INT. J. BIOL. BIOTECH., 17 (4): 725-729, 2020.

AN ASSESSMENT OF HYDROGRAPHIC CONDITIONS OF GHARO CREEK, INDUS DELTAIC REGION IN SUPPORT OF GROUPER AQUACULTURE OPERATIONS

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ABSTRACT

The present study was carried out for the 32-month period from March 2006 to October 2008 to describe the monthly and seasonal physico-chemical characteristics in Gharo Creek, Thatta, Sindh. The results were used to provide a general assessment of water quality in the area and determine the suitability of water quality for supporting grouper and snapper aquaculture activities. This study has shown that conditions in Gharo creek are well within the physiological tolerances of the grouper species of interest for culture (tiger grouper, *Epinephelus fuscoguttatus*).

Keywords: Hydrography, Gharo Creek, grouper aquaculture

INTRODUCTION

Aquaculture programs are water intensive initiatives that require particularly good water quality resources for their success (Diana *et al*., 2013). The study of physico chemical properties of water supply source at the aquaculture pond venture site is mandatory before planning a successful aquaculture. The quality of water determines the performance of physical and biological functions of fish like growth, survival and health in the culture pond (Silva and Ronaldo, 1987). As this stunning system has shown its direct effects on aquatic and human health, it helps to understand the physicochemical characteristics of water and their impact on ecological interrelationships. Over the time it has observed that fish stocks are declining due to overfishing, this is not only a concern of Pakistan's economy but also a worldwide problem that requires solutions from multiple sources (Pauley *et al*., 2002). One remedy that may partially offset the decline observed in fisheries landings is to supplement traditional efforts to marine fish culture along coastal areas (DeSilva and Davy, 2010). The shoreline of Pakistan near the Indus Delta contains wide expanses of brackish water, creeks and mangrove forests where the culture of marine fish species could be conducted (Laghari, 2018). Several commercial finfish species (e.g., snapper and grouper)have more recently received attention throughout Asia due to their suitability in culture and high market price, fortunately these species also have breeding grounds in the coastal waters of Pakistan (Qureshi, 2013).

The River Indus run is fed through numerous tributaries, which flow downstream to its delta in the Arabian Sea. The Indus delta is situated along the Sindh coast, comprising an area of 64,000 ha, with seventeen major creeks and numerous minor creeks (Meynell, 1995; Harrison *et al*., 1997). Gharo Creek is the first major creek of the Indus delta located southwest of Karachi. Gharo Creek is an intertidal creek that stretches about 5.5 km long, 100-400 m wide, and ranges in depth between 3 to 9 m. Current speeds in the creek range from 0.2 to 0.5 m s^{-1}(Harrison *et al*., 1997). It connects to the Phitti Creek at 35 miles and then opens into the Arabian Sea, at its entrance the tides are almost half of the mean sea tides with about a 45-minute lag (Muzaffar *et al*., 2017). The Ghaggar and Dhabeji canals and the Rann Pethani River discharge freshwater as well as domestic and industrial wastes into the Gharo Creek drainage basin; it gradually becomes saline as it mixes with seawater near the coastline (Mahmood *et al*., 2014). During the period from March 2006 to October 2008, the Pakistan Agricultural Research Council (PARC) under its Agriculture Linkage Program (ILP) has sponsored a research project entitled "Fin Fish Culture (Snappers and Groupers) in Ponds along the Gharo Channel". The Gharo Creek area was selected for aquaculture practice because of many advantages that it has brackish water (~6-26%), temperatures rarely exceeds 32 ºC, oxygen ranges between 5-8 mg/L and pH ranges from 7-9, all are believed to be suitable for grouper culture (Hussain and Khatoon, 2006). Several other authors have also studied the physical and chemical characteristics of waters of Gharo Creek (Anon., 2004; Harrison *et al*., 1997; Mahmood *et al*., 2014; Muzaffar *et al*., 2017).The present study was carried out to provide a general assessment of water quality in the area and determine the suitability of water quality for supporting grouper and snapper aquaculture activities.

