

# Journal of Coastal Life Medicine

journal homepage: [www.jclmm.com](http://www.jclmm.com)



Document heading

doi:10.12980/JCLM.3.201514J94

©2015 by the Journal of Coastal Life Medicine. All rights reserved.

## Physicochemical parameters and seasonal variation of coastal water from Balochistan coast, Pakistan

Naeema Elahi<sup>1\*</sup>, Quratulan Ahmed<sup>2</sup>, Levent Bat<sup>3</sup>, Farzana Yousuf<sup>1</sup>

<sup>1</sup>Department of Zoology, University of Karachi, Karachi, 75270 Pakistan

<sup>2</sup>The Marine Reference Collection and Resources Centre, University of Karachi, Karachi, 75270 Pakistan

<sup>3</sup>Fisheries Faculty, Department of Hydrobiology, Sinop University, 57000 Sinop, Turkey

### PEER REVIEW

#### Peer reviewer

Assoc. Prof. Dr. Ebru Yesim Özkan, University of Ege, Fisheries Faculty, Department of Hydrobiology, TR 35100 zmir, Turkey.

Tel: +90 (232) 311 3829

Fax: +90 (232) 388 3685

E-mail: [ebru.yesim.koksal@ege.edu.tr](mailto:ebru.yesim.koksal@ege.edu.tr)

#### Comments

In Pakistan, industrial development, intensive tourism, fishing activities and economic growth are all highly influenced by the quality and quantity of coastal waters. Seasonal availability of surface water is highly responsive to the monsoon climate and physiography of Balochistan.

Details on Page 202

### ABSTRACT

**Objective:** To determine common physico-chemical parameters of coastal water.

**Methods:** Physicochemical properties of water were determined according to the standards of the American Public Health Association. Generally, all those parameters were recorded a small variation between stations. The variation in physico-chemical parameters like salinity, temperature, dissolved oxygen and pH at Gwadar (Coastal water of Balochistan) were recorded.

**Results:** The range of air temperature of coastal water of Balochistan during 2004 and 2006 varies from 25 °C to 37 °C, water temperature ranged from 15.00 °C to 33.00 °C, pH ranged from 7.08 to 8.95, salinity ranged from 37.4‰ to 41.3‰ and dissolved oxygen ranged from 5.32 to 8.67 mg/L.

**Conclusions:** Results showed that these parameters of Balochistan coast of Pakistan is not dangerous for marine habitat and the use of these parameters in monitoring programs to assess ecosystem health has the potential to inform the general public and decision-makers about the state of the coastal ecosystems. To save this vital important habitat, the government agencies and scientists should work with proper attention.

### KEYWORDS

Physicochemical parameters, Balochistan coast, Pakistan

## 1. Introduction

The presence of water on earth is in its self-unique, for the planet earth has few natural liquids. Water is the prime resource of man's food supply and his most important household and industrial tool. But most important is the fact that water is a major constituent of all living matter, comprising up to two-thirds of the human body. Next to the air we breathe, water is mankind's most important substance. Water quality is defined in terms of the chemical physical and biological contents of water. The quality of marine waters changes with the seasons and geographic areas.

Temperature is a limiting factor in the aquatic environment[1,2]. Water

temperature is probably the most important environmental variable. It affects metabolic activities, growth, feeding, reproduction, distribution and migratory behaviors of aquatic organisms[3,4]. It affects solubility of gasses in water, and gas solubility decreases with increased temperature.

Hydrogen ion concentration or pH as one of the vital environmental characteristics decides the survival, metabolism, physiology and growth of aquatic organisms[5]. Optimum range of pH for maximum growth and production of shrimp and carp is recommended as 6.8-8.7. pH is influenced by acidity of the bottom sediment and biological activities. Salinity is a dynamic indicator of the nature of the exchange system. It is expressed as the total concentration of electrically charged

\*Corresponding author: Naeema Elahi, Department of Zoology, University of Karachi, Karachi, Pakistan.

