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Water quality of the river Tawi, near Sitlee pumping station, at Sitlee water treatment complex and at consumer points in old Jammu city.

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Abstract

Drinking water quality, supplied by Public Health Engineering Department in old Jammu city, was assessed for physico – chemical characteristics viz. temperature (both air and water), turbidity, pH, electrical conductivity, free carbon dioxide, dissolved oxygen, BOD, COD, carbonate, bicarbonate, chloride, calcium, magnesium, total hardness, sodium, potassium, sulphate, silicate, nitrate, phosphate, iron, copper, zinc, lead and chromium of raw water of the river Tawi, near Sitlee water treatment complex; treated water at Sitlee water treatment complex and its three distribution points viz. Mohallanarayanian, New plots and Bakshinagar, for two years i.e. 2000 – 2001 and 2001 – 2002 and has been reported. There is alteration in water characteristics in distribution system and is caused by entry of sewage, rain water and sediments due to leaks and cracks, dislocation, defective joints, through valve regulators, back siphonage, etc. in the pipes. WQI value of the water samples at various sampling sites, during both the years, is less than 50 and is indicative of water quality that is optimum for drinking. Comparison of water characteristics with National and International standards further supports its drinking suitability.

Keywords:*Physico-chemical, river Tawi water, Sitlee water treatment complex, consumer points, water quality index.*

Introduction

Supply of the river Tawi water, at Dhoanthly, in old Jammu city, was started before 1947 and at present, due to rise in population and increased water demand, additional supply points viz. Nagrota and Gorkhanagar have been added. However, except a recent report by Khajuria and Dutta (2009), there is no published data on water quality of raw water of the river Tawi, near Sitlee water treatment complex, treated water at Sitlee water treatment complex and its three distribution points, supplied by PHE department to the consumers in old Jammu city. Jammu city, winter capital of the State, is situated at 32^{o} 44´ N-latitude, 74^{o} 54´ E-longitude, at an altitude of 753 feet, above mean sea level. River Tawi, passing through the heart of Jammu, divides the city into old and new. Potable water supply for old Jammu city is mainly from the river Tawi and was started in 1916 A.D. at Dhoanthly treatment complex. Due to an increase in population, Sitleewater supply project was conceived, under MasterPlan, on the bank of the river Tawi, at village Sitlee near Nagrota bye pass, in the year 1979 A.D. and commissioned in 1986 A.D. About two crore gallons of water per day is lifted from the river Tawi; and after treatment at Sitlee treatment complex is supplied to major parts of old city in addition to some new satellite colonies. In order to assess the water quality of raw water, at treatment complex and in the distribution system, present two years study was undertaken and has been described.

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Material & Methods

Sterilized and clean plastic bottles of 2 litres capacity were used for the collection of monthly water samples for physico-chemical analysis by standardized methods (APHA, 1998). Trace metals like iron, copper, chromium, zinc and lead were determined by standardized Atomic Absorption Spectrophotometer (ECIL, model 4139). The Water Quality Index, for assessing the suitability of water for drinking purposes, was calculated (ICMR, 1975 and Kaushik*et al.*, 2002) by the following equation

$WQI = {}^{15}\Sigma_{n=1}\, q_n.W_n$

Results and Discussion

The results of raw water quality of the river Tawi, after treatment at Sitlee treatment complex and at various points in the distribution system viz. Mohallanarayanian, New plots and Bakshinagar, have been depicted in Tables 1 – 5.

The river Tawi

At the sampling site of the river Tawi, near Sitlee water treatment complex, air temperature, water temperature, turbidity, pH, electrical conductivity, free carbon dioxide, dissolved oxygen, BOD, COD, carbonate, bicarbonate, chloride, calcium, magnesium, total hardness, sodium, potassium, sulphate, silicate, nitrate and phosphate, during the year 2000 – 2001 / 2001 – 2002, varied between 9.5 and 33.5 ^{o}C / 10.0 and 34.0 ^{o}C; 10.5 and 31.0 ^{o}C / 11.5 and 30.0 ^{o}C; 3.0 and 420.0 NTU / 7.0 and 487.5 NTU; 7.83 and 8.51 / 7.36 and 8.35; 0.162 and 0.475 mS/cm / 0.141 and 0.333 mS/cm; 2.38 and 5.29 mg/l / 1.60 and 9.44 mg/l; 3.85 and 10.78 mg/l / 5.36 and 7.82 mg/l; 0.25 and 2.20 mg/l / 0.19 and 4.91 mg/l; 4.8 and 28.8 mg/l / 4.8 and 42.0 mg/l; 2.29 and 18.58 mg/l / 2.36 and 11.07 mg/l; 54.90 and 220.75 mg/l / 81.20 and 204.29 mg/l; 5.48 and 10.75 mg/l / 5.42 and 10.46 mg/l; 16.66 and 33.94 mg/l / 23.64 and 41.87 mg/l; 4.64 and 18.86 mg/l / 2.85 and 22.83 mg/l; 63.56 and 156.24 mg/l / 76.47 and 198.42 mg/l; 4.5 and 19.5 mg/l / 7.0 and 19.0 mg/l; 0.05 and 2.5 mg/l / 1.0 and 3.5 mg/l; 4.25 and 21.0 mg/l / 3.0 and 38.5 mg/l; 2.9 and 9.8 mg/l / 2.8 and 8.6 mg/l; 0.25 and 3.0 mg/l / 0.50 and 3.75 mg/l and 0.02 and 0.30 mg/l / 0.02 and 0.41 mg/l, respectively (Khajuria and Dutta, 2009). Turbidity recorded monsoon and winter increase and is caused by soil erosion due to rains. DO showed winter increase and summer decrease. Summer decrease in dissolved oxygen is attributed to high temperature (Jhingran, 1991; Shivanikar*et al.*, 1999; Hutchinson, 2004); high organic load (Koshy and Nayar, 2000); biodegradation and decay of vegetation and restricted flow of river water (Jayaraman*et al.*, 2003). BOD and COD remained low during post-monsoon and winter and high during summer and monsoon. Inflow of dead organic matter from catchment may explain monsoon rise in BOD (Jayaraman*et al.*, 2003) and COD (Koshy and Nayar, 2000 and Jayaraman*et al.*, 2003). Bicarbonate, calcium, magnesium and total hardness observed post-monsoon and winter high and summer and monsoon low record, during both the years of study. Post-monsoon and winter increase in bicarbonate, calcium, magnesium and total hardness may be due to decreased photoperiod and low consumption of these nutrients by primary producers. Increased flush from springs, present along the sides of the river Tawi, may also account for the post-monsoon increase in these nutrients. Summer good consumption by primary producers, due to increased photoperiod, may account for low record of these nutrients. Monsoon fluctuation in bicarbonate, calcium, magnesium and total hardness is attributed to the effect of rains and soil erosion in catchment. Chloride remained high during summer and monsoon. Sodium showed winter increase and summer decrease. During monsoon, it recorded wide fluctuations. Potassium, during the first year, showed monsoon highest record. In the subsequent year, it recorded monsoon, post-monsoon and winter increase. Rains may account for the monsoon increase in sodium and potassium. Sulphate recorded monsoon, post-monsoon and winter increase and summer decrease, during the first year of study. In the second year, it remained high during early monsoon and winter and low during late monsoon, post-monsoon, early winter and summer. Silicate observed summer low and monsoon, post-monsoon and winter high record. Monsoon increase may be attributed to the rains. Increased flush from springs may also account for the post-monsoon increase in sulphate and silicate. Nitrate remained high during summer, monsoon and post-monsoon and low during winter. Summer increase in nitrate may be due to the decomposition of dead organic matter. Its monsoon and post-monsoon increase is attributed to the rains. Phosphate recorded winter decrease and summer and monsoon increase. Summer increase in phosphate is attributed to increased microbial decomposition at high temperature. Surface runoff from catchment and increased soil erosion may account for monsoon increase in phosphate.

