A STUDY ON PHYSICO-CHEMICAL PARAMETERS OF DARWAZAII DAM, LACHI, DISTRICT KOHAT, KHYBER PAKHTUNKHWAI, PAKISTAN

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Abstract: This paper illustrates some important physico-chemical parameters of Darwazai Dam, Lachi, District Kohat, Khyber Pakhtunkhwa, Pakistan to determine its suitability for developing aquaculture in it. Various limnological parameters were studied from March to June 2011. Mean and standard error of different physico-chemical parameters was recorded as follows; pH 7.60 ± 0.00, temperature 27.38°C ± 3.14, dissolved oxygen (DO) 7.00 ± 0.00 mg/L, total dissolved solids (TDS) 679.3 ± 92.31 mg/L, conductivity 1110 ± 165 µs/cm, hardness 123.5± 25.5 mg/L, calcium 69.0± 13.8 mg/L, chloride 28.43 ± 4.50 mg/L, alkalinity 131.0 ± 5.87 mg/L, nitrate 0.42 ± 0.14 mg/L, bromine 0.42 ± 0.14 mg/L, iron 0.3 ± 0.02 mg/L, magnesium 59.0 ± 12.9 mg/L and visibility of sacchi disk was 30.75±0.43cm. The study concludes that all parameters studied are in the optimum range, which could support a large diversity of warm water fishes for developing aquaculture activities in the dam.

Key Words: Darwazai dam, Kohat, Lachi, water quality, physico-chemical parameters, aquaculture

Introduction

The benefits of building small dams are numerous, especially in rural arid areas and where water in general, especially the groundwater is limited (Mufute, et al., 2008). According to Ashraf, et al., 2007 small dams bring significant beneficial impacts on water table (especially where the water table is too shallow for human use) and the subsequent use for domestic as well as irrigation. However, the quality of dams’ water play the key role in identification of their potential water use, as the water quality of dams always remain under the influence of population and other human activities near the dam (Brainwood et al., 2004). Hence limnological studies of water are a very important phenomenon that includes both physical and chemical parameters, which directly affect the biological activity in water bodies. According to Cole (1975), the most important goal of limnology is to study the circulation of materials especially organic substances in the body of water. Life activities of aquatic organisms are also
affected by changes in the physical and chemical parameters of the water. Priyamvada, et al., (2013) described that the productivity of a lake or pond depends upon the quality of its water and soil. For the sustainable use of dams, the land cover and the nature of anthropogenic activities in the catchment areas is extremely important. For example, the concentration of nitrates in water is directly related to arable land and the urban catchment areas are correlated with ammonium-N, orthophosphate-P and suspended solids (Ferrier, et al., 2001).

Darwazai dam is a small dam, located near village Darwazai on Sudal Nullah southeast to Lachi town, district Kohat. The catchments area of the dam is 7.30 sq miles having the height and length of 50 and 1300 feet respectively. It is basically an earth filled dam with upstream and downstream protection by riprap. The top width of the dam is 20 feet. It was completed during the year 1976 at a cost of Rs 2.315 million. The present study, evaluating its suitability for fish farming, is the first effort since its construction.

Materials and Methods

The water reservoir was studied for four months from March to June 2011. Five different collection sites were selected for sampling; one in the middle and rest on four different sides of the dam. Water samples were collected in well cleaned, disinfected, pre-dried, plastic bottles of one liter volume. Standard kits and equipment were used to analyze different physico-chemical parameters of the water.

Temperature was determined by Elth-electronic thermometer (Range -50 to +170), pH by pH meter (portable H-18341), alkalinity and hardness by Lamotteee 5917-01 water pollution detection Kit. Conductivity and total dissolved solids (TDS) were measured by 470-Jenway conductivity meter. Dissolved oxygen was determined by 970-Jenway D.O meter, and chloride, nitrate, bromine, iron, calcium and magnesium by PC Multi Direct Spectrophotometer.

