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Physico-chemical characteristics of raw water of River Tawi, near Sitlee water treatment plant, Jammu

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Abstract

The present study was carried out to assess the drinking quality of raw water of the river Tawi, near Sitlee water treatment plant, water characteristics like temperature, turbidity, pH, electrical conductivity, free carbon dioxide, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, carbonate, bicarbonate, chloride, calcium, magnesium, total hardness, sodium, potassium, sulphate, silicate, nitrate, phosphate, iron, copper, zinc, lead and chromium, were conducted for a period of two years. Monthly range of these physico-chemical parameters is within the permissible limits of drinking water standards, except for turbidity and COD, during different months, during both the years.

Keywords:- *Physico-chemical, River Tawi, Sitlee water treatment plant*

Introduction

Water is the basis of life, a universal solvent and one of the most precious commodities required for survival of any form of life (Singh *et al.*, 2006). It is a primary natural resource required for various purposes like agriculture, forestry, urbanization and many other activities which satisfy human needs. Exponential population growth of man and his innate characteristics have brought severe constraints upon the water. Various kinds of natural and manmade activities like industrial, domestic and agriculture and others create water pollution particularly in fresh water systems and render the water unsuitable for consumption and other uses. In order to evaluate the quality of river Tawi water for drinking purposes, present study was undertaken near Sitlee water treatment plant. The river Tawi originates in the middle Himalayas, below Seoj Dhar peak at Kalikund, near Bhaderwah (Fig. 1). From there it passes through Chenani, where its water feeds to Udhampur, Jhindrah, Surinsar, Nagrota and Jammu, where it bifurcates into Nikki Tawi and Badi Tawi and finally meets Chenab in Pakistan and a hydroelectric project. For Jammu, it is a major source of potable water supply as well as through lift irrigation scheme at Bahu for irrigation purposes.

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Materials and Method

Sterilized and clean plastic bottles of 2 litre capacity were used for the collection of water samples for physico-chemical analysis of water by standardized methods (APHA, 1998 and Khanna, 1993). Various trace metals like iron, copper, chromium, zinc and lead were determined by standardized Atomic Absorption Spectrophotometer (ECIL, model 4139). The Water Quality Index was calculated for assessing the suitability of water for drinking purposes (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 various physico-chemical characteristics of water, for a period of two years, have been tabulated in Table-1 and depicted in Figs. 2a–2v.

Due to lotic conditions, water temperature (10.5, January- 31.0 °C, June/ 11.5, January- 30.0 °C, August) closely followed air temperature (9.5, January- 33.5 °C, May/ 10.0, January, February- 34.0 °C, June) and is in accordance with the findings of Negi *et al.* (2008). Seasonally, water temperature remained high during March-October/ March-September and coincided with increased photoperiod. Decreased photoperiod may explain November-

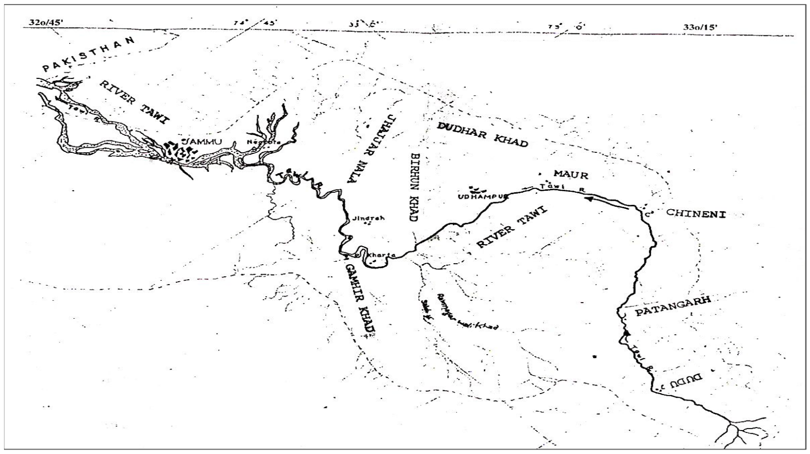

Fig. 1: Map of Tawi river catchment (J&K State)