Sitlee water treatment complex

Air temperature, water temperature, turbidity, pH, electrical conductivity, free carbon dioxide, dissolved oxygen, BOD, COD, carbonate, bicarbonate, chloride, calcium, magnesium, total hardness, sodium, potassium, sulphate, silicate, nitrate and phosphate, at the sampling point of

Table1: Monthly variations in physico - chemical parameters at the river Tawi, near Sitlee water treatment complex, Jammu (August, 2000 - July, 2001 and August, 2001 - July, 2002).

Months Parameters	AT (°C)	WT (°C)	Turb. (NTU)	pH	EC (mS/cm)	Free CO2 (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	CO_3^- (mg/l)	HCO_3^- (mg/l)	Cl^- (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	TH (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	SO_4^- (mg/l)	SiO_3^- (mg/l)	NO_3^- (mg/l)	PO_4^- (mg/l)	Fe^{++} (mg/l)	Cu^{++} (mg/l)	Zn^{++} (mg/l)	Pb^{++} (mg/l)	Cr^{++} (mg/l)
Aug., 2000	25	26.5	268	8.25	0.475	A	4.56	NA	NA	3.84	120.24	8.5	31.39	9.2	116.16	5.5	1	5.5	6.9	0.25	0.18	0.2	*	*	*	*
Sep.	23.5	25.5	6	8.24	0.427	A	5.59	NA	NA	3.64	123.17	9.71	29.36	13.49	128.78	5	1	6.75	7.1	0.25	0.14	0.2	*	*	*	*
Oct.	22.5	21.5	3	8.34	0.32	A	5.61	NA	NA	4.05	140.13	10.75	28.3	17.18	141.41	4.5	0.05	4.75	6.8	0.25	0.04	*	*	*	*	*
Nov.	18	12	6	8.51	0.294	A	4.63	NA	NA	3.77	220.75	8.84	30.53	17.88	149.74	13.5	1	5.25	5.6	0.25	0.05	0.2	*	*	*	*
Dec.	18.5	17	6	8.42	0.266	A	10.78	NA	NA	3.7	217.65	9.63	33.94	16.16	151.16	8.5	1	6.75	3.4	0.25	0.02	*	*	*	*	*
Jan.	9.5	10.5	6	8.51	0.25	A	6.71	NA	NA	18.58	207.89	8.62	31.53	18.86	156.24	15.5	1.5	7	4.7	0.25	0.04	*	*	*	*	*
Feb.	12	15	7.5	8.2	0.263	2.38	6.77	0.25	NA	A	183.53	10.02	24.86	15.55	125	19.5	1	7.25	6.2	0.25	0.04	0.2	*	*	*	*
Mar.	25	21	36	8.32	0.269	A	6.01	0.28	NA	4	140.08	6.59	25.85	11.28	110.9	11	1	5	2.9	2.75	0.06	*	*	*	*	*
Apr.	24	25	8	7.97	0.162	2.49	3.85	0.36	10.64	A	54.9	6.15	16.66	5.34	63.56	4.5	1	4.25	4.2	1	0.1	*	*	*	*	*
May	33.5	28.5	50	8.27	0.265	A	5.6	1.84	4.8	2.29	100.49	8.94	25.49	8.91	100.24	6.5	1	4.75	6.1	1	0.3	1	*	*	*	*
Jun.	33	31	420	7.83	0.192	5.29	6.01	1.9	24	A	113.87	5.48	21.2	4.64	72.11	7	2.5	9.5	7.9	2	0.24	*	*	*	*	*
Jul.	27	28	77.5	8.26	0.331	A	5.86	2.2	28.8	4.82	181.36	6.31	33.38	9.82	123.7	17	2.5	21	9.8	3	0.3	*	*	*	*	*
Aug., 2001	31.5	30	487.5	8.33	0.286	A	6.04	4.91	32.76	2.82	157.82	5.42	41.33	6.59	130.21	15.5	3.5	6.75	7.7	1.5	0.22	*	*	*	*	*
Sep.	28.5	25	8	8.31	0.333	A	6.03	0.62	9.6	11.07	204.29	7.75	36.79	22.29	183.49	19	3.5	7.25	7.4	2	0.24	*	*	*	*	*
Oct.	18	16.5	12.5	8.29	0.308	A	7.56	0.59	4.8	4.1	179.33	6.75	41.87	22.83	198.42	16	2.5	6.5	6.9	2	0.18	*	*	*	*	*
Nov.	18.5	13	9	8.24	0.265	A	7.24	0.34	4.8	3.28	193.79	6.83	39.78	22.8	193.2	15.5	3	6.75	6.5	2	0.16	*	*	*	*	*
Dec.	17	12.5	7.5	8.21	0.216	4.92	6.56	0.67	14.4	A	192.12	7.71	37.69	21.57	182.75	17	3.5	14.5	5.7	1	0.02	*	*	*	*	*
Jan.	10	11.5	7	7.97	0.18	1.6	7.48	0.29	22.78	A	203.08	8.32	35.06	12.3	138.05	17.5	3.5	13.5	5.2	0.75	0.02	*	*	*	*	*
Feb.	10	12	27.5	8.35	0.184	A	7.82	0.19	25.68	6.54	189.76	7.72	31.37	14.53	138	14.5	2.5	15.5	6.3	1.5	0.02	0.2	*	*	*	*
Mar.	24	20	27.5	8.28	0.181	A	6.66	0.52	27.6	4.14	144.32	10.46	35.38	7.14	117.64	9.5	1	8.5	4.5	2	0.41	*	*	*	*	*
Apr.	22	22	16	8.23	0.146	A	5.92	0.92	26.64	2.36	111.84	5.94	25.94	2.85	76.47	7	1	11.5	2.8	2	0.23	0.2	*	*	*	*
May	32.5	28	36	8.08	0.198	27	5.36	0.7	24.48	A	143.44	6.55	23.64	12.89	112.02	10.5	2	3	7.1	1.5	0.2	0.2	*	*	*	*
Jun.	34	29	397.5	7.36	0.142	9.44	6.17	0.7	24.48	A	81.2	7.39	25.67	7.44	94.65	14	3.5	38.5	8.6	3.75	0.27	*	*	*	*	*
Jul., 2002	30	27	472	7.31	0.141	4.21	6.12	0.26	42	A	102.15	10.14	25.17	6.53	89.68	17.5	2.5	27.5	4	0.5	0.04	*	*	*	*	*

