Monthly variations in physicochemical parameters of a flood plain reservoir on River Ravi near Balloki Headworks (Pakistan)

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ABSTRACT

Monthly variations of different physicochemical parameters of water of a flood plain reservoir on River Ravi near Balloki Headworks were studied. Atmospheric temperature ranged from 16.62 to 40.32 (°C). Water temperature ranged from 14.15 to 33.89 (°C). pH ranged from 6.82 to 8.53, dissolved oxygen from 5.00 to 9.46 (mg/l), electrical conductivity from 232.76 to 330 (µS/cm), total dissolved solids from 148.96 to 211.20 (mg/l), turbidity from 4.62 to 63.70 (NTU), visibility from 30.48 to 150 (cm), total hardness from 120 to 160 (mg/l), total alkalinity from 100 to 119 (mg/l) and chlorides ranged from 20.0 to 34.93 (mg/l).

Key words: Physicochemical parameters, flood plain, River Ravi, monthly variations, Balloki Headworks.

INTRODUCTION

Rivers and reservoirs play a major role in agricultural, fishery and electricity production along with the use of water for drinking purposes. Several factors which determine the water quality of a reservoir includes seasonal climatic changes (Chapman, 1996; Barik et al., 2010), seasonal precipitation, wind action, geologic origin of the catchment basin and pattern of hydrological cycle prevalent in the dam (Tundisi & Straskraba, 1999). Several limnological parameters such as conductivity, total dissolved solids, phytoplankton and reservoir morphometry have been used in estimating potential fish yields from reservoirs. Several physicochemical or biological factors, in suitable range, help in increased activities and growth for aquatic animals. On the other hand, some factors exert stress and adversely affect growth and reproduction of different animals (Iwama et al., 2000). Studies on water quality mostly centre on fish production and aquatic biotic integrity (Boyd, 1982; Aboweyere, 1990; King, 1998). Therefore, protection of water quality is very important issue so it should be kept within acceptable range (Quyang et al., 2006).

Limnology covers the biological, chemical, physical, geological, and other attributes of inland waters including rivers, streams, wetlands, lakes, ponds and springs pools etc. It is an interdisciplinary science which deals with the detailed field as well as laboratory studies to understand the structural and functional aspects and suggest solution to all the problems associated with the freshwater environment (Adoni et al., 1985).

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Water quality assessment generally involves analysis of physico-chemical, biological and microbiological parameters and addresses abiotic and biotic status of the ecosystem (IAAB, 1998; Kulshrestha and Sharma, 2006; Mulani et al., 2009).

Recently, lot of work has been done on fresh water reservoirs and changing ecological behavior of reservoirs, ponds and dams (Mirza et al., 2013; Sulehria et al., 2012; Sulehria & Malik, 2012; Janjua et al., 2009; Sulehria et al., 2009a, 2009b; Malik & Sulehria, 2004;).

Temperature is one of the major factors affecting freshwater ecosystems, temporal and spatial distribution of organisms. Invertebrates are most sensitive to changes in temperature. In a shallow pond there could be a substantial increase in temperature over a diurnal period with cooling at night. The upper region of a lake will warm in the sun and, if wind turbulence is low, an underlying cool layer will be present. This thermal stratification is very important in determining other abiotic and biotic factors. Factors controlling the rate of photosynthesis and the amount of oxygen evolved include light, species and abundance of plant (Adeniji, 1991), temperature and turbulence (Welch, 1948; Aaroye, 2007).