Results and Discussion

The limnological parameters of fresh water vary from place to place and month to month due to the climatic differences, the land cover and the nature of anthropogenic activities in the catchment areas (Ferrier et al., 2001). Therefore, both the physical and chemical parameters showed variations throughout the study period.

During the study period, interestingly, the pH value remained constant at 7.6, which confirms water suitability for the growth of aquatic organisms and introducing fish culture in it. The pH is one of the most important features, which may variably cause mortality of fish. As compared to fries and fingerlings, adult fish can tolerate a high pH level. Carps are very sensitive to decreased pH levels. It becomes critical below 5.0 and generally the fish die at pH 4.8. In highly acidic medium the skin and gills of fish are abundantly covered with mucus. The respiratory epithelium is broken down and the gill lamellae are closely compressed and destroyed. Blood pH may be changed if acids or bases are added to or removed from the medium. Acidic water also changes the composition of blood due to which blood chemistry and in response many important life functions get disturbed (Raja, 1992). The pH in the reservoir remained 7.6, which means that the water is fairly alkaline. This pH seems to be suitable for the fish culture.
The water temperature is another important limnological parameter, which affects all vital activities of aquatic organisms. The water temperature fluctuated between 20 °C to 29 °C during entire study period. This water temperature is most suitable for the warm water fish culture as warm water fish prefer temperature ranging between 18-29 °C for their growth and breeding. This result is in close coordination with those of Zaigham and Khan (2009) who described similar temperature range suitable for fish culture in Changhoz Dam, District Karak in the province.

Temperature plays an important role in the stability of an ecosystem because various physical properties of water like viscosity, density, surface tension and thermal stratification of lakes and ponds are directly related to the temperature. Water temperature has great effect on chemical reactions. It has pronounced effect on the solubility of gases in the water like oxygen which is vital for the survival of life and CO₂ which is required for energy harnessing process of photosynthesis. This fact is also supported by Zuane, (1997) who showed experimentally that for every 10 °C raise in temperature, the rate of biochemical reactions doubles.

The average visibility of sacchi disk was 30.75 cm (Table 1) which is ideal for fish culture. Sacchi disc visibility is a measure of turbidity of water. Turbidity of water is due to many reasons like that of presence of phytoplanktons and suspended particles of silt etc. A study by Järvenpää and Lindström, (2004) suggested that increased turbidity can change mating systems and decrease the opportunity for sexual selection as well as selection intensity in the sand goby, Pomatoschistus minutus. Visibility more than 30 cm depicts less turbidity and less availability of natural food.

Dissolved oxygen (DO) is required not only for respiration but also for release of energy from food (Lagler, 1977). The congenial range for warm water fish culture is 5 – 7 mg/ L whereas DO level less than 3 mg/ L is lethal for most fishes (Ali, 1999). A good supply of dissolved oxygen enhances the biological activities. The value of DO fluctuated very little within the normal range from 6 mg/L to 7 mg/L during the study periods. The lowest value of DO was observed in the warmest month but still, it was more than sufficient for our warm water fishes as described above. The DO level confirms the sufficient photosynthetic activity and as a result suitability of the water of Darwazai dam for fish culture.

Alkalinity in freshwater is due to the presence of carbonates and bicarbonates and hydroxides of alkali and alkaline earth metals. Buttner, et al., (1993) described it as the buffering capacity of culture water i.e. water with high alkalinity maintains its pH and vice versa. They have shown that in ponds with low alkalinity, due to photosynthetic activity the morning and afternoon pH could fluctuate between 69 whereas in ponds with higher alkalinity this fluctuation ranges between 7-8. Most of the waters of our province have sufficient alkalinity due to the presence of carbonates and bicarbonates of calcium and magnesium. According to Ali (1999), the most productive range of alkalinity for fish growth is 50-200 mg/L whereas Buttner, et al., (1993) described this range of alkalinity between 20-300 mg/L and mentioned that even higher levels do not harm the fish but interfere with the action of certain
commonly used chemicals like copper sulfate. The observed alkalinity values during the present study, from March to June, were 126 mg/L, 138 mg/L, 143 mg/L and 117 mg/L respectively with an average of 131 mg/L. These values of alkalinity are optimum for fish culture and growth of planktonic life, which serve as natural food for the fish.