treated water, at Sitlee water treatment complex, recorded a well marked annual fluctuation, during the year 2000 – 2001 / 2001 – 2002, of 8.5 and 31.5 ^{o}C / 11.0 and 33.5 ^{o}C; 12.0 and 31.0 ^{o}C / 13.5and 31.0^{o}C; nil and 7.0NTU / nil and 8.0NTU; 6.51 and 8.63 / 6.35 and 8.23; 0.183 and 0.508 mS/cm / 0.147 and 0.347 mS/cm; 1.93 and 21.16mg/l / 0.83 and 39.06mg/l; 3.37 and 7.38mg/l / 6.10 and 9.82mg/l; 0.15 and 0.90mg/l / 0.12 and 0.91mg/l; 15.96 and 28.8mg/l / 5.44 and 19.04mg/l; 1.88 and 14.87 mg/l / 4.91 and 9.49 mg/l; 49.51 and 222.44 mg/l / 32.65 and 207.16 mg/l; 5.59 and 10.75mg/l / 6.63 and 10.43mg/l; 17.66 and 41.01mg/l / 23.50 and 55.82mg/l; 4.08 and 20.24mg/l and 5.42 and 17.76mg/l; 66.01 and 149.24mg/l / 94.11 and 176.53mg/l; 4.5 and 19.0mg/l / 4.5 and 19.0mg/l; 0.05 and 2.0mg/l / 0.05 and 3.5mg/l; 4.0 and 30.0mg/l / 11.5 and 35.0mg/l; 1.2 and 12.3mg/l / 2.3 and 7.1mg/l; 0.25 and 3.25mg/l / 0.25 and 4.0mg/l and 0.02 and 0.32mg/l / 0.02 and 0.46mg/l, respectively.

The present study has revealed that in the treated water samples, there is decrease in various parameters like BOD, carbonates and total hardness and is caused by proper treatment processes i.e. sedimentation, alum treatment, filtration and chlorination.

Distribution points:

Mohallanarayanian:

At Mohallanarayanian sampling point of Sitlee water distribution system, during the year 2000 – 2001 / 2001 – 2002, air temperature, water temperature, turbidity, pH, electrical conductivity, free carbon dioxide, dissolved oxygen, BOD, COD, carbonate, bicarbonate, chloride, calcium, magnesium, total hardness, sodium, potassium, sulphate, silicate, nitrate and phosphate, varied between 9.0and 32.5^{o}C / 12.0 and 32.0 ^{o}C; 12.0and 31.0^{o}C / 13.0 and 33.0^{o}C; nil and 6.0 NTU / nil and 6.0 NTU; 6.83 and 8.63 / 6.85 and 8.34; 0.188 and 0.551 mS/cm / 0.154 and 0.336 mS/cm; 1.28 and 6.68 mg/l / 1.66 and 12.01 mg/l; 3.68 and 6.84 mg/l / 5.78 and 7.91 mg/l; 0.16 and 0.98 mg/l / 0.12 and 0.59 mg/l; 7.98 and 24.0 mg/l / 6.0 and 35.36 mg/l;1.38 and 22.30 mg/l / 4.81 and 11.07 mg/l; 34.65 and 217.87 mg/l / 49.57 and 212.17 mg/l; 6.15 and 20.65 mg/l / 5.42 and 9.56 mg/l; 21.56 and 36.62 mg/l / 25.94 and 41.87 mg/l; 2.97 and 17.26 mg/l / 4.28 and 17.79 mg/l; 66.01 and 147.13 mg/l / 88.23 and 177.53 mg/l; 4.5 and 19.0 mg/l / 4.5 and 19.0 mg/l; 0.05 and 2.0 mg/l / 1.0 and 3.5 mg/l; 4.25 and 28.75 mg/l / 7.0 and 33.75 mg/l; 2.2 and 6.0 mg/l / 3.2 and 6.5 mg/l; 0.5 and 2.0 mg/l / 0.25 and 2.50 mg/l and 0.02 and 0.20 mg/l / 0.01 and 0.35 mg/l, respectively.