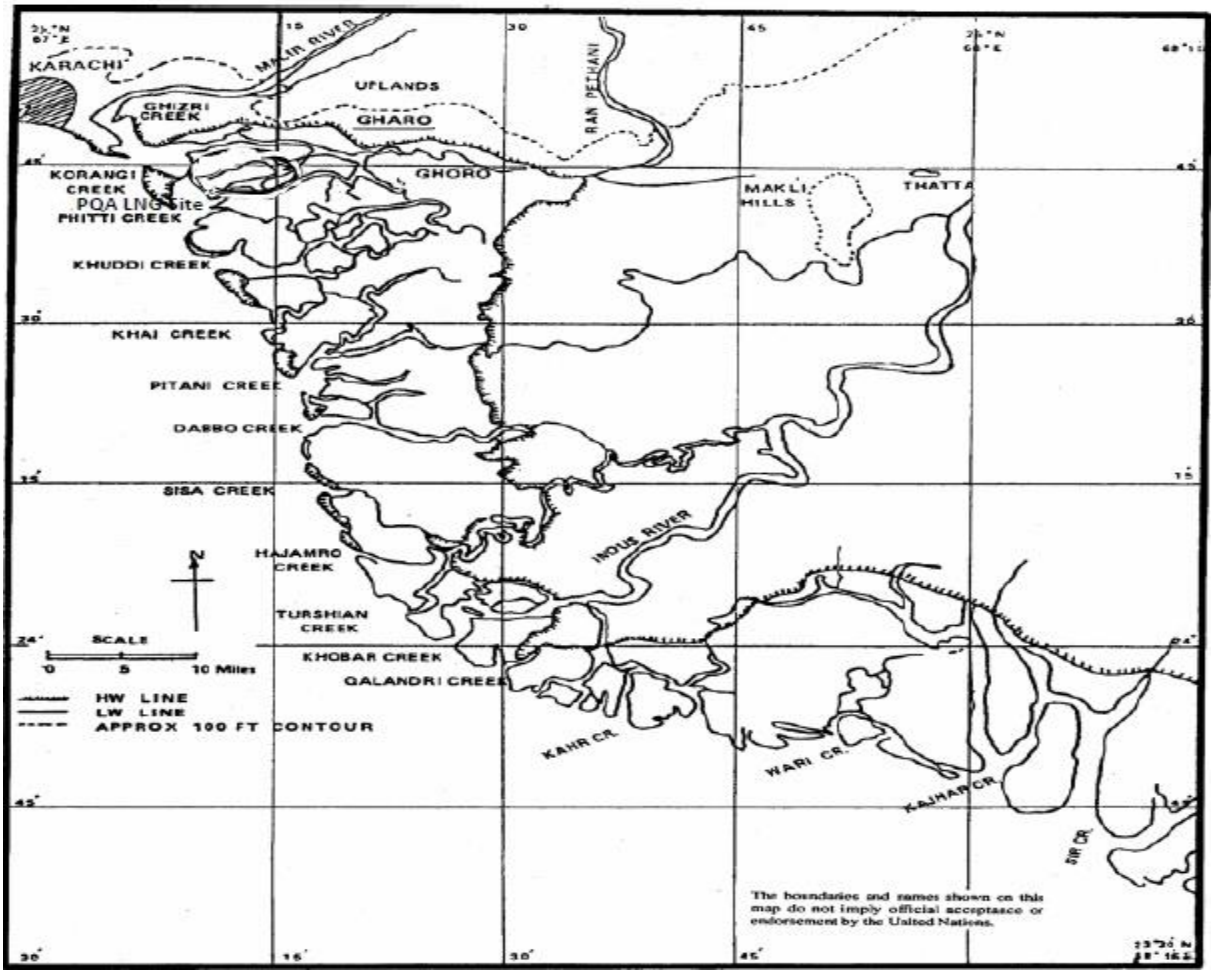

Fig. 1. Map showing the Korangi-Phitti Creek System, the study area Gharo (underlined), located at Thatta, Sindh, Pakistan.