Bromine is found in a meager quantity in the body of fish. Crude fish oil contains about 2.36–9.63 μg g⁻¹ Bromine (Elson et al 1983). In fishes, uptake of many ions is directly from the water through permeable surfaces like gills and oral membranes (Lagler, et al., 1977). Bromide ions (Br⁻) are although required in very small amounts but are essential for homeostasis. According to Das (1989) Br⁻ may be higher in contaminated or polluted water. In other words its low concentration in water proves it to be unpolluted. Sharp, et al., (1976) described the virus killing activity of Bromine in the turbulent flowing water as well. The values of bromine in the water of Darwazai dam remained 0.15 mg/L, 0.51 mg/L, 0.26 mg/L and 0.22 mg/L in the respective months which is within the permissible limits and would be favorable for the fish life.

Conductivity, the ability of water to conduct electrical current, is a measure of the total ions present in it. Conductivity of water is affected due to variation in quantity of inorganic dissolved solids such as chloride, sulfate, sodium, calcium and others (Sue and Kersey, 2010). Conductivity of water generally depends upon the type of rocks through which it flows. If it passes over the less reactive rocks like those of granite it would have low conductance whereas if through its course, it flows through the rocks of lime or clay soil, it would have higher conductance. Conductance is also increased by the pollutants of industrial and domestic origin. Temperature, purity and salinity are also the factors which affect the conductivity of water (Smathers, 2010). It indirectly gives an idea about the total dissolved solids (TDS) in the water body. Conductivity is measured in micro siemens per centimeter (µs / cm). The observed values of conductivity in different months were 1288 µs / cm, 1483 µs / cm, 795 µs / cm and 872 µs / cm. The higher values of conductivity during the months of March and April is in accordance with Sue and Kersy (2010) who related high conductivity in lake LBJ during the period of low water volume.

Average value for total dissolved solids (TDS) was 679.3 mg/L for the study period in Darwazai dam with minimum value and Maximum values as 477 and 883 mg/L. TDS is a measure of all the soluble materials, which mainly includes salts of different metals and non metals like carbonates, bicarbonates, chlorides, sulphates and nitrates of Ca, Mg, Na, K, Fe, and Mn etc. Welch (1952) described that the value of TDS in natural waters vary from 15-300 ppm. Eutrophic lakes generally have higher TDS contents (Ali, 1999). Higher contents of TDS may influence the osmoregulation of freshwater organisms. Temperature and rainfall greatly affects the amount of TDS in the water. Patterson et al (2002) has shown that TDS concentration as high as 4800 mg/L and 3000 mg/L sulfates had reduced average daily gain, DM intake, water intake, and gain/feed.

Measurement of minerals especially calcium is very important because it has great effect on the hardness and productivity of the water reservoir. Skeletal growth in vertebrates is frequently affected by the
availability of basic nutrients and minerals (Lall and Lewis-McCrea 2007). Calcium is the most abundant mineral in fish body comprising 5-2.1% of the weight of an adult’s body. Aqueous calcium content and fish skeletal growth has a strong correlation and the main route of its absorption from water in teleost fishes for skeletal development through chloride cells on the gill membranes (Simkiss 1974; Evans 1998). Importance of calcium in a water body is obvious due to the fact, it is taken up and used in the formation of bones of fishes, formation and the hatching of some fish’s eggs and formation of shells of mollusks (Landau 1991), which are an integral part of almost all the aquatic food chain. The observed values of calcium in March, April, May, and June were 46, 99, 68 and 45 mg/L respectively, which seem satisfactory for fish growth as according to Blanksma (2009) in culture practices, the calcium hardness level is kept between 60-180 mg/L as CaCO3.