New plots:

An annual variation of 12.0 and 37.5^{o}C / 15.0 and 33.5^{o}C; 12.5 and 31.5 ^{o}C / 12.5 and 32.0 ^{o}C; nil and 7.0 NTU / nil and 6.0 NTU; 6.82 and 8.67 / 6.83 and 8.38; 0.184 and 0.593 mS/cm / 0.149 and 0.347 mS/cm; 1.93 and 15.60 mg/l / 0.91 and 13.10 mg/l; 3.18 and 8.86 mg/l / 6.11 and 8.06 mg/l; 0.24 and 0.90 mg/l / 0.15 and 0.83 mg/l; 5.32 and 24.0 mg/l / 4.8 and 15.36 mg/l; 1.88 and 14.87 mg/l / 6.54 and 9.49 mg/l; 54.46 and 224.59 mg/l / 59.13 and 197.31 mg/l; 6.57 and 18.22 mg/l / 6.63 and 11.30 mg/l; 19.60 and 38.47 mg/l / 25.04 and 43.97 mg/l; 4.08 and 23.31 mg/l / 4.28 and 16.21 mg/l; 66.01 and 190.40 mg/l / 82.35 and 172.31 mg/l); 4.5 and 19.0 mg/l / 4.5 and 18.0 mg/l; 0.05 and 2.0 mg/l / 0.05 and 3.0 mg/l; 4.75 and 22.25 mg/l / 5.5 and 29.5 mg/l; 2.2 and 11.5 mg/l / 2.5 and 7.1 mg/l; 0.25 and 3.0 mg/l / 1.0 and 4.50 mg/l and 0.01 and 0.12 mg/l / 0.02 and 0.18 mg/l, respectively, in air temperature, water temperature, turbidity, pH, electrical conductivity, free carbon dioxide, dissolved oxygen, BOD, COD, carbonate, bicarbonate, chloride, calcium, magnesium, total hardness, sodium, potassium, sulphate, silicate, nitrate and phosphate was observed at New plots sampling point of Sitlee water distribution system, during the year 2000 – 2001 / 2001 – 2002.

Bakshinagar:

At the Bakshinagar sampling point of Sitlee water distribution system, air temperature, water temperature, turbidity, pH, electrical conductivity, free carbon dioxide, dissolved oxygen, BOD, COD, carbonate, bicarbonate, chloride, calcium, magnesium, total hardness, sodium, potassium, sulphate, silicate, nitrate and phosphate during the year 2000 – 2001 / 2001 – 2002, recorded an annual fluctuation of 15.0 and 35.0 ^{o}C / 15.0 and 32.5 ^{o}C; 14.0 and 30.5^{o}C / 13.0 and 29.5^{o}C; nil and 7.0 NTU / nil and 3.0 NTU; 7.25 and 8.60 / 7.23 and 8.26; 0.294 and 0.630 mS/cm / 0.192 and 0.599 mS/cm; 1.41 and 15.60 mg/l / 1.66 and 32.75 mg/l; 3.14 and 8.79 mg/l / 5.04 and 8.08 mg/l; 0.14 and 0.93 mg/l / 0.11 and 0.88 mg/l; 7.2 and 19.2 mg/l / 6.0 and 38.08 mg/l; 1.88 and 22.30 mg/l / 4.91 and 9.49 mg/l; 54.86 and 372.53 mg/l / 138.0 and 391.63 mg/l; 9.89 and 48.38 mg/l / 8.31 and 44.67 mg/l;

Table 2: Monthly variations in physico - chemical parameters of treated water (sump tank) of Sitlee water treatment complex, Jammu (August, 2000 - July, 2001 and August, 2001 - July, 2002)

Months Parameters	AT (°C)	WT (°C)	Turb. (NTU)	pH	EC (mS/cm)	FCO_2 (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	CO_3^- (mg/l)	HCO_3^- (mg/l)	Cl^- (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	TH (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	SO_4^{--} (mg/l)	SiO_3^- (mg/l)	NO_3^- (mg/l)	PO_4^{---} (mg/l)	Fe^{++} (mg/l)	Cu^{++} (mg/l)	Zn^{++} (mg/l)	Pb^{++} (mg/l)	Cr^{++} (mg/l)
Aug., 2000	25.5	26.5	3	7.23	0.508	5.83	3.9	NA	NA	A	78.21	8.4	34.42	7.97	118.68	5.5	0.05	30	3.9	0.25	0.32	*	*	*	*	*
Sep.	23.5	25	2.5	7.81	0.432	2.49	5.08	NA	NA	A	78.23	8.5	28.85	13.8	128.7	4.5	0.05	25.25	3.1	0.75	0.05	*	*	*	*	*
Oct.	23	25	2.5	8.39	0.33	A	6.51	NA	NA	8.1	138.07	10.75	23.29	20.24	141.46	4.5	0.05	23	2.9	0.25	0.07	*	*	*	*	*
Nov.	16.5	14	N	8.63	0.294	A	4.83	NA	NA	9.44	218.83	9.43	23.4	16.65	126.9	12.5	1	24.5	2.1	0.5	0.08	*	*	*	*	*
Dec.	13.5	14	3	8.37	0.261	A	7.38	NA	NA	1.88	222.44	8.43	34.7	15.18	149.24	8.5	1	6	3.9	0.25	0.02	*	*	*	*	*
Jan.	8.5	12	6	8.55	0.25	A	5.94	NA	NA	14.87	219.23	9.85	33.95	14.94	146.16	14.5	1	5	2.7	0.25	0.04	*	*	*	*	*
Feb.	14	16.5	3	8.12	0.274	3.96	4.13	0.15	NA	A	190.59	9.71	24.8	13.22	116	19	1	6.25	3.1	1.5	0.02	*	*	*	*	*
Mar.	20	22	3	7.59	0.28	2.82	6.66	0.41	NA	A	113.93	8.79	34.12	8.14	118.63	11	1	21.5	1.2	2.25	0.08	*	*	*	*	*
Apr.	25	28	3	7.79	0.183	2.31	3.37	0.46	15.96	A	96.07	5.59	17.66	5.24	66.01	5	1	4	3.6	2.25	0.11	*	*	*	*	*
May	30	31	N	7.84	0.261	1.93	4.17	0.35	16.8	A	93.48	7.82	24.51	6.53	88.01	7	1	7.75	4.5	1.5	0.04	*	*	*	*	*
Jun.	31.5	31	2.5	6.51	0.263	21.16	6.09	0.9	24	A	49.51	8.77	32.77	4.08	98.55	5.5	2	21.75	12.3	3.25	0.04	*	*	*	*	*
Jul.	29	28	7	7.41	0.354	4.45	6.65	0.51	28.8	A	83.33	10.1	41.01	5.2	123.9	11	1.5	29.75	7.1	2	0.07	*	*	*	*	*
Aug., 2001	31	29	N	7.6	0.324	4.13	6.1	0.91	14.04	A	88.95	6.63	39.16	6.59	124.86	9.5	1.5	33.25	5.8	0.25	0.46	*	*	*	*	*
Sep.	28	27	2.5	8.23	0.347	A	6.15	0.62	9.6	9.49	193.03	8.61	38.95	15.73	161.9	19	3.5	32.25	4.9	1.5	0.08	*	*	*	*	*
Oct.	18	19	N	8.13	0.299	1.83	8.53	0.31	14.4	A	203.01	7.79	39.78	17.76	172.31	15.5	2.5	31.5	4	1.25	0.08	*	*	*	*	*
Nov.	16	14	N	8.05	0.243	2.75	8.42	0.51	9.6	A	203.81	6.65	41.87	17.46	176.53	15.5	3	31.75	4	0.75	0.08	*	*	*	*	*
Dec.	12.5	13.5	N	8.08	0.202	3.66	7.91	0.67	14.4	A	207.16	9.37	39.6	17.76	171.9	17	3	12.5	5.1	1.25	0.02	*	*	*	*	*
Jan.	11	14	3	8.23	0.188	A	8.29	0.66	17.08	4.91	195.09	9.26	34.13	14.53	144.95	17.5	3	11.5	4.7	1	0.02	*	*	*	*	*
Feb.	11.5	13.5	2.5	8.21	0.191	4.81	9.82	0.2	12.84	A	189.56	9.37	36.9	11.18	138.05	14.5	2.5	13.5	5.8	2	0.02	*	*	*	*	*
Mar.	22	21.5	3	7.92	0.189	2.08	6.55	0.12	9.2	A	131.09	9.51	35.38	7.14	117.64	9.5	1	18	3.9	1.75	0.14	*	*	*	*	*
Apr.	20	24	3	8.12	0.147	0.83	6.38	0.63	13.32	A	109.44	6.65	23.5	8.57	94.11	7	0.05	14	2.3	2	0.22	*	*	*	*	*
May	32	30.5	2.5	7.96	0.222	4.36	6.34	0.53	5.44	A	100.97	8.6	26	11.46	112.02	9.5	1	17.5	6.3	2.25	0.06	*	*	*	*	*
Jun.	33.5	31	8	6.35	0.306	39.06	6.5	0.61	19.04	A	32.65	10.43	55.82	8.11	172.61	13.5	2.5	35	7.1	4	0.07	*	*	*	*	*
Jul., 2002	30	29.5	3	7.13	0.205	6.32	6.65	0.8	6	A	64.59	8.58	34.16	5.42	107.62	4.5	1.5	28	3.5	1.25	0.12	*	*	*	*	*

