BDL	BDL	3.1	BDL	BDL	BDL	BDL	BDL	BDL	3.1
Phosphate	0.2	BDL	0.5	0.3	BDL	0.2	0.2	0.2	0.3	0.3	0.7
Nickel	1.02	0.98	1.52	0.97	0.61	0.55	0.53	0.49	0.41	0.46	0.48
Lead	0.87	0.94	0.98	1.05	0.81	0.51	0.52	0.22	0.22	0.23	0.21
Chromium	1.65	1.32	1.36	2.04	0.87	0.83	0.63	0.45	0.43	0.42	0.42
Copper	0.21	0.16	0.17	0.27	0.12	0.15	0.17	0.32	0.32	0.31	0.28
Zinc	3.35	2.91	3.27	5.13	2.12	2.13	2.14	1.97	1.88	1.81	1.79
Iron	39.5	34.8	36.7	56.7	22.3	24.6	23.7	24.5	23.8	23.3	23.5
Manganese	0.46	0.38	0.48	0.49	0.32	0.29	0.25	0.24	0.25	0.23	0.19
Cadmium	1.23	1.16	1.68	1.15	0.79	0.63	0.67	0.48	0.45	0.44	0.54

All parameters are mg/L except for pH and conductivity, Unit for conductivity is µS/cm
BN – Budha Nallah

Table 2: Characteristics of some major Outfalls samples in Budha Nallah at various locations

Parameters	O 1	O 2	O 3	O 4	O 5	O 6	O 7	O 8	O 9	O 10
pH	7.7	7.2	7.1	7.1	7.2	7.6	7.4	7.3	7.3	8.2
Conductivity	2500	1710	1180	3450	1020	925	920	790	660	2660
TDS	1718	1164	800	2342	683	624	620	519	496	1808
SS	46	258	34	3068	492	240	309	197	200	752
DO	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
COD	152	376	552	3880	832	352	684	636	544	391
BOD	65	75	195	-	366	147	263	241	238	130
Tatal Hardness	709	512	518	1580	423	151	323	283	265	1531
Calcium	183	138	118	411	110	40	80	68	65	95
Magnesium	60	40	53	133	36	12	29	27	25	83
Sodium	393	198	89	275	86	171	110	89	69	447
Potassium	18	14	12	13	12	14	13	11	12	19
Chloride	605	305	137	208	132	263	170	126	106	520
Sulphate	25	82	43	320	16	18	16	15	10	268
Ammonical Nitrogen	11.2	BDL	20.1	117.6	BDL	BDL	BDL	BDL	BDL	11.0
Nitrate	5.6	BDL	10.8	52	BDL	BDL	BDL	BDL	BDL	5.0
Phosphate	0.2	0.32	BDL	-	BDL	0.6	0.48	0.27	0.21	1.2
Nickel	0.27	1.32	0.33	-	0.3	0.42	0.23	0.21	0.33	0.55
Lead	0.66	0.83	0.86	-	0.79	0.78	0.71	0.31	0.28	BDL
Chromium	0.25	2.23	0.6	-	0.21	0.6	0.48	0.44	0.33	BDL
Copper	0.33	0.21	0.08	-	0.05	0.07	0.06	0.13	0.24	0.08

Zinc	0.14	4.54	4.1	-	0.69	1.12	0.89	0.87	1.66	0.2
Iron	2.61	38.6	17.4	-	4.02	13.8	8.62	11.31	15.9	1.52
Manganese	1.43	0.46	0.33	-	0.26	0.24	0.27	0.19	0.18	0.66
Cadmium	0.41	1.51	0.52	-	0.47	0.6	0.54	0.47	0.32	0.03

All parameters are mg/L except for pH and conductivity, Unit for conductivity is µS/cm
O – Outfalls in Budha Nallah