Tel: +923152447531

E-mail: [naeema\\_elahi@hotmail.com](mailto:naeema_elahi@hotmail.com)

Foundation project: Supported by University of Karachi for scientific research project.

Article history:

Received 28 Nov 2014

Received in revised form 8 Dec 2014

Accepted 25 Dec 2014

Available online 4 Feb 2015

ions (cations) in water in part per thousand (‰). The cations included either as a mass of these ions per unit volume or as milli-equivalent of the ions per volume of water. It determines distribution of organisms in aquatic environments. Dissolved oxygen (DO) affects the solubility of and availability of nutrients. Its low levels can result in damages to oxidation state of substances from the oxidized form to the reduced form, thereby increasing the levels of toxic metabolites. Dissolved carbon dioxide in aquatic environment increases with decreases of DO.

Balochistan coastline has approximately 800 km long and the Balochistan beaches provide important habitat special mangroves forests[6] for several globally important species including the green turtle[7]. Significant increased marine water pollution in Balochistan coasts is usually considered to be the immediate causes of mangrove loss in Pakistan[6]. Marine water pollution upsets the balance of the nature and negatively influences any kind of aquatic life, and the main reasons of the marine pollution in Balochistan coasts of Pakistan are agriculture, industrial and urban water pollution and the fisheries activity[6,8].

The objective of the present research is to measure seasonally water temperature (°C), air temperature (°C), salinity (‰), pH, DO (mg/L), from Balochistan coast.

## 2. Materials and methods

### 2.1. Physicochemical parameters

The present study was carried out from January, 2004 to December, 2006. Physicochemical properties of water were determined according to the standards of the American Public Health Association[9]. The common physical parameters of water (temperature, pH, salinity and total DO) have been determined.

### 2.2. Water temperature

The samples of water were collected from the coast of Baluchistan. The water temperatures were measured at the sampling point with mercury-in-glass thermometer, which was immersed in water 6 cm below the water surface and left to stabilize for 5 min. Water temperatures were recorded in degree centigrade (°C).

### 2.3. Air temperature

The air temperatures were measured at the sampling sites with mercury-in-glass thermometer. For air temperature, the thermometer was held up right in the air with the fingers and with the lower part exposed to the air for about 4-5 min. The average values for air and water temperatures were recorded in degrees centigrade (°C).

### 2.4. pH

The pH was determined with Griffin pH meter. The electrodes were immersed in water samples and the potential difference between them was measured. Standardization was done using buffer solutions of pH values.

### 2.5. Salinity (‰)

Salinity was measured using by salinometer, the probe end of the meter was dipped into the water while the value at the pointer of the

scale was read off and recorded. The salinity was recorded in parts per thousand (‰).

### 2.6. DO (mg/L)

Fixing of DO was carried out in the field. A total of 100 mL water was measured into a clean oxygen bottle and flushed several times until all air bubbles had escaped. About 2 millimeters of Winkler's solution I (MnSO<sub>4</sub> solution) and another 2 mL of Winkler's solution II (KI+NaOH solution) were added to the bottle using a pipette. Bottle was closed and thoroughly shaken to ensure proper mixing. A brown precipitate forms at the bottom of the bottle after this process. Bottle was transported to the laboratory for analysis. DO was analyzed for the hydrochemistry parameters. DO was measured in milligrams per liter (mg/L).

## 3. Results

In the present study temperature, salinity, DO and pH from the coast of Balochistan, Pakistan were presented during 2004-2006. In this study, water temperature of the studied area varied from 15.00 °C to 33.00 °C during 2004-2006, while air temperatures varied from 25.00 °C to 37.00 °C (Table 1). Generally, all those parameters recorded a small variation between stations where the average temperatures for water and air recorded as 24.80 °C and 27.32 °C, respectively. The highest water salinity (41.3‰) was recorded in summer of 2006 and lowest salinity value (37.4‰) was recorded in summer of 2004. In summer of 2004, the highest water pH of the study area was recorded as 8.95 and the lowest pH (7.08) was recorded both in autumn of 2005 and summer of 2006. Finally, the highest DO (8.67 mg/L) was recorded in both winter and summer of 2005 and the lowest DO (5.32 mg/L) was recorded in spring of 2004 (Table 2). An average of salinity was 39.31 ‰, pH was 8.61 units and DO was 7.13 mg /L. Monthly values of the present study are shown in Figures 1-4.