Table 3: Monthly variations in physico - chemical parameters at MohallaNarayanian sampling point, Jammu (August, 2000 - July, 2001 and August, 2001 - July, 2002)

Months Parameters	AT (°C)	WT (°C)	Turb. (NTU)	pH	EC (mS/cm)	FCO_2 (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	CO_3^- (mg/l)	HCO_3^- (mg/l)	Cl^- (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	TH (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	SO_4^{--} (mg/l)	SiO_3^- (mg/l)	NO_3^- (mg/l)	PO_4^{---} (mg/l)	Fe^{++} (mg/l)	Cu^{++} (mg/l)	Zn^{++} (mg/l)	Pb^{++} (mg/l)	Cr^{++} (mg/l)
Aug., 2000	26.5	27.5	6	7.69	0.551	2.49	5.03	NA	NA	A	76.24	9.71	35.44	14.11	146.46	5.5	1	22.75	3.5	0.5	0.2	*	*	*	*	*
Sep.	23	25.5	3	8.08	0.399	2.5	5.76	NA	NA	A	68.42	9.71	33.41	15.34	146.4	4.5	0.05	25	2.6	1.25	0.09	*	*	*	*	*
Oct.	21.5	24.5	N	8.47	0.32	A	6.13	NA	NA	5.06	142.19	10.75	31.39	16.56	146.42	4.5	0.05	23.25	2.8	0.5	0.08	*	*	*	*	*
Nov.	12	15.5	N	8.53	0.284	A	5.91	NA	NA	6.6	217.87	9.43	30.02	17.26	145.93	12.5	1	24.5	2.9	0.75	0.06	*	*	*	*	*
Dec.	15	15.5	3	8.54	0.266	A	6.84	NA	NA	5.65	216.69	8.43	30.71	17.14	147.13	8.5	1	6.5	2.4	0.75	0.03	*	*	*	*	*
Jan.	9	12	3	8.63	0.26	A	4.92	NA	NA	22.3	188.99	8.85	32.74	15.67	146.16	14.5	1	5.5	2.2	0.75	0.03	*	*	*	*	*
Feb.	15	17.5	3	8.39	0.277	A	4.64	0.89	NA	1.38	201.18	20.65	24.06	15.55	124	19	1	6.75	2.3	0.75	0.02	*	*	*	*	*
Mar.	20.5	22	2.5	7.48	0.303	3.53	6.61	0.76	NA	A	99.97	8.24	32.06	10.02	121.21	12	1	24.75	2.5	2	0.11	*	*	*	*	*
Apr.	25.5	29	6	7.99	0.188	2.13	3.68	0.28	7.98	A	100.65	6.15	21.56	2.97	66.01	5	1	4.25	3	0.5	0.11	*	*	*	*	*
May	32.5	31	N	7.88	0.278	1.28	5.76	0.16	12	A	72.91	7.82	26.47	7.12	95.35	7	1	15	4.9	1.75	0.03	*	*	*	*	*
Jun.	32	31	N	6.83	0.307	6.68	6.34	0.22	19.2	A	34.65	6.87	36.62	3.5	105.76	5.5	2	28.75	6	0.75	0.04	*	*	*	*	*
Jul.	29.5	29	N	7.32	0.334	3.96	6.77	0.98	24	A	88.23	9.46	34.34	6.93	114.18	10.5	1.5	27.25	2.5	2	0.05	*	*	*	*	*
Aug., 2001	31.5	30	3	7.57	0.312	4.13	6.68	0.47	18.72	A	74.61	5.42	36.98	7.91	124.7	9	2.5	33.75	4.9	0.25	0.35	*	*	*	*	*
Sep.	28.5	28	N	8.31	0.336	A	5.78	0.12	19.2	11.07	204.29	8.6	38.95	9.17	134.92	19	3.5	31	4.7	1.75	0.17	*	*	*	*	*
Oct.	18.5	19	N	8.04	0.309	1.83	7.59	0.37	19.2	A	207.16	7.79	41.87	17.79	171.53	16	2.5	28.75	4.2	2.5	0.07	*	*	*	*	*
Nov.	13.5	15	N	8.1	0.246	1.83	7.91	0.21	24	A	212.17	7.27	37.69	17.76	167.29	16	3	29.25	5	1.5	0.1	*	*	*	*	*
Dec.	12.5	13	2.5	8.2	0.21	1.68	6.9	0.24	24	A	197.13	8.26	39.78	16.49	167.19	17.5	3	10.5	5.3	1	0.04	*	*	*	*	*
Jan.	13	13.5	2.5	8.31	0.188	A	7.8	0.4	17.08	4.91	188.1	7.72	39.67	10.06	140.35	17.5	3	9	4.9	0.75	0.01	*	*	*	*	*
Feb.	12	14	6	8.34	0.191	A	6.59	0.45	21.4	4.81	186.42	8.82	32.29	13.97	138.05	14.5	2.5	12	5.6	1.5	0.09	*	*	*	*	*
Mar.	29	23	3	8.19	0.192	2.36	6.38	0.57	20.24	A	135.9	8.55	35.3	4.28	105.88	9.5	1	12.5	4.6	1	0.18	*	*	*	*	*
Apr.	26	26.5	2.5	8.04	0.154	1.66	5.9	0.58	22.2	A	113.05	6.6	25.94	5.71	88.23	7.5	1	13.5	3.2	1	0.3	*	*	*	*	*
May	32	31	6	8.09	0.193	4.91	6.51	0.35	13.6	A	118	7.58	30.83	8.56	112.12	6.5	1	7	5.7	2	0.07	*	*	*	*	*
Jun.	32	33	N	6.85	0.225	12.01	6.48	0.59	35.36	A	57.37	9.56	33.49	6.7	111.36	12	2.5	25	6.5	0.75	0.04	*	*	*	*	*
Jul., 2002	31	30	2.5	7.03	0.227	5.38	6.65	0.53	6	A	49.57	9.36	37.76	6.53	121.07	4.5	2	21.5	4.7	1.25	0.02	*	*	*	*	*