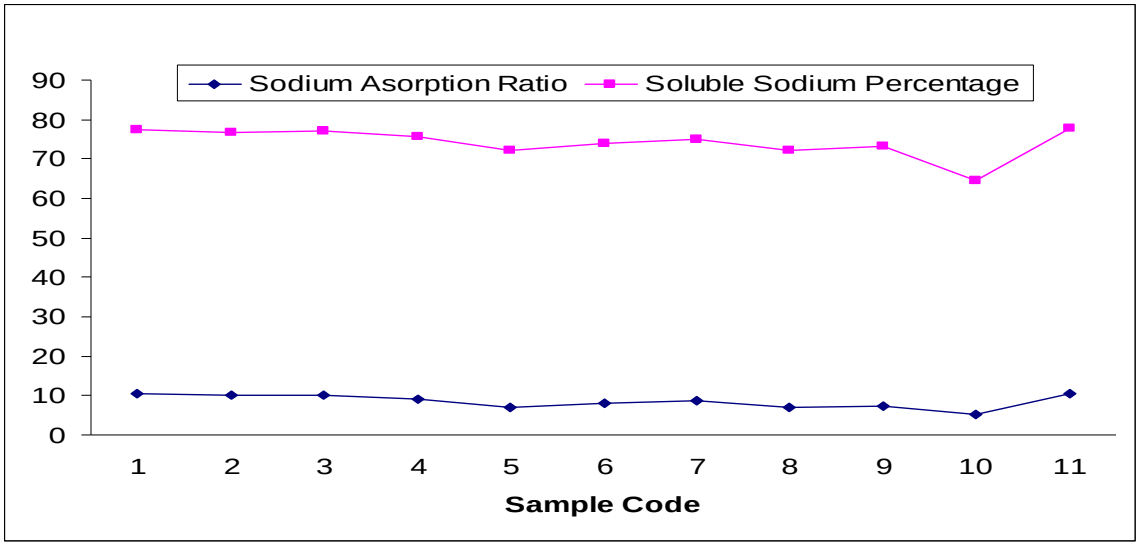

Figure 2: SAR and SSP at different locations of Budha Nallah

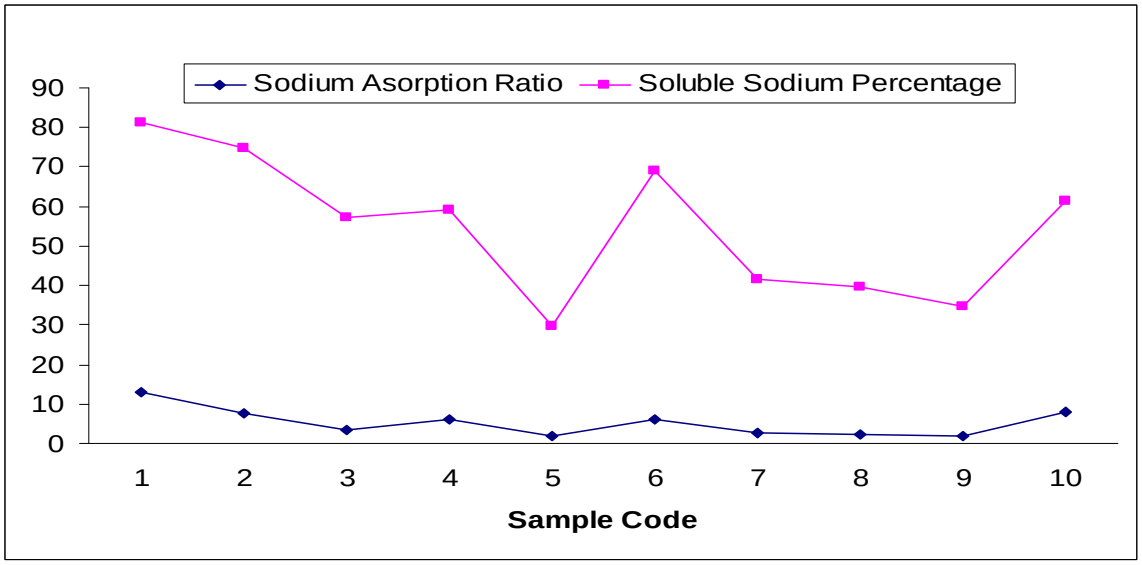

Figure 3: SAR and SSP at major outfalls of Budha Nallah

Table 3 : Characteristics of river Satluj water samples at various locations

Parameters	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10
pH	8.2	8.1	8.0	8.1	8.1	8.0	7.7	7.9	7.8	7.8

Conductivity	350	1350	1270	650	400	415	550	490	500	280
TDS	230	904	856	424	260	268	378	335	328	184
SS	BDL	24	14	12	12	BDL	142	147	128	13
DO	6.6	Nil	Nil	2.8	4.4	6.3	Nil	Nil	2.1	6.2
COD	12	122	116	76	20	12	259	195	220	16
BOD	< 5	21	32	12	6	< 5	20	28	25	< 5
Tatal Hardness	148	516	492	209	153	160	175	160	231	132
Calcium	38	130	132	48	37	39	40	39	54	31
Magnesium	13	46	39	21	14	15	18	15	23	13
Sodium	23	128	121	48	30	31	62	57	25	10
Potassium	4	12	13	9	6	3	7	4	8	2
Chloride	15	185	186	74	34	31	89	78	38	9
Sulphate	35	42	42	33	30	29	23	21	17	13
Ammonical Nitrogen	BDL	28	28	5.6	BDL	BDL	BDL	BDL	BDL	BDL
Nitrate	BDL	11.8	11.8	2.0	BDL	BDL	BDL	BDL	BDL	BDL
Phosphate	BDL	BDL	BDL	BDL	0.14	0.2	0.38	0.26	0.11	0.1
Nickel	BDL	BDL	BDL	BDL	BDL	BDL	0.012	0.063	0.19	1.018
Lead	0.03	0.07	0.06	0.03	0.05	0.02	0.03	0.02	0.08	0.03
Chromium	BDL	BDL	BDL	BDL	BDL	BDL	0.007	0.003	0.14	BDL
Copper	BDL	BDL	BDL	BDL	BDL	0.003	0.01	0.009	0.12	0.003
Zinc	0.01	0.03	0.03	0.09	0.04	0.03	0.23	0.91	0.8	0.03
Iron	0.28	0.4	0.27	0.37	1.6	0.52	4.25	3.73	11.3	2.29
Manganese	0.01	0.08	0.07	0.02	0.08	0.01	0.009	0.007	0.12	0.03
Cadmium	0.01	0.02	0.01	BDL	BDL	BDL	0.011	0.023	0.17	0.04