MATERIALS AND METHODS

Gharo Creek is located approximately 60 kilometers south-east of Karachi (24°45'27"N, 67°31'44"E) in the Sindh Province (Fig. 1). This study is a part of the project on grouper and snapper fish culture in tidal fed brackish water ponds during the period from March 2006 to October 2008 for the period of 32 months (Qureshi, 2013). Gharo Creek has a mesohaline to polyhaline system and is influenced by a warm-temperate climate (Mallin, 2004). The unique feature of creeks in the Indus delta ecosystem is the reverse salt wedge at their mouth as described by Harrison *et al*., 1997. The reduced flow of fresh water below Kotri barrage on River Indus (located approximately 200 km upstream) into the creeks is a setback but there is considerable dilution of the seawater by the freshwater flow from irrigation channels, Ghaggar and Dhabeji canals, Rann Pethani River discharge as well as domestic and industrial wastes into the Gharo Creek drainage basin. This process has created swampy conditions along the creek, resulting in an increase in salinity of the soil (Beg, 1995; Kalhoro *et al*., 2016). The seasonal monsoon impacts the region, as the wind blows (8 to 9 m S^{-1}) during the SW summer monsoon pushing surface water into the creeks, resulting in exceptional flood tides. During the winter and spring the winds of the NE monsoon season push the surface water downstream, resulting in exceptional ebb tides (Harrison *et al*., 1997).

During the study, physical parameters (atmosphere and water temperature, pH, salinity and dissolved oxygen) were recorded fortnightly from each of five experimental tidal fed earthen ponds (165 x 85 x 7 feet dimension) that receive water by tidal exchange from the main channel of Gharo Creek. Water was allowed to enter each pond until a water depth of up to 1.5 m was reached, at which point the water level was maintained throughout the remainder of the study by a monk valve or gate (Qureshi and Khatoon, 2015). In situ measurements included atmospheric and surface water temperature (ºC), which were measured by using a mercury hand thermometer; pH was determined by using a pH meter (JENCO_607); and salinity (‰) was recorded with the help of an ATAGO refractometer.

Dissolved oxygen (DO) (mg/L) was fixed immediately after collection and then determined by Winkler's titration method in the laboratory. The monsoon seasons were defined as Northeast (NE) November-March, Southwest (SW) May-September and transitional periods April (1st) and October (2nd) following the classification of Ali-Khan (1976/1977). All physical parameters were examined monthly and seasonally.

RESULTS

During the study, mean seasonal water temperature ranged from a low of 15.1ºC in January during the NW monsoon period to a high of 31.1º C during the April Transitional period (Table 1). In general, the lowest air and water temperatures were observed during the NE monsoon period, while the SW monsoon period showed the least variability (27.4 º C – 29.9 º C; Table 1, Figure 2). Air temperature followed a similar pattern with the coolest temperatures and highest variability occurring during the NE monsoon, while the warmest and least variable temperatures occurred during the SW monsoon period. Salinity varied month to month with the lowest values observed occurring in September 2006 (Fig. 2). In general, the lowest mean salinities were recorded during the end of the Southwest monsoon period (Table 1). Seasonally, salinity stayed low (<20‰) through the October Transitional period and into the first two months of the NE monsoon period. The greatest change in salinity occurred during the SW monsoon period in 2006, where a 20‰ drop from May to September was observed and then during the following NE monsoon period where an 11‰ increase was observed between November 2006 and March 2007 (Fig. 2). Mean DO levels of 5.5 or greater were recorded throughout each season during all three years of the study. The highest mean DO values were recorded during December, primarily due to highest DO values from the entire study period being recorded during December 2006. Mean pH values ranged from a high of 8.2 during the start of the NE monsoon to a low of 7.4 during the end of the same season (Table 1). Relatively high pH values were recorded at the beginning of the study period in 2006, after which they declined through the 2007 NE monsoon season and, except for a slight increase during the October 2007 Transitional period, stayed relatively stable during the remainder of the study period (Fig. 2).