Table 4: Monthly variations in physico - chemical parameters at New plots sampling point, Jammu (August, 2000 - July, 2001 and August, 2001 - July, 2002).

Months / Parameters	AT (°C)	WT (°C)	Turb. (NTU)	pH	EC (mS/cm)	FCO_2 (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	CO_3^- (mg/l)	HCO_3^- (mg/l)	Cl^- (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	TH (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	SO_4^- (mg/l)	SiO_3^- (mg/l)	NO_3^- (mg/l)	PO_4^- (mg/l)	Fe^{+++} (mg/l)	Cu^{++} (mg/l)	Zn^{++} (mg/l)	Pb^{++} (mg/l)	Cr^{++} (mg/l)
Aug., 2000	26	27	N	7.8	0.598	7.49	6.14	NA	NA	A	124.15	18.22	37.97	23.31	190.4	17.5	0.05	21.5	3.6	0.75	0.12	*	*	*	*	*
Sep.	25	26	2.5	8.02	0.427	2.49	4.81	NA	NA	A	101.66	10.93	38.47	21.47	184.34	4.5	1	15	2.9	0.25	0.1	*	*	*	*	*
Oct.	24	24.5	3	8.25	0.34	A	5.86	NA	NA	6.08	134.98	12.09	30.37	20.24	159.09	4.5	0.05	13.5	4	0.5	0.07	*	*	*	*	*
Nov.	18.5	14	3	8.44	0.294	A	4.21	NA	NA	1.88	224.59	8.25	31.55	14.8	139.59	12.5	1	4.75	5.9	0.75	0.05	*	*	*	*	*
Dec.	15.5	14	7	8.49	0.261	A	8.86	NA	NA	7.54	208.06	9.63	29.09	20.57	157.2	8.5	1	6.75	2.4	0.75	0.03	*	*	*	*	*
Jan.	12	12.5	3	8.67	0.25	A	4.46	NA	NA	14.87	204.11	9.85	31.53	16.65	147.17	14.5	1	7	2.9	0.75	0.1	*	*	*	*	*
Feb.	15	12.5	3	8.38	0.286	A	3.58	0.46	NA	1.98	180	15.79	29.67	15.06	136	19	1	7	2.4	0.75	0.01	*	*	*	*	*
Mar.	22	21.5	3	7.49	0.288	4.23	6.31	0.24	NA	A	125.55	9.34	33.09	9.4	121.21	11	1	19.25	2.2	3	0.05	*	*	*	*	*
Apr.	37.5	29	6	8.01	0.184	2.49	3.18	0.36	5.32	A	86.92	7.26	19.6	4.15	66.01	5	1	13	2.8	2	0.1	*	*	*	*	*
May	34	31.5	N	7.76	0.276	1.93	5.44	0.9	12	A	93.48	6.7	25.49	7.42	94.13	7	1	7.25	4.7	1.25	0.03	*	*	*	*	*
Jun.	33.5	30.5	N	6.82	0.271	15.6	6.21	0.26	19.2	A	54.46	6.57	35.66	4.08	105.76	5.5	2	21	11.5	3	0.04	*	*	*	*	*
Jul.	27.5	28.5	N	6.97	0.341	11.9	6.68	0.26	24	A	93.13	8.2	34.34	10.4	128.45	10.5	1.5	22.25	7.1	2.25	0.06	*	*	*	*	*
Aug., 2001	30.5	29.5	N	7.37	0.317	7.23	6.24	0.83	14.04	A	97.56	6.63	39.16	6.59	124.78	9.5	2	29.5	5.5	1.75	0.18	*	*	*	*	*
Sep.	28.5	28	N	8.28	0.347	A	6.27	0.74	9.6	9.49	189.82	8.61	32.46	15.73	145.71	18	3	21.5	4.3	1	0.16	*	*	*	*	*
Oct.	21.5	19.5	N	7.93	0.302	0.91	7.42	0.5	4.8	A	197.31	7.27	41.89	15.22	167.09	16	2.5	18.75	4.9	1.75	0.09	*	*	*	*	*
Nov.	18	14.5	N	7.95	0.232	1.37	7.24	0.34	14.4	A	193.79	7.79	43.97	15.28	172.31	15.5	3	10	7.1	1.5	0.07	*	*	*	*	*
Dec.	15.5	12.5	2.5	7.89	0.208	0.91	6.39	0.67	4.8	A	177.08	8.2	41.87	15.12	167.09	17.5	3	7.5	4	1.25	0.02	*	*	*	*	*
Jan.	16	14	3	8.38	0.189	A	7.59	0.77	14.24	6.54	191.43	7.73	34.13	15.65	149.55	17.5	2.5	9.5	4.9	1.25	0.07	*	*	*	*	*
Feb.	15	14.5	6	8.1	0.192	1.04	8.06	0.66	12.84	A	186.43	8.8	32.2	16.21	147.25	14.5	2.5	5.5	3.1	1.75	0.05	*	*	*	*	*
Mar.	28.5	23.5	3	7.92	0.194	2.49	6.19	0.22	9.2	A	144.32	8.56	35.88	10	129.41	9.5	1	22	2.5	1	0.08	*	*	*	*	*
Apr.	25	25	2.5	8.03	0.149	1.66	6.11	0.44	13.32	A	108.24	6.65	25.04	4.28	82.35	7	0.05	14.5	2.9	2	0.08	*	*	*	*	*
May	33.5	31.5	2.5	7.98	0.215	4.91	6.34	0.35	13.6	A	118.9	8.81	30.73	8.59	112.02	9	1	10.25	5.9	1.5	0.08	*	*	*	*	*
Jun.	33	32	N	6.83	0.235	13.1	7.04	0.15	15.36	A	59.13	11.3	37.95	6.76	122.49	12.5	2.5	22.5	6.4	4.5	0.06	*	*	*	*	*
Jul., 2002	26	31.5	2.5	6.73	0.215	8.58	6.92	0.54	6	A	63.09	10.14	34.16	9.8	125.56	4.5	1.5	24.5	3.5	1.5	0.07	*	*	*	*	*