Hardness of water is generally due to carbonates and bicarbonates of minerals especially calcium and magnesium. Hardness and calcium are important indicators of water quality (Saurina, et al., 2002). Buttner (1993) described 50 mg/L hardness as minimum requirement for fish culture below which fish show poor growth. Observed values for the hardness were determined as 86, 194, 128, and 96 mg/L during the study period from March to June, which seem satisfactory for growth and survival of fish and other aquatic fauna.

As described by Ali (1999), standard method for calculating salinity is to determine the chloride concentration in the water and by using following formula, the salinity could be calculated.

\[
\text{Salinity (g/L)} = 0.03 + 1.805 \times \left(\text{Chloride in mg/L}\right)
\]

According to Landau (1991) the amount of salts in sea water can also be calculated by measuring the amount of chlorine because the ratio of all the major elements in the oceans including chlorine is constant. Salinity has a great effect on the life of aquatic organisms. Aquatic fauna can be distinguished into stenohaline (e.g. Onchorhyncus, Salmon etc.) and euryhaline (e.g. Tilapia, Ictalurus and Cyprinus carpio etc.) on the basis of salinity tolerance. Salinity not only affects osmoregulation, it also influences the concentration of unionized ammonia (Buttner 1993).

Calculated values of chlorine in different months were 18.7 mg/L, 30 mg/L, 40 mg/L and 26 mg/L respectively, whereas the relative values of salinity were determined as 33.8 g/L, 54.18 g/L, 72.15 g/L and 45.15 g/L.

In the present study, nitrates were also analyzed, which is an oxidized form of nitrogen. Nitrates have a vital importance for the growth of plants and animals essentially for the growth of blue green algae, which increase the productivity of ponds and reservoirs. Growth and abundance of other phytoplankton also depends on the availability of nitrates in water. Although, it is an important requirement for aquatic plants but its higher levels cause serious health hazards. The intoxication with nitrates is produced with exposure levels >50 mg/L through drinking water (WHO, 2004). Nitrate itself is non-toxic, but in the gastrointestinal tract, a percentage of nitrates are reduced into nitrites (Eisenbrand, et al., 1980), which are ten times more toxic than nitrate because of...
Nitrites are then absorbed into the bloodstream, reach the tissues. Their main adverse effect is that they disturb the balance between antioxidants and pro-oxidants in favor of the later, resulting in oxidative stress (Ahsan, et al., 2003; Ellis, et al., 1998; Halliwell and Gutteridge, 1984). According to Buttner, et al., (1993) nitrite is toxic to fish and causes “brown blood” disease and its concentrations of 0.5 ppm reduce growth. The main source of nitrate pollution is the agricultural runoff as described by Rodríguez-Estival (2010). The observed values of nitrates during the study period were 0.2, 0.2, 0.5, and 0.8 mg/L respectively with an average of 0.42 mg/L seems suitable for the growth of aquatic flora without causing any harm to animal life in the reservoir.

In many ground waters, iron is present. Iron when reacts with oxygen gets converted into its oxides which make small clumps. These clumps may settle on the gills of the fish and cause suffocation, irritation and stress. The level of iron in the water of Darwazai dam was negligible with the highest value 0.13 mg/Lin March and the lowest value 0.02 mg/L in April as shown in the Table 2.

Magnesium is an important mineral present in freshwater. Its carbonates and bicarbonates impart hardness to water. It is an essential mineral found in the body of vertebrates. It is an important constituent of vertebrate bones and not only found in the serum but also present in bound form with proteins acting as cofactor for different enzyme (Ahmad 1982). It plays an indirect role in the productivity of the water body as it is essential for the formation of chlorophyll molecule. Increase in Mg concentration does not have any effect on mineralization of bones but reducing its concentration to 0.3–0.4 mM decreases reabsorption (Raisz 1969). Mg concentration fluctuated between 40 – 95 mg/L with an average of 59 mg/L during the study period, which is within the permissible limit.

