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STUDIES ON THE EFFECT OF SEASONAL VARIATIONS ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF MIXED WATER FROM RIVERS RAVI AND CHENAB AT UNION SITE IN PAKISTAN

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Abstract: The present study was designed to demonstrate the seasonal variations in physico-chemical parameters of mixed water of Rivers Ravi and Chenab, for a period of ten months from February to November 2000. Water samples were collected on monthly basis and have been analyzed for estimation of Water temperature, Light penetration, Surface tension Density, Specific gravity, Boiling point, Turbidity, pH, D.O., Free CO_2, Alkalinity, Acidity, Electric conductivity, Carbonates, Bicarbonates, Total Solids, Total Volatile Solids, Total Dissolved Solids, Total Volatile Dissolved Solids. Air temperature, rain and clouds were also recorded. These parameters were compared with standard water quality indicators to indicate probable pollution in mixed water. The overall water quality of the study site remained within the safe limits throughout the study period. An attempt has been made to explain the effect of seasonal changes on physico-chemical characteristics of mixed water of Rivers Ravi and Chenab.

***Key words*:** *Seasonal variations, physico-chemical, characteristics, Ravi, Chenab*

INTRODUCTION

Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties[1]. Any characteristic of water in production systems that effects survival, reproduction, growth and production of aquaculture species, influences management decisions, causes environmental impacts or reduces product quality and safety which can be considered a water quality variable. Other factors being equal, aquaculture species will be healthier, production will be more efficient, environmental impacts less and quality better in culture systems with "good" water quality than in those with "poor" water quality[2].

Water quality provides current information on concentration of various parameters at a given place and time. Water quality principles furnish the basis for judging the suitability of water for its designated uses and for improving existing conditions. For optimum development and management of water for the beneficial uses, current information is needed which is provided by water quality programs. The unequal distribution of water on the surface of earth and the fast declining availability of useable fresh water, are the major concerns in terms of water quantity and quality [1].

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 natural condition [3]. The continuous monitoring of the river's water quality is very essential to determine the state of pollution in our rivers. This information is important to communicate to general public and the Government in order to develop the policies for the conservation of the most important natural freshwater resources.

MATERIALS AND METHODS

The present study was conducted at the union site of Rivers Ravi and Chenab (Rachna Doaab) at Bakar Pur, Kabirwala nearly 100Km away from Multan (Fig. 1). The sampling started from 27th February 2000 and continued up to 30th November, 2000. The study period consisted of 10 months. The samples were taken from the subsurface in plastic bottles of 1.5litre capacity on monthly basis. At the time of sampling the air and water temperatures were recorded by using

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alcoholic 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 was determined by using digital pH meter (Model WTW-pH 90). While all other parameters were determined by the methods as described by Boyd [4] , APHA [5] , Boyd & Tucker[2].

These parameters were compared with standard water quality indicators to indicate probable pollution in mixed water. An attempt has been made to explain the effect of seasonal changes on physico-chemical characteristics of mixed water of Rivers Ravi and Chenab.

RESULTS

The summary of the results is given in Table 1.

The water temperature was 10.5˚Cin November as compared to 33.0˚C in August. The lowest light penetration (3cm) was observed in July and the highest value (27cm) in February showing the flooding and rainy summer season. The maximum boiling point (96.0˚C) was observed in February and May and minimum (93.5˚C) was observed in July. Clouds were 25% in the month of March, less than 25% in August while the clouds were totally absent in other months during the sampling dates. Rain was not observed through out the study period during the sampling dates. Maximum density (1.0177gm/ml) was observed in the month of May while the minimum value (1.0149 gm/ml) was observed in March. The maximum specific gravity (1.0275) was observed in May and the minimum value (1.0179) in March. The minimum turbidity (0.063mg/litre) was observed in February while the maximum turbidity (1.213mg/litre) in July showing the flooding and raining in this month. The turbidity showed seasonal variations. The lowest viscosity (0.6887mNS/m^2) was observed in October and the highest value (0.0788mNS/m^2) in July. The minimum value of surface tension was observed in the month of March (66.1603dynes/cm) and maximum in May (73.6375dynes/cm).