**Table 1**

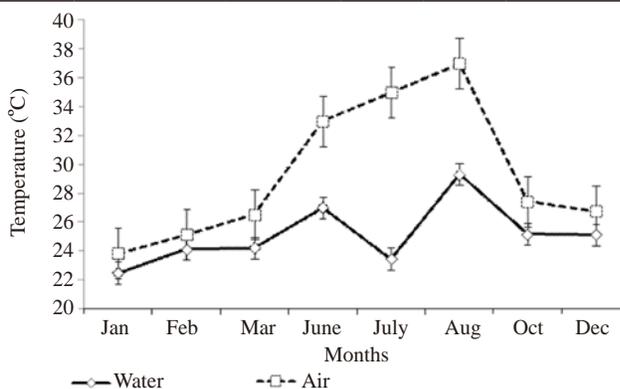
Mean temperature values of water and air from Balochistan coast during 2004-2006.

Years	Parameters	Seasons	Min. (°C)	Max. (°C)	Mean±SD
2004	Water temperature	Winter	18.00	30.00	28.00±1.25
		Spring	17.10	26.10	23.00±1.68
		Summer	25.30	31.50	29.00±2.77
		Autumn	26.10	29.00	27.50±0.62
2004	Air temperature	Winter	19.00	30.00	30.00±2.69
		Spring	21.00	25.00	25.10±2.21
		Summer	21.90	34.00	30.00±2.69
		Autumn	25.00	33.10	29.00±1.01
2005	Water temperature	Winter	20.10	26.00	23.10±1.16
		Spring	23.00	27.10	25.10±1.25
		Summer	21.00	29.00	23.00±2.04
		Autumn	21.00	26.00	23.00±1.30
2005	Air temperature	Winter	21.00	30.00	25.20±1.62
		Spring	24.00	28.50	26.50±1.20
		Summer	23.00	32.00	27.00±2.51
		Autumn	21.00	31.00	27.00±1.98
2006	Water temperature	Winter	15.00	25.00	21.00±2.52
		Spring	17.10	33.00	25.00±2.64
		Summer	23.00	28.00	22.00±1.64
		Autumn	25.00	29.00	28.00±0.88
2006	Air temperature	Winter	16.00	30.00	23.00±2.66
		Spring	17.10	33.00	23.00±2.18
		Summer	21.00	37.00	35.00±2.06
		Autumn	26.00	30.00	27.00±1.68

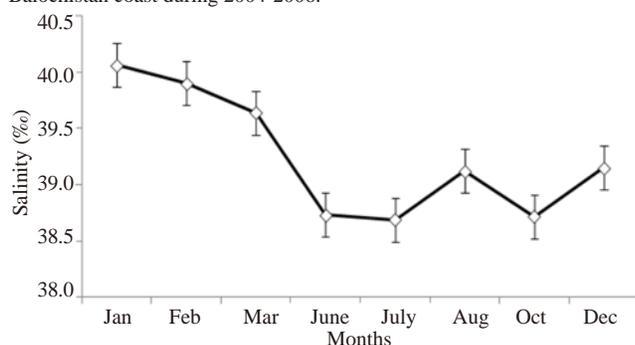
**Table 2**

Seasonally mean values of physicochemical parameters of water from Balochistan coast during 2004-2006.