**Conclusions and Suggestions**

It is concluded that all the analyzed physical and chemical parameters of the water of Darwazai dam, Lachi, district Kohat are suitable for the fish growth. Therefore, the reservoir is suitable for the warm water fish culture. It is therefore suggested that warm water fishes like rohu (*Labeo*), mori (*Cirrhinus*), thaila (*Catla*), silver carp and grass carps be stocked regularly in the reservoir to fully utilize this very important natural resource. Aquaculture in Darwazai dam will largely improve cheap protein supply as well as the socio economic conditions of the people of the area by generating employment opportunity.

**Table 1. Mean and standard error of different physical parameters of water of Darwazai dam, Lachi, Kohat**

<table>
<thead>
<tr>
<th>Parameters with Units/ Months</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>X±SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.6</td>
<td>7.6</td>
<td>7.6</td>
<td>7.6</td>
<td>7.6±0.00</td>
</tr>
<tr>
<td>Temperature °C</td>
<td>20</td>
<td>25.5</td>
<td>29</td>
<td>25</td>
<td>27.38±3.14</td>
</tr>
<tr>
<td>Sacchi Disk visibility (cm)</td>
<td>32</td>
<td>32</td>
<td>30</td>
<td>32</td>
<td>30.75±0.43</td>
</tr>
</tbody>
</table>
Table 2. Mean and standard error of different chemical parameters of water of Darwazai dam, Lachi, Kohat

<table>
<thead>
<tr>
<th>Parameters with Units/ Months</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>X±SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen (mg/L)</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>7.00±0.00</td>
</tr>
<tr>
<td>Alkalinity (mg/L)</td>
<td>126</td>
<td>138</td>
<td>143</td>
<td>117</td>
<td>131.0±5.87</td>
</tr>
<tr>
<td>Bromine (mg/L)</td>
<td>0.15</td>
<td>0.51</td>
<td>0.26</td>
<td>0.22</td>
<td>0.42±0.14</td>
</tr>
<tr>
<td>Conductivity (µs/cm)</td>
<td>1288</td>
<td>1483</td>
<td>795</td>
<td>872</td>
<td>1110±165</td>
</tr>
<tr>
<td>TDS (mg/L)</td>
<td>778</td>
<td>883</td>
<td>477</td>
<td>579</td>
<td>679.3±92.31</td>
</tr>
<tr>
<td>Calcium (mg/L)</td>
<td>46</td>
<td>99</td>
<td>68</td>
<td>45</td>
<td>69.0±13.8</td>
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<tr>
<td>Hardness (mg/L)</td>
<td>86</td>
<td>194</td>
<td>128</td>
<td>86</td>
<td>123.5±25.5</td>
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<tr>
<td>Chloride (mg/L)</td>
<td>18.7</td>
<td>30</td>
<td>40</td>
<td>25</td>
<td>28.043±4.50</td>
</tr>
<tr>
<td>Salinity (g/L)</td>
<td>33.8</td>
<td>54.18</td>
<td>72.23</td>
<td>45.15</td>
<td>51.34±7.04</td>
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<tr>
<td>Nitrate (mg/L)</td>
<td>0.2</td>
<td>0.2</td>
<td>0.5</td>
<td>0.8</td>
<td>0.42±0.14</td>
</tr>
<tr>
<td>Iron (mg/L)</td>
<td>0.13</td>
<td>0.02</td>
<td>0.06</td>
<td>0.10</td>
<td>0.077±0.135</td>
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<tr>
<td>Magnesium (mg/L)</td>
<td>40</td>
<td>95</td>
<td>60</td>
<td>41</td>
<td>59.00±11.33</td>
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References