The monthly variation in pH ranged between 8.0-9.0. The maximum value (9.0) was observed in August and the minimum value (8.0) in the months; June, July, September, October and November. The maximum electric conductivity (18mV) was observed in February and minimum (07mV) in August. The maximum dissolved oxygen (9.1mg/litre) was observed in November and the minimum value (4.6mg/litre) in February. D.O. almost gradually increased up to July and then decreased in August. The value again increased in September. It declined in October but again increased in November reaching its maximum value showing a relationship with free CO_2. The maximum CO_2 (4.95mg/litre) was observed in February and the minimum value (1.98mg/litre) was observed in June, August and November. It showed direct relationship with dissolved oxygen. The maximum alkalinity (40mg/litre) was observed in April and October while minimum value (28mg/litre) was observed in June. The maximum acidity (2.0mg/litre) was observed in three months; February, April and July while the minimum value (1.0mg/litre) in four months; May, August, September and November. The maximum carbonates (4.0mg/litre) were observed in May to nil in September and November. The value increased gradually from February to May then decreased from June to November showing the seasonal fluctuations. The maximum bicarbonates (38mg/litre) was observed in October and the minimum value (26mg/litre) in June. The maximum hardness (348.50mg/litre as $CaCO_3$) was observed in May and minimum value (212.21mg/litre as $CaCO_3$) in September. The maximum total solids (1.46mg/litre) were observed in July while the minimum (0.21mg/litre) in September. The values showed the seasonal fluctuations throughout the study period. The maximum (Total Volatile solids) T.V.S. (0.10mg/litre) was observed in October and the minimum value (0.01mg/litre) in July. The maximum (Total Dissolved Solids) T.D.S. (0.65mg/litre) was observed in October and minimum value (0.25mg/litre) in May. The maximum (Total Volatile Dissolved Solids) T.V.D.S. (0.36mg/litre) was observed in October

and minimum value (0.03mg/litre) was in February.

DISCUSSION

Fresh water environments, unlike the marine ones, are subjected to variations in the environmental factors such as temperature, dissolved gases, light penetration, density, turbidity [6] etc. These factors are responsible for the distribution of organisms in different fresh water habitats according to their adaptations, which allow them to survive in that specific habitat [7,8]. The dispersal of a fish, therefore, depends entirely on its facility to accommodate itself to a variety of physical conditions and the degree of vitality by which it is enable to survive under more or less sudden changes [9]. The study site is very important ecologically because of the fact that the two major rivers combine at this point. River Ravi runs through most populated and industrialized region, therefore heavily polluted by industrial effluents and urbanization [10,11]. Chenab passes through less industrialized and urbanized areas. So it is interesting to study the impact of water from river Ravi on the quality of Chenab water at site of their union.

Temperature fluctuations, both diurnal and seasonal, are more evident in fresh water habitats. Flowing waters, however, lack wide fluctuations in temperature. Air temperature showed an increasing trend reaching maximum in April, June and August while water temperature was maximum in August and then both had a decreasing trend till November in the present study.

In winter, the photoperiod was shorter than summer. Photoperiod is directly related to temperature [12]. Photoperiod and temperature, both were maximum in June. D.O. also showed negative relationship with the temperature and photoperiod. When the photoperiod was minimum (10:25 hours), D.O. was maximum (9.1mg/litre) and when the photoperiod was maximum (14:08 hours), DO was less (4.6mg/litre). This level is slightly lower than safe limits which is 5mg/l. The possible reason is that the water level in this month was low and the discharge of effluents might be very high.

The minimum value (0.063mg/litre) of turbidity was observed in February and highest value (1.213mg/litre) in July showing floods and rains in this month which bring clay, sand and organic matter from the adjoining areas of both the rivers. After the month of July, the turbidity decreased gradually. Turbidity showed an inverse relationship with the light penetration. When turbidity was low, light penetration was high and when the turbidity was high, light penetration was low. Salam and Rizvi [13] reached the same conclusion while working on River Chenab at Chenab Bridge, Muzaffargarh.

Cloud cover remained 25% only in March and less than 25% in July 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 mixed water of River Ravi and River Chenab was maximum (96.0˚C) in February and May and minimum (93.5˚C) in July. The boiling point of water rises due to the presence of total solids, total dissolved solids and suspended solids.

Density of river water varies at different sites and at different times. These differences may be due to variations in temperature and salt content of the water [14]. There is a linear increase in water density with increase in dissolved solids. The change in water density due to temperature fluctuations is more important [7]. Specific gravity and density are related with each other [9].