February/ October-February decrease in water temperature (Dhanapakiam *et al.*, 1999). Turbidity varied between 3.0 (October) and 420.0 NTU (June) / 7.0 (January) and 487.5 NTU (August). It recorded March, May-August/ February, March, May-August increase and is caused by soil erosion during monsoon (June-August) and winter (February, March, 2000-2001/ March, 2001-2002) rains (Table-1).

pH, ranged between 7.83 (June) and 8.51 (November, January)/ 7.36 (June) and 8.35 (February). It remained low in the month of February, April and June/ December, January and May-July, when free carbon dioxide was present. An inverse relationship of pH and free carbon dioxide is already known (Wetzel, 2001) and may explain June lowest record of pH, during both the years, when free carbon dioxide was maximum.

Electrical conductivity fluctuated between 0.162 (April) and 0.475 µS/ cm (August)/ 0.141 (July) and 0.333 µS/ cm (September) and recorded increase from July to October/ August to October increase.

Dissolved oxygen varied between 3.85 (April) and 10.78 mg/l (December)/ 5.36 (May) and 7.82 mg/l (February) and showed winter (December-February/ November-February) increase and summer (March-May) 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, during the year 2001– 2002, varied between 0.19 (February) and 4.91 mg/l (August) and 4.8 (September, October) and 42.0 mg/l (July), respectively. Seasonally, BOD remained comparatively low during post-monsoon (September, October) and winter (November-February) and high during summer (March-May) and monsoon (June-August). COD observed post-monsoon (September, October) and early winter (November, December) low and late winter (December-February), summer (March-May) and monsoon (June-August) high record. 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 (54.90, April - 220.75 mg/l, November / 81.20, June - 204.29 mg/l, September), calcium (16.66, April - 33.94 mg/l, December, 23.64, May - 41.87 mg/l, October), magnesium (4.67, June - 18.86 mg/l, January/ 2.85, April - 22.83 mg/l, October, November) Water Quality Index (WQI) ranged between 29.92 (December) and 154.53 (June) / 43.32 (November)

Table-1 : Monthly variation in physico-chemical parameter at the River Tawi, near Sitlee water treatment plant, Jammu

Months / Parameters	AT (°C)	WT (°C)	Turb. (NTU)	pH	EC (µS/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	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	126	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	26	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	26	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	3.27	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	7.81	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	*	*	*	*	*

Note: A- Absent; NA- Not analysed; *- Below detectable limit and total hardness (63.56, April - 156.24 mg/l, January / 76.47, April- 198.42 mg/l, October) observed post-monsoon (September, October) and winter (November-February) high and summer (March-May) and monsoon (June-August) 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 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. In summer good consumption by primary producers, due to increased photoperiod, may account for low record of these nutrients. In monsoon fluctuation in bicarbonate, calcium, magnesium and total hardness is attributed to the effect of rains and soil erosion in catchment. Due to absence of pollution (sewage / industrial effluents/ agricultural) upstream the present site of analysis, chloride remained low and observed narrow fluctuation between 5.48 (June) and 10.75 mg/l (October)/ 5.42 (August) and 10.46 mg/l (March). Chloride remained comparatively high during summer (March-May) and monsoon (June-August). Sodium fluctuated between 4.5 (October, April) and 19.50 mg/l (February)/ 7.0 (April) and 19.00 mg/l (September) and showed winter (November-February) increase and summer (March-May) decrease. During monsoon (June-August), it recorded wide fluctuations (Table-1). Potassium, during the first year, observed narrow fluctuations between 0.05 (October) and 2.50 mg/l (June, July) and showed monsoon (June and July) highest record. In the subsequent year, it varied from 1.00 (March, April)- 3.50 mg/l (August, September, December, January, June) and showed monsoon (June-August), post-monsoon (September, October) and winter (November-February) increase. Rains may account for the monsoon increase in sodium and potassium.