Dissolved oxygen concentration and the pH of water bodies are also important parameters which determine the spatial and temporal distribution of aquatic organisms particularly the fish fauna. Dissolved oxygen is required for respiration by most aquatic animals. Dissolved oxygen combined with other important elements such as Carbon, Sulphur, Nitrogen and Phosphorous to form carbonate, sulphate, nitrate and sulphate respectively which constitute the required compounds for aquatic organisms for survival.
(Mirza et al. 2013). Dissolved oxygen and pH affects directly or indirectly other water parameters such as transparency, viscosity, total dissolved solids and conductivity (Whitney, 1942). Photosynthesis by aquatic plants during the daylight removes carbon dioxide (CO₂) from the medium hence pH would increase. At night, respiratory processes of aquatic organisms release CO₂ into the medium and pH declines. Similarly warm waters develop increased pH levels due to conversion of CO₂ into organic carbon by photosynthesis and the rate may exceed the rate of the release of CO₂ from organic carbon by the process of respiration (King, 1970).

Anthropogenic impact such as urban, industrial and agricultural activities as well as natural processes (precipitation inputs, erosion, etc.) diminish the surface water quality lowering the use of water for drinking, agricultural and other purposes (Carpenter et al. 1998). The concentrations of toxic materials such as heavy metals, pesticides, and nutrients in excess not only affect human health but also cause various problems such as loss of oxygen, fish deaths and loss of biodiversity. It is, therefore, necessary that the water quality should be checked at regular intervals for increased density and diversity of aquatic organisms. Due to spatial and temporal fluctuations in water quality, a monitoring program providing a representative and reliable estimation of the quality of surface waters is necessary (Dixon & Chrisswell 1996). The assessment of the water quality can be performed by classification, modeling, and interpretation of the monitored data (Simeonov et al., 2003, Boyacýðlu, 2006).

The purpose of this study was to evaluate the seasonal variations of the water quality parameters, to determine temporal and spatial variations in water quality and to investigate the similarities or dissimilarities of water quality between the sampling sites.

MATERIALS AND METHODS

Study area

The floodplain understudy is situated on River Ravi near Balloki Headworks in District Kasur, Pakistan. It is 65 Km from Lahore lying at a Latitude: 31° 11’ 25” North, and at Longitude: 73° 52’ 40” East. The total area of the floodplain is about 8.6 Km. It has distinct tropical climate with a marked monsoonal effect with an average rainfall of 52.01mm, humidity 70.40% and average atmospheric temperature ranging from a minimum of 5°C in winter to a maximum of 50°C in summer. Water level varies in different months of the year, being highest in summer (July to September) and lowest in winter (October to April) every year.

Sampling

Monthly variations of physicochemical characteristics of water were studied from January to December, 2012. Samples were taken separately in one liter sample bottles for the evaluation of physicochemical parameters. Atmospheric and water temperature (°C), pH, dissolved Oxygen (mg/l), electrical conductivity (µS/cm), total dissolved solids (mg/l), turbidity (FTU) and transparency (cm) were measured on the spot. Temperature and DO were measured by DO meter (DO200 Ecosence), electrical conductivity and total dissolved solids were measured by conductivity meter (EC300 Ecosence), pH was measured by pH meter (PH100 Ecosence), turbidity was measured by turbidity meter (Hi 93703 HANNA). Transparency was measured by secchi disc plate of 20 cm in diameter, painted with alternate black and white quadrates. For the determination of total hardness (mg/l ), total alkalinity (mg/l ), chlorides (mg/l ) and free CO₂ , ppm , water was taken in IL sampling bottles and brought to the Laboratories at Govt. College University, Lahore, for further processing, employing methods described in APHA (2005) and Hach (2003).

Statistical analysis

XLSTAT 2013 for MS Excel 2007 was used in analyzing the data sets. Graphs were plotted with the help of MS Excel 2007.