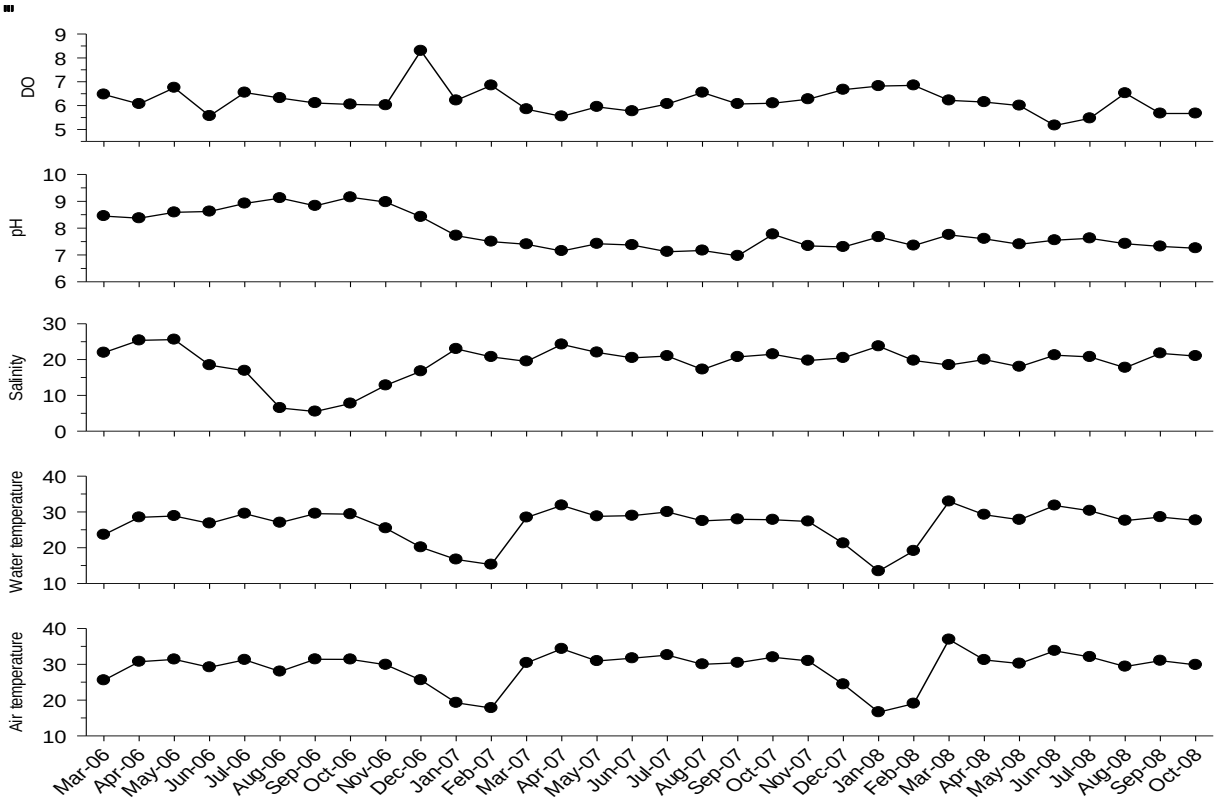

Fig. 2. Monthly variation in mean physical parameters in Gharo Creek, during the period from March 2006 to October 2008. Light gray shading indicates Northeast monsoon season; Dark gray with cross hatched shading indicates Southwest monsoon season.

Table 1.Seasonal variations in the mean physical parameters (±SD) in Gharo Creek, during the period from March 2006 to October 2008. Monthly data are pooled over sampling years. Light gray shading indicates Northeast monsoon season; Dark gray shading indicates Southwest monsoon season.

