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Seasonal Variations of Physico-Chemical Characteristics of River Soan Water at Dhoak Pathan Bridge (Chakwal), Pakistan

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ABSTRACT

The present study was designed to demonstrate the seasonal variations in physico-chemical parameters of River Soan water for a period of ten months from May 2001 to February 2002. Water samples were collected on monthly basis and analyzed for estimation of water temperature, light penetration, surface tension, density, specific gravity, boiling point, turbidity, pH, dissolved oxygen, free CO_2, alkalinity, acidity, carbonates, bicarbonates, total solids, total dissolved solids and total dissolved volatile solids. Air temperature, clouds and rain were also recorded. These parameters were compared with water quality standards to indicate probable pollution in the river Soan. The overall water quality of the study site remained with in the safe limits through out the study period. An attempt has been made to explain the effect of seasonal changes on physico-chemical characteristics of river Soan water.

Key Words: Seasonal variations; Physico-chemical characteristics; River Soan

INTRODUCTION

Soan is a seasonal river of Punjab. It originates from Murree hills, passes near Rawalpindi, Fateh Jung, Pindi Ghab, Talagang, Mianwali and finally falls in the Indus River near Kalla Bagh. Water of Soan is used for drinking and irrigation purposes in Potohar region of Punjab.

Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties. Any characteristic of water that effects the survival, reproduction, growth and production of aquaculture species, influences management decisions, causes environmental impacts or reduces product quality and safety can be considered a water quality variable. Other factors being the same, aquaculture species will be healthier, production will be more, environmental impacts will be less and quality better in culture systems with “good” water quality than in those with “poor” water quality (Chhatawal, 1998).

Water quality provides current information about the concentration of various solutes at a given place and time. Water quality parameters provide the basis for judging the suitability of water for its designated uses and to improve existing conditions. For optimum development and management for the beneficial uses, current information is needed which is provided by water quality programmes (Lloyd, 1992). Unequal distribution of water on the surface of the earth and fast declining availability of useable fresh water are the major concerns in terms of water quantity and quality (Boyd & Tucker, 1998).

Rivers and lakes are very important part of our natural heritage. They have been widely utilized by mankind over the centuries, to the extent that very few, if any are now in a natural condition (Leonard, 1971). A continuous monitoring of water quality is very essential to determine the state of pollution in our rivers. This information is important to be communicated to the general public and the Government in order to develop policies for the conservation of the precious fresh water resources (Ali *et al*., 2000). Present study was designed to monitor seasonal variation in water quality parameter to investigate limiting factors, which could adversely affect the plants and animals, including fish production in this important river.

MATERIALS AND METHODS

In the present study, seasonal variations in physical and chemical parameters of River Soan were studied at Dhoak Pathan Bridge about 25 km from Talagang, district Chakwal. The sampling started on 21st May 2001 and continued up to February 22, 2002. The study period consisted of ten months. The samples were taken from below the water in plastic bottles of 1.5 L capacity on monthly basis. At the time of sampling, the air and water temperatures were recorded by using alcohalic bulb and digital thermometers. Light penetration was recorded with the help of Secchi’s disk. Dissolved oxygen was determined by using an oxygen meter (Jenway Model 9071). pH and conductivity were determined by using digital pH and conductivity meter (Model WTW-pH 90). While all other parameters were determined by the methods as described by Boyd and Tucker (1998). These parameters were compared with water quality standards to indicators to indicate probable pollution in river water.

RESULTS

The overall range in air temperature observed was 18-38^{o}C while the water temperature was minimum (12^{o}C) in November and maximum (31^{o}C) in May (Table I). The lowest light penetration was observed in May and July (1.2 cm) and the highest value was observed in December (20.9 cm) showing the winter season. The maximum boiling point (98^{o}C) was observed in September, December and February and minimum (95^{o}C) in October. Clouds were 25% in the months of October and January, 50% in August while there was no clouds in all other months during sampling dates. No rain was observed at sampling site through out the study period during the sampling dates. Maximum water density (1.022 g/mL) was observed in the month of June while the minimum value was observed in July (0.992 g/mL). The maximum specific gravity (1.025) was observed in June and minimum (0.796) in September. The minimum turbidity (0.02 mg/L) was observed in December while maximum (0.48 mg/L^{1}) in July indicating flooding and raining in this month. The lowest viscosity (0.857 mNS/m^{2}) was observed in February and maximum viscosity (1.0572 mNS/m^{2}) was observed in June. The minimum (69.28 dynes cm^{-1}) value of surface tension was observed in February while maximum (72.63 dynes cm^{-1}) in May (Table I).