RESULTS AND DISCUSSION

A summary statistics of the different water parameters recorded during the whole year are shown in Table 1. Air temperature was recorded maximum in April (40.32 °C) and minimum in January (16.62 °C). Water temperature was recorded maximum in July (33.89 °C) and minimum in December (14.15 °C). The present observation revealed that the annual air temperature cycle maintained a close parallel relationship with annual cycle of water temperature. Both showed similar trends having highest values in summer and lowest values in winter respectively. Both the temperatures started to increase from February, reached at peak during summer (April to June) and then dropped suddenly in August, mainly due to rain fall and mixing of incoming cold water of river with hot flood plain stagnant water. Differences between air and water temperatures were maximum during summer and minimum during winter. This increase and decrease in temperature corresponded to the
seasonal and climatic variations in the region. This observation was also in agreement with the findings of Hidetoshi (2002), Kolo & Oladimeji (2004) and Caldwell (2003).

pH was maximum in July (8.53) and minimum in December (6.82). pH started increasing steadily from January to May. This increase in pH was due to increase in temperature until July and then dropped abruptly in August. The increase in pH in warm months may be due to the increase of CaCO$_3$ in stagnant waters and increased amount of nitrates, phosphates and ultimately eutrophication in summer. Kamble _et al_ (2009) has also reported that HCO$_3$ ions formed during summer, due to reduced photosynthesis also increased pH. Sudden decrease in pH in August was due to stirring effect of incoming water in stagnant water of the flood plain. Silva & Ronald (1987), Araoye (2009) and Mustapha (2009) had also reported the similar findings.

DO is a very important indicator of a water body's ability to support aquatic life. Aquatic organisms need dissolved oxygen for their survival. In present studies maximum concentration of dissolved oxygen was present from November (8.0 mg/l) to February (7.68 mg/l) being maximum in January (9.46 mg/l), while minimum amount of Oxygen was observed in summer, being lowest in June (5.0 mg/l). Oxygen concentration started increasing from July during rainy season. It might be due to water agitation and influx of rain and flood water into the flood plain. Flood water having increased oxygen concentration, was responsible for improving oxygen concentration in water. Low quantity of oxygen in summer can be attributed to the decreasing solubility level of oxygen during increasing temperature in summer months, along with the increasing decomposition ratio in warm days. Similarly higher amount of oxygen during winter months may be due to increasing solubility of oxygen during winter along with the decrease in decomposition ratio in winter months. Similar observation was recorded by Janjua _et al_ (2009) and Morrison _et al_ (2001).

Electrical conductivity was highest in June (330 µS/cm) and lowest in January (232.76 µS/cm). Electrical conductivity increased with increase in temperature. In warm month's evaporation in water bodies resulted in decrease in the total quantity of water, causing increase in electrical conductivity. In the present study maximum conductivity was recorded in June (300 µS/cm) and minimum in January (232.76 µS/cm). It increased from January to June and then decreased abruptly in July and August due to dilution effect caused by rain and flood water. Again increase in conductivity in September was due to increase in water temperature and again decrease from October to December was due to decrease in water temperature. This also agreed with the findings of Mirza _et al_ (2013) and Kolo & Oladimeji (2004).

Total dissolved solids were maximum in June (211.2 mg/l) and minimum in January (148.97 mg/l). TDS values decreased in July and August, then increased in September, after which the values decreased up till January. From January the TDS values again started to increase till it reached to maximum in June. The TDS values followed the same trend as Electrical conductivity. It is seen that a linear relationship existed between TDS and EC. TDS can be calculated by multiplying the electrical conductivity with a specific factor (usually which ranged from 0.55 to 0.75). A similar trend of TDS was also observed by Mustapha, (2009) and Singh _et al_ (2010). Samal (2001) had also concluded that Electrical conductivity would increase with increase in TDS values.

Turbidity was found highest in July (63.7 NTU) and low turbidity was observed from September to April, being minimum in February (6.42 NTU). High value of turbidity in July was due to the maximum agitations of water caused by rainfall. During rainstorm particles from surrounding land also washed into the river making the water a muddy brown colour, indicating higher turbidity. Similarly during high flows, water velocities were faster and water volumes were higher, which could more easily stir up and suspend materials from the stream bed, increasing turbidities.