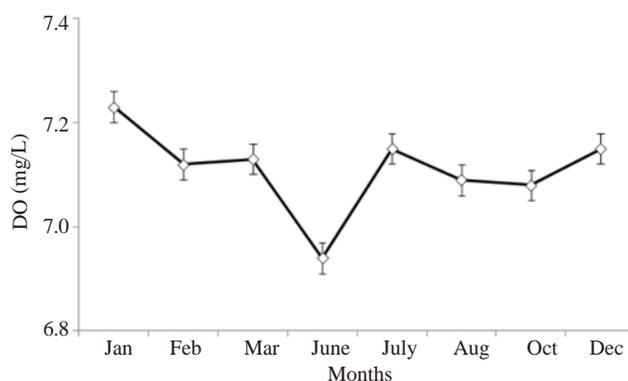
Years	Parameters	Seasons	Min.	Max.	Mean±SD
2004	Salinity (‰)	Winter	38.00	40.00	39.90±0.87
		Spring	37.90	38.00	40.00±0.83
		Summer	37.40	40.00	39.00±0.60
		Autumn	37.90	39.10	38.10±0.47
	pH	Winter	8.01	8.71	8.23±0.18
		Spring	7.09	7.99	8.12±0.80
		Summer	7.99	8.95	8.12±1.04
		Autumn	7.36	8.55	8.18±0.23
	DO (mg/L)	Winter	6.02	8.19	7.16±0.53
		Spring	5.32	6.01	7.20±0.51
		Summer	6.02	8.19	7.09±0.53
		Autumn	6.02	8.00	7.05±0.55
2005	Salinity (‰)	Winter	38.00	40.00	40.00±0.18
		Spring	39.20	40.00	40.00±0.21
		Summer	38.00	40.00	39.00±2.47
		Autumn	38.00	40.00	39.00±0.86
	pH	Winter	7.38	8.91	8.19±0.77
		Spring	7.99	8.84	8.18±0.22
		Summer	8.12	8.93	8.21±0.77
		Autumn	7.08	8.81	8.81±0.74
	DO (mg/L)	Winter	6.02	8.67	7.12±0.52
		Spring	6.05	8.39	7.12±0.55
		Summer	6.03	8.67	7.09±0.58
		Autumn	6.01	8.63	7.19±0.86
2006	Salinity (‰)	Winter	38.00	40.00	39.0±1.32
		Spring	38.00	41.00	39.0±0.85
		Summer	39.00	41.30	39.3±0.88
		Autumn	38.2	40.10	39.1±0.56
	pH	Winter	7.38	8.87	8.14±0.77
		Spring	8.01	8.89	8.17±0.17
		Summer	7.08	8.22	8.06±0.71
		Autumn	8.01	8.76	8.19±1.02
	DO (mg/L)	Winter	6.02	8.19	7.20±0.56
		Spring	6.43	8.12	7.18±0.48
		Summer	6.08	7.78	7.02±0.67
		Autumn	6.14	8.39	7.60±0.52



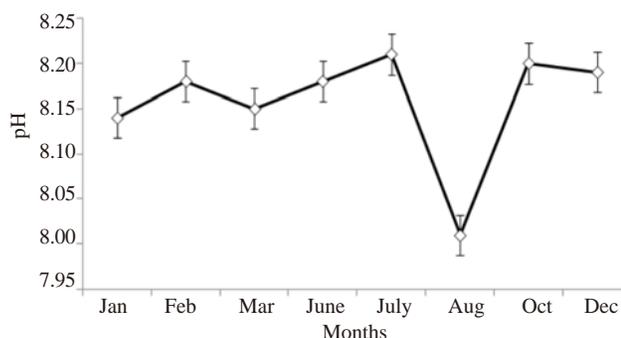
**Figure 1.** Monthly mean temperature values of water and air from Balochistan coast during 2004-2006.