The monthly variation in pH ranged between 8.0-9.0. The maximum value (9.0) was observed in August and minimum value (8.0) in months of June, July, September, October and November. The maximum electric conductivity (19 mv) was observed in June and minimum (7 mv) in August. The maximum dissolved oxygen (9.3 mg L^{-1}) was observed in December and minimum value (4.6 mg l^{-1}) in February. The maximum alkalinity (36 mg L^{-1}) was observed in February while minimum value (19 mg L^{-1}) was observed in August. The maximum acidity (2 mg L^{-1}) was observed in two months, July and February, while the minimum value (1 mg L^{-1}) in the water of three months, May, August and September. The carbonates in Soan River were below detectable limits. The maximum bicarbonates (34.2 mg L^{-1}) were observed in January while minimum value (19 mg L^{-1}) was observed in August. The maximum total solids (4.24 mg L^{-1}) were observed in July while minimum value (0.56 mg L^{-1}) was observed in September. The maximum total dissolved solids were observed (4.43 mg L^{-1}) in June and minimum (0.53 mg L^{-1}) in October. The maximum total volatile solids (0.29 mg L^{-1}) were observed in June and minimum (0.29 mg L^{-1}) in November (Table I).

DISCUSSION

Fresh water environments, unlike the marine ones, are subjected to variations in the environmental factors such as temperature, dissolved oxygen, light penetration, turbidity, density, etc. These factors are responsible for distribution of organisms in different fresh water habitats according to their adaptations, which allow them to survive in that specific habitat (Jaffries & Mills, 1990). The dispersal of a fish, therefore, depends entirely on its facility to accommodate itself to a variety of physical conditions and degree of vitality by which it is enable to survive under more or less sudden changes (Ali, 1999). The importance of study site is that it is a famous site for the fossils and is located in Potohar region. This is also the first study on seasonal variations in physical and chemical parameters of River Soan at any site.

Temperature fluctuations, both diurnal and seasonal, are more evident in fresh water habitats. Flowing waters, however, lack wide fluctuations in temperature (Leonard, 1971). Air temperature was maximum in June while water temperature was maximum in May and then both had a

Table I. Seasonal variation of physical and chemical properties of river Soan at Dhoak Pathan Bridge

Parameters	May 2001	June	July	Aug	Sep	Oct	Nov	Dec. 2001	Jan. 2002	Feb. 2002
Water Temperature (^{0}C)	31	29.5	26.5	29.9	24	20	12	9	14.5	17
Conductivity (mv)	9	19	11	7	9	13	10	18	14	11
PH	8.2	8	8	9	8	8	8	8.5	8.5	8.2
Dissolved O_2 (mg L^{-1})	6.7	6.1	6.8	6.9	7.4	8.1	8.6	9.3	5.1	4.6
Turbidity (mg L^{-1})	0.05	0.41	0.48	0.03	0.05	0.03	0.03	0.02	0.04	0.06
Alkalinity (mg L^{-1})	29.6	32.4	22.4	19	19.4	20.6	31.6	25.8	34.2	36
Acidity (mg L^{-1})	1	1.5	2	1.1	1	1.8	1.2	1.5	1.8	2
Viscosity (mNS/m^{2})	0.9358	1.0572	0.9774	0.9813	0.9578	0.9823	0.9506	0.9126	0.8872	0.8570
Density (mg L^{-1})	0.9804	1.022	0.992	0.996	0.994	0.997	0.996	0.988	1.017	1.014
Specfic gravity	0.983	1.025	0.995	0.999	0.796	0.999	0.999	0.990	1.014	1.020
Light penetration (cm)	1.2	2.4	1.2	1.4	7.3	11.2	20.2	20.9	22.3	18.7
Boiling point (^{0}C)	96	97	96	97	98	95	97	98	97	98
Surface tension (dynes cm^{-1})	72.63	71.37	71.02	70.78	71.23	70	69.35	71.35	70.54	69.28
Rain	0	0	0	0	0	0	0	0	0	0
Clouds %	0	0	0	50	0	25	0	0	25	0
Carbonates (mg L^{-1})	0	0	0	0	0	0	0	0	0	0
Bicarbonates (mg L^{-1})	29.6	32.4	22.4	19	19.4	20.6	31.6	25.8	34.2	36
Total solids (mg L^{-1})	0.83	4.24	2.24	1.11	0.56	0.62	0.67	0.78	0.93	0.98
TDS (mg L^{-1})	0.81	4.83	0.90	0.55	0.58	0.53	0.63	0.71	0.76	0.80
TVS (mg L^{-1})	0.14	0.29	0.021	0.14	0.06	0.09	0.05	0.07	0.09	0.12