Transparency values were recorded maximum in December (150 cm) and minimum in July (30.48 cm). Reduced transparency during rainy season (July) might be due to the erosion of soil by precipitation and the transport of silt particles through run off. On the other hand, higher transparency values during dry season were due to the absence of flood water, surface run off and setting effect of suspended solids. Lower readings of transparency indicated turbid or coloured water. Transparency and turbidity were inversely proportional to each other. Mirza _et al_ (2013) and Khan & Chaudhury (1994) also made similar observations. Mustapha (2009) reported that low transparency in the wet season might be due to the washing of debris, organic matter and silt into flood plain through run off.

Total hardness and alkalinity are expressed as CaCO$_3$ which is not correct. Total hardness means the concentration of cations and alkalinity means the concentration of anions. Hardness is
Table 1: Summary statistics of Water parameters recorded from January 2012- December 2012

<table>
<thead>
<tr>
<th>Months</th>
<th>Air temp. (°C)</th>
<th>Water temp. (°C)</th>
<th>pH</th>
<th>DO. (ppm)</th>
<th>E.Cod. (µS/cm)</th>
<th>TDS (mg/L)</th>
<th>Turbidity (FTU)</th>
<th>Visibility (cm)</th>
<th>T. H</th>
<th>T.A (mg/l)</th>
<th>Chlorides (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>16.62</td>
<td>15.01</td>
<td>7.5</td>
<td>9.46</td>
<td>232.76</td>
<td>148.9664</td>
<td>6.19</td>
<td>106.68</td>
<td>140</td>
<td>108.53</td>
<td>34.93</td>
</tr>
<tr>
<td>Feb</td>
<td>29.26</td>
<td>24.11</td>
<td>7.6</td>
<td>7.68</td>
<td>239.85</td>
<td>153.504</td>
<td>4.62</td>
<td>99.314</td>
<td>143</td>
<td>110</td>
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<tr>
<td>Mar</td>
<td>31.36</td>
<td>27.72</td>
<td>7.7</td>
<td>5.65</td>
<td>270.84</td>
<td>173.3376</td>
<td>4.87</td>
<td>106.68</td>
<td>150</td>
<td>116.53</td>
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</tr>
<tr>
<td>Apr</td>
<td>40.32</td>
<td>30.7</td>
<td>7.8</td>
<td>5.5</td>
<td>278</td>
<td>177.92</td>
<td>5.68</td>
<td>93.98</td>
<td>153</td>
<td>117</td>
<td>29.8</td>
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<td>32.65</td>
<td>30.07</td>
<td>7.9</td>
<td>5.3</td>
<td>300</td>
<td>192</td>
<td>28.39</td>
<td>94.488</td>
<td>154</td>
<td>118</td>
<td>29.8</td>
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<tr>
<td>Jun</td>
<td>34.34</td>
<td>30.9</td>
<td>8.3</td>
<td>5</td>
<td>330</td>
<td>211.2</td>
<td>22.23</td>
<td>58.42</td>
<td>160</td>
<td>119</td>
<td>28.66</td>
</tr>
<tr>
<td>Jul</td>
<td>37.78</td>
<td>33.89</td>
<td>8.5</td>
<td>6</td>
<td>247.86</td>
<td>158.6304</td>
<td>63.7</td>
<td>30.48</td>
<td>150</td>
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<td>Aug</td>
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<td>8</td>
<td>7.12</td>
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<td>7.88</td>
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<td>Nov</td>
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<td>6.9</td>
<td>8</td>
<td>258.26</td>
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<td>7.39</td>
<td>86.36</td>
<td>141</td>
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<tr>
<td>Dec</td>
<td>16.92</td>
<td>14.15</td>
<td>6.8</td>
<td>9.4</td>
<td>242.11</td>
<td>154.9504</td>
<td>5.6</td>
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<td>139</td>
<td>112.13</td>
<td>30.13</td>
</tr>
<tr>
<td>Minimu m</td>
<td>16.62</td>
<td>14.15</td>
<td>6.8</td>
<td>5</td>
<td>232.76</td>
<td>148.9664</td>
<td>4.62</td>
<td>30.48</td>
<td>120</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>Maximu m</td>
<td>40.32</td>
<td>33.89</td>
<td>8.5</td>
<td>9.46</td>
<td>330</td>
<td>211.2</td>
<td>63.7</td>
<td>150</td>
<td>160</td>
<td>119</td>
<td>34.93</td>
</tr>
<tr>
<td>Mean</td>
<td>28.38</td>
<td>25.47</td>
<td>7.7</td>
<td>6.94</td>
<td>265.66</td>
<td>170.02</td>
<td>16.38</td>
<td>87.33</td>
<td>143.33</td>
<td>113.04</td>
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<tr>
<td>St. Er.</td>
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<td>1.87</td>
<td>0.2</td>
<td>0.48</td>
<td>8.09</td>
<td>5.18</td>
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<td>9.09</td>
<td>3.19</td>
<td>1.49</td>
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<tr>
<td>St.Dev.</td>
<td>7.75</td>
<td>6.47</td>
<td>0.5</td>
<td>1.55</td>
<td>28.03</td>
<td>17.94</td>
<td>17.46</td>
<td>31.47</td>
<td>11.05</td>
<td>5.17</td>
<td>3.744722</td>
</tr>
</tbody>
</table>