Sulphate varied from 4.25 (April) - 21.00 mg/l (July)/ 3.00 (May) - 38.50 mg/l (June). It recorded monsoon (June-August), post-monsoon (September, October) and winter (November-February) increase and summer (March-May) decrease, during the first year of study. In the subsequent year, sulphate remained high during early monsoon (June and July) and winter (December-February) and low during late monsoon (August), post-monsoon (September, October), early winter (November) and summer (March-May). Increased flush from springs may account for the post-monsoon increase in sulphate (Hutchinson, 2004). Silicate fluctuated between 2.90 (March) and 9.80 mg/l (July)/ 2.80 (April) and 8.60 mg/l (June) and observed summer (March-May) low and monsoon (June-August), post-monsoon (September, October) and winter (November-February) high record. Monsoon increase may be attributed to the rains. Increased flush from springs may also account for the post-monsoon increase in silicate. Nitrate varied from 0.25 (August – February) and 3.00 mg/l (July) / 0.50 (July) to 3.75 mg/l (June). It remained high during summer (March-May), monsoon (June-August) and post-monsoon (September, October) and low during winter (November-February). Summer increase in nitrate may be due to the decomposition of dead organic matter. Monsoon and post-monsoon increase is attributed to the rains (Jhingran, 1991; Horne and Goldman, 1994). Phosphate fluctuated between 0.02 (December) and 0.30 mg/l (May), / 0.02 (December-February, May) to 0.41 mg/l (March), during the first/ second year of the analysis. It recorded winter (November-February) decrease and summer (March-May) and monsoon (June-August) increase. Summer increase in phosphate is attributed to the environmental temperature, pH of the water (Jhingran, 1991); increased rate of organic decomposition (Hutchinson, 2004). Monsoon increase may be due to the rains (Jhingran, 1991).

Iron was observed in the month of August (0.20), September (0.20), November (0.20), February (0.20) and May (1.00)/ February (0.20), April (0.20) and May (0.20), during the first/second year of study and remained below detectable limit during greater part of the year. Other trace elements like copper, zinc, lead and chromium remained below detectable limit during both the years of study.

Comparison of the various physico-chemical characteristics of water, with National and International Standards (ISI, 1974; ICMR, 1975; BIS, 1991; WHO, 1992) reveals that all the parameters remain within permissible limits of drinking water standards (Table-2) except for turbidity and COD, during different months, during both the years.

Table-2: Comparison of water quality of the river Tawi near Sitlee water treatment complex, Jammu with National and International standards