Table II. Safe water quality standards. (Boyd & Tucker, 1998; Ali *et al.*, 2000)

Parameters	Safe Levels
Turbidity	Water with less than 2.5mg/liter turbidity may have 12.8 times more plankton and 5.5 times more fish production than in waters with a turbidity exceeding 100mg/liter.
Electric Conductivity	Maximum acceptable electric conduction for irrigation purpose is 1.25 m.mhos. /cm. It is proportional to total dissolved solids. Natural waters have electric conductivity between 20-1500m.mhos/cm. EC above 400m. mhos/cm does not limit productivity but productivity does not increase with increasing EC.
pH	The pH range for diverse fish production is 6.5-9, for irrigation purpose is 6.0-8.2. 4.0 acid death point, 4.0-5.0 no reproduction, 4.0-6.5 slow growth, 11.0 alkaline death point.
Dissolve Oxygen	Minimum acceptable level is 5.0 mg/liter for reproduction of desirable fish. 0.0 mg/liter small fish survive- short exposure, 0.3-1.0 mg/liter lethal if exposure is prolonged, and 3.5mg/liter fatal to several fish species within 20 hours.
Alkalinity	0.0-0.2 mg/liter low fish production 20-40 mg/liter medium fish production 40-90 mg/liter high fish production Less than 10 mg/liter rarely produce large carps.
Acidity	Low pH (Below 4.5) High Acidity High pH (Above 8.0) Low Acidity Fish production increases when acid waters are limed to increase total alkalinity above 20mg/liter.
Total Hardness	More than 15mg/liter is suitable for fish growth. Less than 15 mg/liter cause slow growth of fish and require liming for high fish production. Less than 5 mg/liter hardness causes death of fish.
Total Solids	Waters with less than 2.5 mg/liter of total solids cause 5.5 time more production of fish than the waters with total solids exceeding 100 mg/liter.
Total dissolved solids	Represents total mineral contents, which may or may not be toxic. Low total dissolved solids indicate enough fish diversity while maximum of 400mg/liter is required for maximum fish diversity.
Light penetration	Light penetration has inverse relationship with turbidity. Waters with less than 2.5 mg/liter turbidity show more light penetration, 12.8 times more planktons and 5.5 times more fish production. While the waters with turbidity exceeding 100mg/liter have low light penetration and fish production. Good waters Light penetration above 600mm. Satisfactory Light penetration above 300mm. Poor waters Light penetration above 100mm.
Carbonates and Bicarbonates	Their presence in water restores the equilibrium, prevents wide variations in pH of water and does not allow dropping below 4.5 and rising above 8.3.

decreasing trend till December in present study.

Photoperiod was shorter in winter than summer. Photoperiod is directly related to temperature (Odum, 1971). Photoperiod and temperature, both were maximum in June. Dissolved oxygen also showed negative relationship with temperature and photoperiod. When the photoperiod was minimum (10.25 h), D.O. was maximum (9.3 mg/L) and when the photoperiod was maximum (14.08 h), D.O. was minimum (4.6 mg/L). This low level of D.O. is slightly lower than safe limits, which is 5mg/L. The possible reason is that the water level in this month was low as Soan is a seasonal river.