All parameters are mg/L except for pH and conductivity, Unit for conductivity is µS/cm
R – River

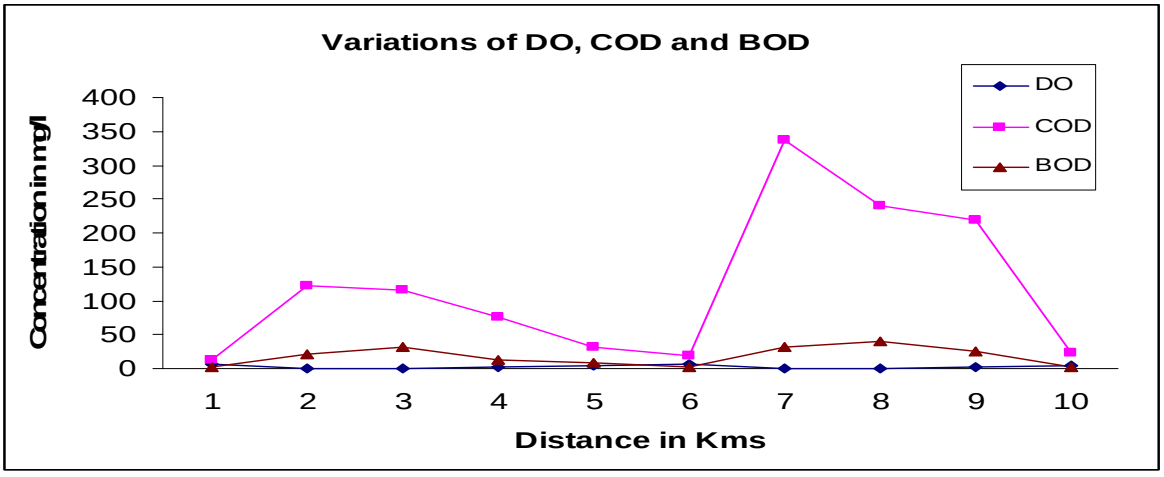

Figure 4: Variations of DO, COD and BOD with respect to distance

At station R-6 (Iqbal Nagar bridge upstream), the average values of DO, BOD and COD are found to be 6.3 mg/l, < 5 mg/l and 20 mg/l respectively. Manifesting purposes except for direct drinking

(without treatment and disinfection). Beyond station R-6 (Sidhwan Bet Bridge) the river gets heavily polluted the average values of DO, BOD and COD are Nil -2.6 mg/l, 20 – 40 mg/l and 195 – 264 mg/l respectively upto the confluence of river Satluj and river Beas due to the discharge of domestic and industrial wastes through Budha Nallah. Therefore, water at these stations is not suitable for drinking, recreation and bathing purposes.

Figure 5 indicates water is 'fit' with respect to SAR and SSP falls under 'permissible' to 'good' category.

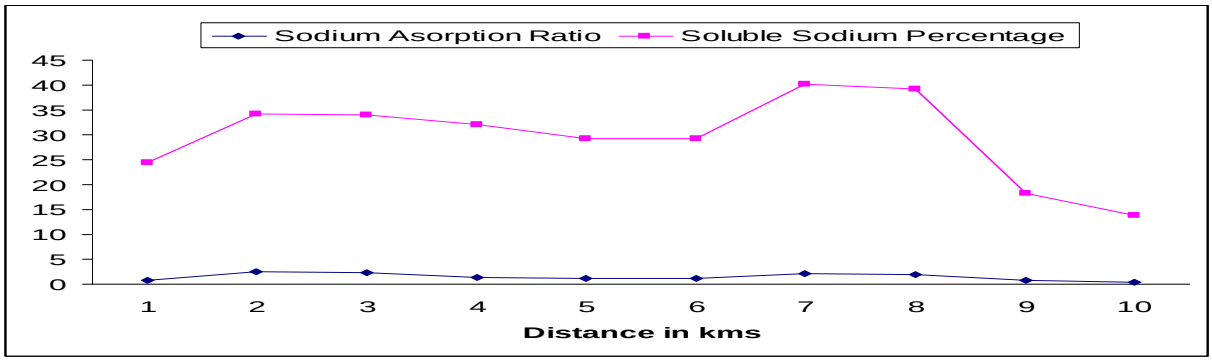

Figure 5: SAR and SSP with respect to distance

The studies indicate that the Budha Nallah carries the domestic sewage and industrial effluents including washings from cattle breeding and milking sheds. The water quality of river Satluj indicated deterioration in its quality at locations downstream of confluence with Budha Nallah as compaired to upstream quality with respect to parameters DO, BOD, TDS and heavy metals. The river quality downstream of discharges from Budha Nallah fall under Class E of inland surface water classification (IS-2296 : 1982) as compared to the quality upstream quality falling under Class A with respect to DO and BOD parameters.

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