T.H=Total hardness; T.A.=Total alkalinity

mainly concerned with the concentration of calcium and magnesium ions. Total hardness was found highest in June (160 mg/l) and lowest in August (120 mg/l). It showed positive correlation with temperature. As temperature increased total hardness also increased. Similarly with decrease in temperature hardness also decreased. The high values of hardness during summer can be attributed to increased rate of evaporation of water in a flood plain during summer. Sudden change in hardness in August is due to rain fall and addition of flood water to increased rate of evaporation of water in a flood plain. Similar findings were observed by Mirza et al (2013) but different findings were produced by Mirza et al (2013).

Total alkalinity of water is due to presence of mineral salts in it. It is primarily caused by the presence of carbonate and bicarbonate ions. Total alkalinity also followed almost same pattern as Total hardness, being highest in June and lowest in August. High values in June were due to evolution of CO₂ during decomposition of organic matter in summer and reduction of water in the flood plain. The lowest alkalinity in August was attributed to the dilution factor in August, due to rain fall and incoming flood water. Similar results were produced by Mirza et al (2013).

Chloride is one of the important parameter in water. Its concentrations vary widely, especially in pond waters, ranging from less than 1mg/l to more than 100 mg/l. The Chlorides is also one of the important indicators of Pollution. The value of chlorides was present from 20 to 35 mg/l, in pond waters, ranging from less than 1mg/l to more than 100 mg/l. The Chlorides is also one of the important indicators of Pollution. The value of chlorides was present from 20 to 35 mg/l, in present studies. Maximum values were recorded in the months from December to February whereas maximum value was recorded in August. High concentrations of chlorides might be due to the invasion of domestic and agricultural wastes. High domestic wastes are added to the river near Lahore, which ultimately are responsible for rise in chloride contents in the flood plain. Similar results were also reported by Ahmad (2004).

The physico-chemical characteristics of water analyzed during the study period revealed that due to anthropogenic activities, the water quality is deteriorating day by day. Therefore, there is an urgent need to properly manage wastes in the cities and control and monitor human activities in order to ensure minimized effects of these parameters on the River Ravi.
Fig. 1: Different physicochemical parameters of water i.e., Air temperature (°C), water temperature (°C), pH, dissolved oxygen (mg/l), electrical conductivity (µs/cm), total dissolved solids (mg/l), turbidity (NTU), visibility (cm), total hardness (mg/l), total alkalinity (mg/l) and chlorides (mg/l).

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