Table 5: Monthly variations in physico - chemical parameters at Bakshinagar distribution point, Jammu (August, 2000 - July, 2001 and August, 2001 - July, 2002).

Months / Parameters	AT (°C)	WT (°C)	Turb. (NTU)	pH	EC (mS/cm)	FCO_2 (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	CO_3^- (mg/l)	HCO_3^- (mg/l)	Cl^- (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	TH (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	SO_4^- (mg/l)	SiO_3^- (mg/l)	NO_3^- (mg/l)	PO_4^- (mg/l)	Fe^{+++} (mg/l)	Cu^{++} (mg/l)	Zn^{++} (mg/l)	Pb^{++} (mg/l)	Cr^{++} (mg/l)
Aug., 2000	26.5	27.5	3	7.59	0.522	4.16	4.64	NA	NA	A	93.84	14.57	39.49	8.59	133.83	7.5	0.05	24.5	6.3	4.75	0.11	*	*	*	*	*
Sep.	25.5	26.5	3	7.85	0.494	5.83	5.37	NA	NA	A	120.24	14.37	45.56	25.15	217.17	17.5	0.05	21.75	3.6	8.75	0.09	*	*	*	*	*
Oct.	23.5	24	3	8.11	0.36	6.64	6.36	NA	NA	A	259.79	48.38	63.79	34.36	300.5	16	2	14.25	4	11.5	0.1	*	*	*	*	*
Nov.	18	14	2.5	8.27	0.37	A	4.38	NA	NA	1.88	253.38	20.04	32.56	28.37	197.96	18	1	5.5	5.3	13.5	0.07	*	*	*	*	*
Dec.	16.5	15.5	7	8.4	0.294	A	8.79	NA	NA	3.77	232.03	13.25	29.9	23.5	171.31	10.5	1	8.5	4.4	2	0.03	*	*	*	*	*
Jan.	16.5	15	3	8.6	0.32	A	5.01	NA	NA	22.3	234.35	16	33.14	24	181.45	19.5	1	7.25	3.7	3.5	0.04	*	*	*	*	*
Feb.	15	19.5	7	8.26	0.37	A	4.68	0.14	NA	14.29	215.29	21.86	30.47	21.87	166	26	2	9	4.4	4.25	0.02	*	*	*	*	*
Mar.	22.5	22.5	3	7.57	0.305	1.41	6.36	0.38	NA	A	109.28	9.89	32.06	9.4	118.63	12.5	1	20	2.7	3.25	0.06	*	*	*	*	*
Apr.	35	28	3	7.71	0.355	7.47	3.14	0.46	15.96	A	157.83	15.65	34.31	9.5	124.69	14	1	7.75	5.8	2.25	0.14	*	*	*	*	*
May	32.5	30.5	N	7.81	0.428	2.89	5.81	0.93	7.2	A	140.22	15.09	38.23	11.88	144.25	13.5	1.5	12.75	7.6	11.75	0.1	*	*	*	*	*
Jun.	32	29.5	N	7.25	0.294	15.6	6.01	0.79	16.8	A	54.86	16.57	36.62	2.92	103.36	5.5	2.5	28.5	12.3	3.5	0.07	*	*	*	*	*
Jul.	28	26	2.5	7.57	0.63	14.55	5.94	0.85	19.2	A	272.53	41.66	64.4	27.74	274.8	38.5	4	10.25	6.7	13.5	0.13	*	*	*	*	*
Aug., 2001	31	28	2.5	7.57	0.398	8.26	5.04	0.88	9.36	A	140.61	17.48	54.39	17.13	206.17	20.5	3	27.25	8.6	7.75	0.16	*	*	*	*	*
Sep.	28	28.5	2.5	8.22	0.351	A	6.64	0.35	9.6	9.49	231.64	9.19	34.62	20.98	172.69	19	3.5	25	5	10.5	0.12	*	*	*	*	*
Oct.	21	19	3	7.87	0.321	1.83	8.03	0.11	19.2	A	203.81	8.31	43.97	16.49	177.58	17	2.5	21	5.6	11.5	0.08	*	*	*	*	*
Nov.	18.5	14.5	2.5	7.92	0.264	2.75	8.08	0.21	14.4	A	208.83	8.57	46.06	15.22	177.53	16	3	9.5	7.5	19.75	0.08	*	*	*	*	*
Dec.	15	13	N	7.74	0.221	1.83	6.73	0.84	19.2	A	213.84	8.82	43.97	15.2	172.31	17	3	13	6.1	2	0.02	*	*	*	*	*
Jan.	15.5	15	3	8.26	0.204	A	7.19	0.47	7.12	4.91	208.07	9.92	32.29	19	158.76	19	3	12.5	5.2	2	0.01	*	*	*	*	*
Feb.	15.5	14	2.5	7.99	0.242	3.21	8.04	0.47	8.56	A	229.71	14.34	42.44	20.12	188.67	18	2.5	14	7.2	6	0.02	*	*	*	*	*
Mar.	29	24	2.5	7.89	0.192	1.66	5.85	0.51	9.2	A	138.3	10.46	35.38	7.14	117.64	10.5	1	21.5	3.9	2.5	0.06	*	*	*	*	*
Apr.	25.5	25	3	7.99	0.205	2.49	5.9	0.14	13.32	A	138	11.41	30.66	10	117.62	12	1	16.5	3.4	5	0.28	*	*	*	*	*
May	32.5	27	2.5	7.69	0.599	18.88	7.04	0.53	19.04	A	391.63	44.67	73.29	28.65	300.69	9.5	3.5	12.75	13.3	20	0.08	*	*	*	*	*
Jun.	32.5	29.5	N	7.23	0.52	32.75	6.37	0.48	38.08	A	260.37	32.6	60.28	28.41	267.27	35	3	21.5	8.2	3.75	0.05	*	*	*	*	*
Jul., 2002	26.5	29	2.5	7.3	0.377	15.91	6.52	0.67	6	A	180.27	24.97	61.13	14.16	210.76	16	2	23.5	4	11.25	0.2	*	*	*	*	*