Parameters↓	River Tawi		Standards						
			WHO		BIS	ICMR		ISI tolerance limit	
	1st year	2nd year	Ac	Al		Ac	Al	Ac	Mp
Turb. (NTU)	3.0 - 420.0	7.0 - 487.5	5	25	5	5	25	10	25
pH	7.83 - 8.51	7.36 - 8.35	7.0 - 8.5	6.5 - 9.2	6.5 - 8.5	7.0 - 8.5	6.5 - 9.2	6.0 - 8.5	6.5 - 9.2
EC (µS/cm)	0.162 - 0.475	0.141 - 0.333	--	300	--	--	300	--	300
FCO_2 (mg/l)	2.38 - 5.29	1.6 - 9.44	--	--	--	--	--	6	--
DO (mg/l)	3.85 - 10.78	5.36 - 7.82	5	--	5	--	--	4	6
BOD (mg/l)	0.25 - 2.2	0.19 - 4.91	3	5	3	--	--	--	
COD (mg/l)	4.8 - 28.8	4.8 - 42.0	10	20	--	--	--	--	
CO_3'' (mg/l)	2.29 - 18.58	2.36 - 11.07	--	--	--	--	--	--	--
HCO_3' (mg/l)	54.9 - 220.75	81.2 - 204.29	30	150	--	--	120	150	300
Cl' (mg/l)	5.48 - 10.75	5.42 - 10.46	250	1000	250	200	1000	250	1000
Ca^{++} (mg/l)	16.66 - 33.94	23.64 - 41.87	75	150	75	75	200	75	200
Mg^{++} (mg/l)	4.64 - 18.86	2.85 - 22.83	50	150	30	50	200	30	150
TH (mg/l)	63.56 - 156.24	76.47 - 198.42	300	600	300	200	600	300	600
Na^{+} (mg/l)	4.5 - 19.5	7.0 - 19.0	175	200	--	--	--	20	--
K^{+} (mg/l)	0.05 - 2.5	1.0 - 3.5	--	--	--	--	--	--	--
SO_4'' (mg/l)	4.25 - 21.0	3.0 - 38.5	200	400	150	200	400	200	400
SiO_3'' (mg/l)	2.9 - 9.8	2.8 - 8.6	--	--	--	--	--	20	
NO_3' (mg/l)	0.25 - 3.0	0.5 - 3.75	50	100	45	20	100	20	50
PO_4''' (mg/l)	0.02 - 0.30	0.02 - 0.41	0.1	1	--	--	--	0.1	
Fe^{+++} (mg/l)	* - 1.0	* - 0.2	0.3	1	0.3	0.1	1.0	0.3	1
Cu^{++} (mg/l)	*	*	1	1.5	--	1.0	3.0	0.05	1.5
Zn^{++} (mg/l)	*	*	5	15	--	5.0	15.0	5.0	10.0
Pb^{++} (mg/l)	*	*	0.05	0.1	--	0.1		0.1	
Cr^{++} (mg/l)	*	*	0.05	--	--	0.05		0.05	

Note: Ac- Acceptable; N- Nill; Al- Allowable; Mp- Maximum permissible

Table-3: Water Quality Index (WQI) of various physico-chemical characteristics at the river Tawi, near Sitlee water treatment complex, Jammu

Months	River Tawi
Aug., 2000	107.79
Sep.	41.36
Oct.	40.79
Nov.	47.21
Dec.	29.92
Jan.	42.28
Feb.	39.38
Mar.	49.7
Apr.	48.62
May	61.9
Jun.	154.53
Jul.	80.15
Aug., 2001	194.02
Sep.	50.63
Oct.	44.46
Nov.	43.32
Dec.	49.93
Jan.	46.02
Feb.	54.25
Mar.	56.93
Apr.	56.71
May	59.94
Jun.	139.34
Jul., 2002	166.61