Surface tension of water varies with temperature and with the content of dissolved solids [15]. Therefore in the present study, it showed relationship with the solids dissolved in water and had higher values in those months.

Viscosity was increasing with relation to solids present in water. More the solids more the viscosity of water was observed. In present study the maximum value of viscosity was observed in the month of July when the dissolved solids were also more 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 [8]. The favorable range of pH is 6.5-9.0 at daybreak, are most suitable for fish production [2]. pH range in the present 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 [4]. Similar types of results were observed in the present study as dissolved oxygen decreased with increase in temperature. D.O. also had an inverse relationship with photoperiod. When the photoperiod was long dissolved oxygen value was low and when photoperiod was short the dissolved oxygen value was high. Ali *et al*., [17] and Chaudhry *et al*., [18] also arrived at the same conclusion.

The presence of free CO_2 during the whole study period may be due to pH range 8.0-9.0 [4]. The water having less than 9.0pH value has free CO_2 and it is evident from the present results that pH remained in this range throughout the study period. The values of free CO_2 showed an inverse relationship with DO during the present study. This may be due to the fact that at high temperature productivity decreases and process of decomposition results in the production of CO_2 in the surrounding water. Most species survive in water containing up to 60mg/litre of free CO_2 [4].

Several factors influence the conductivity including temperature, ionic mobility and ionic valencies. In turn, conductivity provides a rapid means of obtaining approximate knowledge of total dissolved solids concentration and salinity of water sample [18].

Brown [19] reported that total hardness acts as limiting factor for alkalinity. Calcareous water with alkalinity more than 50ppm is most productive, 0.0-20ppm for low production, 20-40ppm for medium and 40-90ppm for higher production. All the ponds above 90ppm of total alkalinity have been found to be productive [20]. Alkalinity of a natural fresh water is generally caused by carbonates and bicarbonates in hydroxides of Ca^{++}, Mg^{++}, Na^{+}, K^{+}, NH_4^{+} and Fe^{++}. Carbonates and bicarbonates are the major components of alkalinity. They have positive correlation with the alkalinity [20].

In natural unpolluted waters, the acidity is mainly contributed by the dissolved CO_2. In polluted waters, weak acids like CH_3COOH may contribute significantly to the total acidity. In some industrial waters, organic acids may also contribute to the acidity [21] .In present study both alkalinity and acidity were within the safe limits (Table2).

Hardness is due to soluble calcium and magnesium salts present in water medium, which is expressed in $CaCO_3$ equivalent [20] A pond water having a hardness of 15ppm or above is satisfactory for growth of fish and do not require addition of lime but water having less than 11ppm require liming for higher production of fish [20]. Therefore it is concluded that the water in the present study falls in satisfactory condition for the growth of fish [22].

Total solids showed a positive increasing trend with season showing peak in July. Total solids also showed a positive correlation with turbidity as observed by [23] . Total dissolved solids indicate the total amount of inorganic chemicals in solution. The portion of the dissolved solids has carbonates, bicarbonates, sulphates and chlorides of sodium and calcium. A maximum value of 400mg/litre of TDS is permissible for diverse fish population [24] . Total volatile solids and total volatile dissolved solids showed seasonal fluctuations through out the study period.

The overall water quality of the study site remained within the safe limits throughout the ten months of study period (see Table 2) which shows that the mixed water is fit to support biodiversity. Definitely more studies are required to compare the water quality of both rivers before and after union.

TABLE 1: SEASONAL VARIATION OF PHYSICAL AND CHEMICAL PROPERTIES OF MIXED WATER OF RAVI AND CHENAB RIVER AT BAKIRPUR KABIRWALA (SITE OF UNION)