Parameters	Jan N=8	Feb N=8	Mar N=12	Apr N=12	May N=12	Jun N=12	Jul N=12	Aug N=12	Sep N=12	Oct N=12	Nov N=8	Dec N=8
Mean Air Temp.(℃) ± SD	17.9±3.0	18.4±1.1	30.9±5.0	33.1±2.9	30.8±0.6	31.5±2.1	32.0±0.8	29.1±1.2	30.9±0.6	31.1±1.1	30.4±2.4	25.0±2.1
Mean Water Temp.(℃) ± SD	15.1±2.5	17.2±2.8	29.5±4.4	31.1±2.2	28.5±0.7	29.2±2.4	29.9±0.7	27.4±0.7	28.7±1.1	28.3±1.7	26.4±1.8	20.7±2.4
Mean Salinity (‰) ± SD	23.4±1.3	20.3±2.9	20.0±3.6	23.2±2.9	21.9±4.0	20.1±2.5	19.5±3.3	13.8±5.7	16.0±8.0	16.8±7.0	16.3±4.5	18.6±4.0
Mean pH ± SD	7.7±0.4	7.4±0.4	7.9±0.5	7.7±0.6	7.8±0.7	7.85±0.6	7.89±0.9	7.90±1.0	7.71±0.9	8.05±0.9	8.16±0.9	7.86±0.9
Mean DO mgL^{-1} ± SD	6.5±0.9	6.9±0.2	6.2±0.8	5.9±0.6	6.2±0.6	5.50±0.8	6.03±0.8	6.46±0.5	5.95±0.5	5.94±0.5	6.15±0.3	7.48±1.0

Total N = 128.

DISCUSSION

As overfishing of many fisheries around the world continues aquaculture operations need to expand to meet a growing need for high quality food resources. Worldwide, aquaculture provided almost half of the seafood consumed in 2009 (FAO, 2010). With about 40% of the effort occurring in coastal and brackish waters (Diana *et al*., 2013), it is important to have a good understanding of the aquatic resources available to support such operations. Many successful Asian aquaculture operations exist around the region with some of the success due to having a good understanding of the available resources (De Silva and Davy, 2010).

The southeastern coast of Pakistan contains many creeks that cut through the expansive mangrove forests that exist in the area (Gov't of Pakistan, 1991; Shah *et al*., 2007; Khatoon *et al*., 2014). These forested islands may potentially be able to support the culture of finfish (e.g., *Lutjanus argentimaculatus* and *Epinephelus fuscoguttatus*) that have been the focus of aquaculture efforts in recent years (Abbas, 2001; Mustafa *et al*., 2015). It has been estimated there are almost one million people that derive their livelihoods from either direct fishing activities or the related support industries, but none of the 120 marine species that are part of the fisheries are actively being cultured (Laghari, 2018). It is logical that the use of these mangrove areas be utilized for aquaculture of marine species, if the conditions are agreeable. Therefore for the aquaculture experiments the site was selected along the Gharo Creek and it is also located at the close proximity to Karachi, Pakistan. The results of most hydrological properties (e.g., temperature, pH, nutrients, dissolved oxygen etc.) play a vital role for the growth of the organisms within the ecosystem (Smitha and Shivashankar. 2013; Varsani and Manoj, 2016). In the study by Mustafa *et al*. (2015) tiger grouper were found to grow well in salinity between 29.7 – 31.0‰; temperature between 26.4 – 28.9 ºC; and DO between 5.8 – 6.4 mg/l. This three years study has shown that all hydrographic conditions observed in the Gharo Creek were found in the range and well within the physiological tolerances of the tiger grouper, *E. fuscoguttatus*. This bodes well for successful culture of this and other highly prized marine species of interest. Temperature plays an important role in the metabolic activities of most animals (Varunprasath and Daniel, 2010). Since cool temperatures which are characteristic of the NE monsoon were observed during this study (a 20 ºC change), continued study is warranted to understand the impact of the variation in temperature and salinity that results from the seasonal monsoons. An understanding of seasonal cycles of temperature, as well as, the animal's response (growth and survival) is important for any successful aquaculture operation. A similar understanding of salinity tolerances is required for successful culture. Stenohaline species may not grow or survive if subjected to salinities outside its natural range. The SW Monsoon was subject to an exceptional heavy flood due to rain during August 2006 and large discharge of freshwater from the Indus River into Gharo Greek which lowered salinities below 10‰. These conditions are not unusual for the area and have been observed around the region with summer peaks and monsoonal troughs in temperature and salinity (Desai, 1992; Kumar, 2008). Despite the wide range of hydrographic conditions that result from seasonal monsoon conditions. This study suggests that the measured hydrographic parameters in Gharo Creek waters are suitable to support grouper aquaculture operations**.**

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(*Accepted for publication September 2020*)