**Figure 2.** Monthly mean salinity (‰) of Balochistan coastal water during 2004-2006.



**Figure 3.** Monthly mean DO (mg/L) of Balochistan coastal water during 2004-2006.



**Figure 4.** Monthly mean pH of Balochistan coastal water during 2004-2006.

#### 4. Discussion

Temperature is affected by time of the day. High temperatures may be recorded in daytime and become low at night. Temperature may cause thermal stratification occurs in the oceans. Usually the physical factors do not directly affect the fish growth but several causes some indirect influence. Gwadar is arid and hot and it lies in a warm south-east monsoon period (summer) and light north-east monsoon calm period (winter) temperature zone where the oceanic affects/effects maintain low temperature in south-west monsoon period (summer) and higher in north-east monsoon calm period (winter). Water temperature of the hottest month was August and the coolest month was January. In Gwadar, temperature did not indicated any substantial effect on the progressive development of fish, as the ranges of temperature were noticed within the limits of warm water fishes. The result indicated the monthly maximum and minimum value of water temperature and air temperature. The lowest air temperature was recorded in 2006. Temperature affects physical, chemical and biological processes in water bodies. The temperatures recorded at sample locations ranged from 15.00 °C to 33.00 °C with mean value 24.80 °C. The water temperatures of Balochistan coast were within Water Pollution Control Regulations of the Official Gazette Environment Law (No. 2872) (<25 °C) for water[10].

The data of salinity contents showed a frequent increase in salinity year-wise. Frequency in different periods showed at various spot.

In Pakistan, industrial development, intensive tourism, fishing activities and economic growth are all highly influenced by the quality and quantity of coastal waters. Seasonal availability of surface water is highly responsive to the monsoon climate and physiography of Balochistan. In terms of quality, the surface water of the country is vulnerable to pollution from untreated industrial wastes and municipal wastewater, and run off from chemical fertilizers and oil spillage in the

coastal area from the operation of sea and ports.

The pH is also an important variable in water quality assessment as it influences many biological and chemical processes. This concentration is the pH of neutrality and is equal to 7. The pH higher than 7 indicates increasing salinity and basicity while values lower than 7 tend towards acidity *i.e.*, increase in hydrogen ion concentration. Abowei noted that pH higher than 7 but lower than 8.5 is ideal for biological productivity while pH lower than 4 is detrimental to aquatic life[11]. Most organisms including shrimps do not tolerate wide variations of pH over time. And if such conditions persist, death may occur. Therefore, waters with little change in pH are usually more conducive to aquatic life. High alkaline pH can occur in eutrophic reservoirs where the green plants accumulate high amounts of CO<sub>2</sub> during the day for photosynthetic activity. Low water pH most frequently occurs during the spring, especially when acidified snow melts. EPA recommended water quality criteria that pH should not exceed the established limits for open ocean waters, *i.e.*, the optimal pH range for fish is from 6.5 to 8.5[12]. Both alkaline and acidity pH values have a negative impact on fish especially their gills. In the present study, the hydrogen ion concentration of pH ranged between 7.08 and 8.95. The highest pH values were recorded in summer of 2004 and the lowest was recorded in both autumn of 2005 and summer of 2006. The optimal value of pH was in July and the minimal value of pH was in August. *Sardinella* spp. can bear wide ranges of temperature, pH, salinity and DO. Comparative investigation of physicochemical factors of water and the growth of *Sardinella* spp. indicated the condition of species was influenced by the differences in the values of physicochemical parameters of Balochistan coast of Pakistan.