Parameters	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov
Water Temperature(^{0}C)	17.5	25	28	31	31	32	33	28	25	10.5
Conductivity (mV)	18	14	11	9	19	11	7	9	13	10
PH	8.5	8.5	8.2	8.2	8	8	9	8	8	8
Dissolved O_2 (mg/l)	4.6	5.1	6.1	5.4	7	7.3	6.7	9	8.4	9.1
Turbidity (mg/l)	0.063	0.093	0.143	0.395	0.413	1.213	0.292	0.16	0.32	0.18
Alkalinity (mg/l)	36	38	40	34	28	34	34	30	40	30
Hardness (mg/l)	313.7	336.5	352.4	348.5	275.7	224.5	217.0	212.2	343.3	246.6
Carbonates (mg/l)	2	2	3	4	2	3	3	0	2	0
Bi-carbonates (mg/l)	34	36	37	30	26	31	31	30	38	30
Acidity (mg/l)	2	1.5	2	1	1.5	2	1	1	1.8	1
Viscocity (mNS/m^2)	0.7725	0.7806	0.7479	0.6979	0.7530	0.7879	0.7099	0.7721	0.6880	0.6946
TDS (mg/l)	0.37	0.6	0.41	0.25	0.32	0.32	0.38	0.32	0.65	0.32
TVS (mg/l)	0.02	0.02	0.01	0.02	0.06	0.08	0.06	0.07	0.1	0.05
Clouds %	0	25	0	0	0	0	25	0	0	0
Rain	0	0	0	0	0	0	0	0	0	0
Density (mg/l)	1.0173	1.0149	1.0164	1.0177	1.0177	1.0169	1.0167	1.0168	1.0168	1.0171
Specific Gravity	1.0203	1.0179	1.0194	1.0208	1.0207	1.0199	1.0197	1.0198	1.0198	1.0202
Surface Tension (dynes/cm)	68.2801	66.1603	73.0293	73.6375	73.1227	71.0575	70.5561	70.5631	71.7914	73.3392
Dissolved CO_2 (mg/l)	4.95	3.96	3.96	3.96	1.98	2.97	1.98	3.96	3.56	1.98
Boiling Point (^{o}C)	96	94	95	96	94	93.5	94	94	95	95

Table 2: Safe Water quality standards.

Parameters	Safe Levels	
Turbidity	Waters with less than 2.5mg/litre turbidity may have 12.8 times more plankton and 5.5 times more fish production than waters with a turbidity exceeding 100mg/litre [18].	
Electric Conductivity	Maximum acceptable electric conductivity for irrigation purpose is 1.25m.mhos/cm. It is proportional to total dissolved solids. Natural waters normally has EC 20-1500 umhos/cm. EC above 400umhos/cm does not limit productivity but productivity does not increase proportionally with conductivity [4].	
PH	pH range for diverse fish production is 6.5-9.0, for irrigation purpose its range 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 [5].	
DO_2	Minimum acceptable level is 5.0mg/litre for reproduction of desirable fish. 0.0mg/litre Small fish survive – short exposure, 0.3-1.0mg/litre Lethal if exposure is prolonged, 3.5mg/litre Fatal to several species of fish within 20 hours [4].	
Free CO_2	At high photosynthetic activity pH increases in water. Therefore, appreciable amount of CO_2 does not occur in water with a pH above 8.34. It has inverse relationship with DO_2. Most species survive containing 0.00mg/litre – 60mg/litre of free CO_2 [4].	
Alkalinity	0.0-2.0mg/litre 20mg/litre-40mg/litre 40mg/litre-90mg/litre Less than 10ppm rarely produce large crops	Low production of fish Medium production of fish High production of fish[5]
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/litre [5].	
Total Hardness	More than 15mg/litre is satisfactory for growth of fish. Less than 15mg/litre cause slow growth of fish and require liming for higher fish production. Less than 5mg/litre cause death of fish [20]	
Total Solids	Waters with less than 2.5mg/litre of total solids cause 5.5 times more production of fish than the waters with total solids exceeding 100mg/litre [18].	
Total Dissolved Solids	Represents total mineral content which may or may not be toxic. Low total dissolved solids indicate enough fish diversity while a maximum of 400mg/litre for diverse population [4].	
Light Penetration	Light penetration has inverse relationship with turbidity. Waters with less than 2.5mg/litre turbidity show more light penetration, 12.8 times more plankton and 5.5 times more fish production. While the waters with turbidity exceeding 100 mg/litre have low light penetration and low fish production . [18] Good waters Light penetration above 600mm, Satisfactory Light penetration above 300mm, Poor waters Light penetration above 100mm [8]	
Carbonates & Bicarbonates	Their presence in waters restore the equilibrium, prevent wide variations in pH of water and does not allow to drop below 4.5 and rise above 8.3 [14].	

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