The minimum value of turbidity (0.02 mg/L) was observed in December and highest value (0.48 mg/L) in July showing floods and rains at various places from where river Soan passes, which brings clay, sand and organic matter from adjoining areas of the river. After July, there was a rapid decrease in water turbidity. Turbidity showed an inverse relationship with light penetration. When turbidity was low, light penetration was high and when turbidity was high light penetration was low. Salam and Rizvi (1999) and Ali *et al.* (2000) reached the same results while working on River Chenab and Rachna Doaab respectively.

Cloud cover was 25% in October and January and 50% in August while they were totally absent in other months during the study period. Rainfall was not observed during the sampling dates, which is far less than the annual rainfall of the study area, predicting a drought.

Boiling point of river Soan was maximum (98^{o}C) in September, December and February and minimum (95 ^{o} C) in October. The boiling point of water rises due to presence of total solids, total dissolved solids and total volatile solids (Lloyd, 1992).

Density of river varies at different sites and different times. These differences may be due to variations in temperature and salt concentration of water. There are fluctuations in water density with increase or decrease in total dissolved solids. The change in density due to temperature fluctuations is more important. Specific gravity and density are related with each other (Schwoerbel, 1987).

Surface tension of water varies with temperature and with the contents of dissolved solids (Odum, 1971). Therefore in the present study, it showed relationships with dissolve solids and water temperature. Higher values of surface tension were observed in months with higher values of temperature and dissolved solids.

Viscosity was increasing with relation to solids present in water. More the solids, more the viscosity of water was observed. In the present study, the maximum value of viscosity was observed in the month of June when the dissolved solids were also maximum.

The pH of water is important because many biological activities can occur only within a narrow range. Thus, any variation beyond acceptable range could be fatal to a particular organism. The favorable range of pH 6.5-9.0 at daybreak, are suitable for fish production (Chhatawal, 1998). pH range in the present the study was 8.0-9.0 touching the upper limit of favorable range, which indicates that water is suitable for fish production.

Dissolved oxygen showed maximum values in winter season. It may be due to temperature variations. Dissolved oxygen showed inverse relationship with water temperature (Ali, 1999). Similar type of results were observed in present study as dissolved oxygen decreased with increase in temperature. Dissolved oxygen also had an inverse relationship with photoperiod. When the photoperiod was long, the dissolve oxygen value was low and when photoperiod was short, dissolved oxygen value was high. Ali *et al.* (2000) and Chaudhry *et al.* (1990) also arrived at the same conclusion.

Several factors influence the conductivity including temperature, ionic mobility and ionic valencies. In turn, conductivity provides a rapid mean of obtaining approximate knowledge of total dissolved solids concentration and salinity of water sample (Odum, 1971).

Brown (1993) reported that total hardness acts as limiting factor for alkalinity. Calcareous water with alkalinity more than 50 ppm is most productive, zero-20ppm for low production, 20-40 ppm for medium production and 40-90 ppm for higher production. Carbonates and bicarbonates in hydroxides of Ca, Mg, Na, K, NH_4 and Fe generally cause alkalinity of natural fresh water. Carbonates and bicarbonates are the major components of alkalinity; they have positive correlation with alkalinity.

In natural unpolluted waters, the acidity is mainly contributed by dissolved CO_2. In polluted waters, weak acids like CH_3COOH may contribute significantly to the total acidity. In some organic waters, organic acids also contribute to acidity (Brown, 1993). In present study, both alkalinity and acidity were with in the safe limits (Table II).

Total solids showed a positive increasing trend with season showing peak in June. Total solids also showed a positive correlation with turbidity as observed by other authors (Chaudhary *et al*., 1990; Salam & Rizvi, 1999). Total dissolved solids indicate the total amount of inorganic chemicals in solution. The portion of dissolved solids has carbonates, bicarbonates, sulphates and chlorides of sodium and calcium. A maximum value of 400 mg L^{-1} of total dissolved solids is permissible for diverse fish population (Chhatwal, 1998). Total dissolved and total volatile solids showed seasonal fluctuations through out the study period.

The overall water quality of the study site remained within the safe limits throughout ten months of study period (Table II), which shows that water of Soan is fit to support biodiversity. Definitely more studies are required at different sites of river Soan to compare the water quality of river at different time and places.

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