29.90 and 74.40 mg/l / 30.66 and 73.29 mg/l; 2.92 and 34.36 mg/l / 7.14 and 28.65 mg/l; 103.36 and 300.50 mg/l / 117.62 and 300.69 mg/l; 5.5 and 38.5 mg/l / 9.5 and 35.0 mg/l; 0.05 and 4.0 mg/l / 1.0 and 3.5 mg/l; 5.5 and 28.5 mg/l / 9.5 and 27.25 mg/l; 2.7 and 12.3 mg/l / 3.4 and 13.3 mg/l; 2.0 and 13.5 mg/l / 2.0 and 20.0 mg/l and 0.02 and 0.14 mg/l / 0.01 and 0.28 mg/l, respectively.

Comparative analysis of various parameters of water samples in the distribution system has shown an increase in BOD, COD, magnesium, total hardness, sodium, potassium, sulphate and nitrate from the values seen at Sitlee water treatment complex and is in accordance to the observations of Wende and Characklis, 1990; Dhanapakiam*et al.*, 1999; Pillai*et al.*, 1999; Jayaraman*et al.*, 2003; Khan *et al.*, 2005. This has its correlation with entry of sewage and sediments into the distribution pipes, through leaks and cracks, dislocation, defective joints, collection of water in i. valve regulator, etc. in the pipes (Pathak, 1969; WHO, 1999; SarmaandBhattacharyya, 2001; Park, 2002). Collection of water at various places and its entry into the pipes may also explain changes in various water quality parameters including BOD and COD.

The concentration of trace metals like iron, copper, zinc, lead and chromium remained below the detection limit of the equipment (0.1 – 0.2 abs. units of air acetylene), in the river Tawi raw water, treated water at Sitlee water treatment complex, Mohallanarayanian, New plots and Bakshinagar, except for iron which was observed at the river Tawi raw water only, during the year 2000 – 2001 / 2001 – 2002.

All the samples of the river Tawi raw water, treated water (sump tank unit) and its three distribution points viz. Mohallanarayanian, New plots and Bakshinagar, during both the years, show Water Quality Index (WQI) less than 50 (Table 8), except in the month of June / August (the river Tawi raw water), April (treated water at Sitlee water treatment complex, 1st year), February (Mohallanarayanian, 2nd year) and April (New plots, 1st year). This is indicative of water quality that is suitable for drinking without causing health problems.

Although WQI and comparison of the various physico-chemical characteristics of water at source, water treatment complex and its three distribution points, with National and International Standards (Tables 6,7) reveals that water is suitable for consumers. However, there is change in water quality in the distribution system. For ensuring standard quality of potable water to the consumers' safety and health, the following recommendations are made to the PHE department for consideration and taking remedial measures on priority:

i. the main distribution pipes, primaries, secondaries and tertiaries should be regularly monitored for any leakages to be plugged on war footing;

ii. since the safe life of GI pipes reportedly is 15 – 20 years and old city has pipe layouts as old as 30 – 50 years, these should be replaced by new layouts. The domestic supply pipes, if found rusted or in bad shape, should be replaced at the cost of the consumers;

iii. the turncock points / valves should be kept leak proof and the holes / pits housing these points should be maintained in such a manner that dirt / dirty water from any source does not enter the pit;

iv. regular monitoring of water quality on daily / weekly basis should be conducted at consumer points, besides the treatment complexes and the intermediate storage points;

v. jumbles of pipes (1/2″ and 3/4″ dia) make a common site in old city. Instead the department should provide single (2″ or 3″ dia) pipes passing along the consumer houses to avoid any leakages, contamination at site;

vi. all the pipes in the old city – which pass through or across municipal drains and even nullahs should be shifted to eliminate chances of sewage contamination through leaky joints;

vii. public stand post, wherever these are on or near the municipal drains, should be suitably relocated;

viii. the water supply should be made regular, with full pressure to eliminate the use of booster pumps, which currently suck not only water, but the impurities of inner film and all the pollutants entrapped therein;

ix. PHE department should establish water testing laboratories at each treatment plant and mini kit laboratories at each intermediary storage points, equipped with most modern equipments and materials, for fool proof testing of water samples. Also these laboratories be manned with technically qualified and trained staff. The department should also coordinate with municipal and health authorities in ensuring a better quality of water supply so that the chances of outbreaks of diseases carried, or borne by water, are minimized.

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