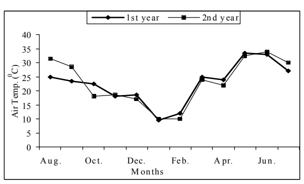

Fig. 2a

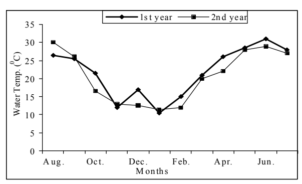

Fig. 2b

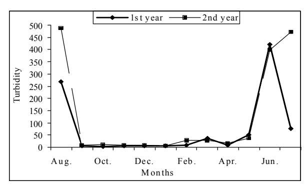

Fig. 2c

Monthly variation in air and water temperature and trbidity of River Tawi

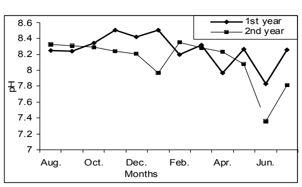

Fig. 2d

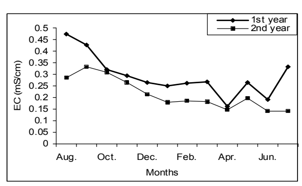

Fig. 2e

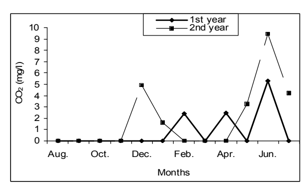

Fig. 2f

Monthly variation in pH, electrical conductivity and free CO_2 of River Tawi

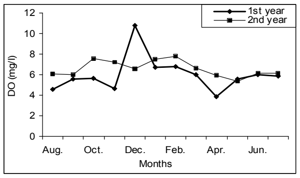

Fig. 2g

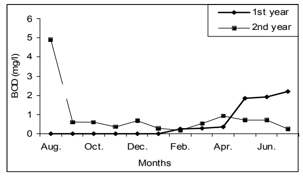

Fig. 2h

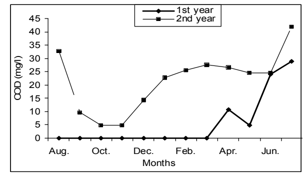

Fig. 2i

Monthly variation in DO, BOD and COD of River Tawi

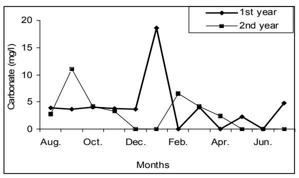

Fig. 2j

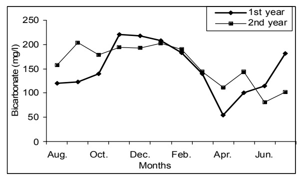

Fig. 2k

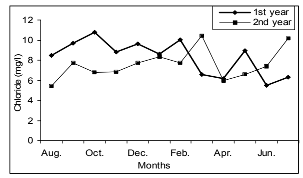

Fig. 2l

Monthly variation in carbonate, bicarbonate and chloride of River Tawi

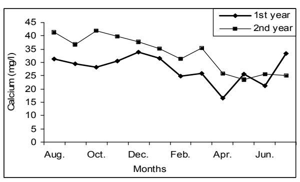

Fig. 2m

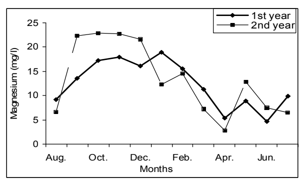

Fig. 2n

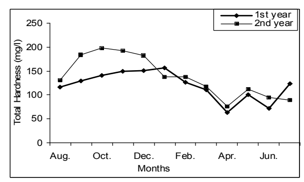

Fig. 2o

Monthly variation in calcium, magnesium and total hardness of River Tawi

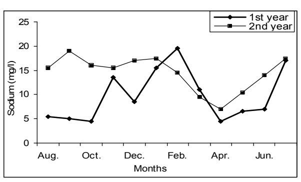

Fig. 2p

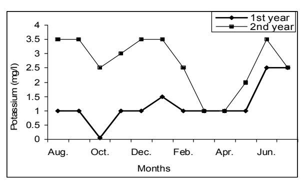

Fig. 2q

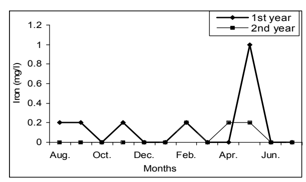

Fig. 2r

Monthly variation in sodium, potassium and iron of River Tawi

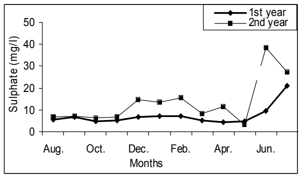

Fig. 2s

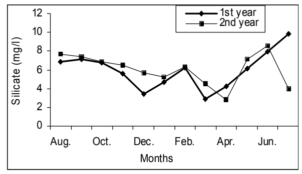

Fig. 2t

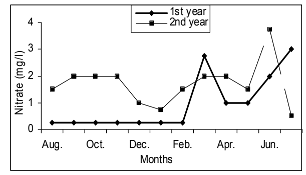

Fig. 2u

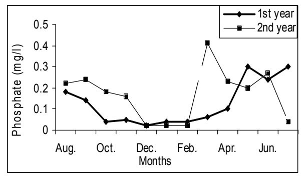

Fig. 2v

Monthly variation in sulphate, silicate, nitrate and phosphate of River Tawi

and 194.02 (August), during the first / second year indicates that raw water is unsuitable (Table-3).

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