The amount of DO in water is very important for aquatic organisms. Oxygen is essential to all forms of aquatic life, including those organisms responsible for the self-purification processes in natural waters. DO affects the growth, survival, distribution, behavior and physiology of shrimps and other aquatic organisms[13]. Oxygen distribution also strongly affects the solubility of inorganic nutrients since it helps to change the redox potential of the medium. It can determine whether the environment is aerobic or anaerobic[11]. The solubility of oxygen decreases as temperature and salinity increase. DO criteria may be used appropriately in a risk assessment framework[14]. EPA estimated the water quality criteria based on the available data of DO concentrations necessary to protect aquatic life and uses associated with aquatic life[12]. It is indicated that DO can be the criteria for saltwater because hypoxia is a significant problem for certain coastal waters[12]. As a stressor, hypoxia can occur naturally but can not controlled directly[14]. Oxygen concentration is an important factor for aquatic life. There is a relationship between water temperature and fish metabolic rate. In the natural surface of water, fish can easily tolerate the seasonal changes in temperature. However, if the water temperature change suddenly, the impact on fish will become negatively. For aquatic animals, extended periods of DO below 5 mg/L can cause adverse effects to larval life-stages[12]. Oxygen is essential in aerobic organisms and its insufficiency at the mitochondria results in reduction in cellular energy and a subsequent loss of ion balance in cellular and circulatory fluids. If this condition persists, death will ultimately occur[14]. EPA suggests that if DO exceeds the chronic protective value (4.8 mg/L) for growth, the site meets objectives for protection, which if it is below the limit (2.3 mg/L) for juvenile and adult survival, the site does not meet objectives for protection[14]. However, if the DO is between these values, the site requires evaluation of duration and intensity of

hypoxia to determine suitability of habitat for the larval recruitment objective[14]. In the present study, DO concentrations were more than 5 mg/L. Natural water is usually replenished with DO fifty-fifty in a balanced manner with air[15]. Normally, decrease in DO takes place owing to some factors as rise in water temperatures respiration of plants and animals and mingling of toxic materials.

Water is the most vital element among the natural resources, and is crucial for the survival of all living organisms. Water quality guidelines provide basic scientific ecologically relevant toxicological threshold values to protect specific water uses. Important physical and chemical parameters influencing the aquatic environment are temperature, rainfall, pH, salinity, DO and carbon dioxide. These parameters are the limiting factors for the survival of aquatic organisms (flora and fauna). The use of water quality indices simplifies the presentation of results which related to water body and they are based on the biological parameters as well as the values of various physicochemicals in the coastal waters.

The Balochistan coast of Pakistan is highly polluted due to direct or indirect discharge of untreated industrial and domestic wastes. Common sense suggests that waste waters discharged into the sea influence the physicochemical properties of the sea waters, particularly used for recreational purpose and having an economic value for the city[16]. However, no remarkable variation was observed in the distribution of salinity, DO and pH in the stations during the period of 3 years. In conclusion, the results of the present study indicated that these parameters of Balochistan coast of Pakistan is not dangerous for marine habitat and the use of these parameters in monitoring programs to assess ecosystem health has the potential to inform the general public and decision-makers about the state of the coastal ecosystems.

Water quality of the coastal environment effects on aquatic organisms. However, the use of coastal areas for permanent human settlements, shipping and untreated domestic, industrial and agricultural wastes drain into the sea via the rivers can directly change the quality of the coastal waters[17,18]. To keep a clean marine environment, studies should be done and decisions should be taken. Therefore, the main goals are to reduce the number of pollution incidents in watercourses, eliminate the sources of pollutants, and minimize the consequences of accidental discharges on marine ecosystem. In order to prevent the local marine pollution in the coastal cities drainage and treatment/discharge systems should be built[19,20]. Khattak *et al.* strongly suggested that the government organizations and non-governmental organizations should take seriously actions for the environmental pollution[8].

### Conflict of interest statement

We declare that we have no conflict of interest.

### Acknowledgements

This work was supported by University of Karachi for scientific research project.

### Comments

#### Background

Marine environment is one of the most vital elements among the natural resources, and is crucial for the survival of living organisms,

food production, and economic development. In terms of quality, the surface water of the Balochistan coast, Pakistan is vulnerable to pollution from untreated industrial effluents and domestic wastes, and run off from chemical fertilizers, oil and fishing activities in the coastal area. The present study evaluates common physicochemical parameters of water in the Balochistan coast, as it affects the environment, ultimately to the aquatic life.

### Research frontiers

The present study is based on physicochemical parameters in coastal waters collected from Balochistan coasts during January, 2004 and December, 2006. The variation in physicochemical parameters like salinity, temperature, DO and pH at Gwadar (Coastal water of Balochistan) were recorded. These physicochemical parameters related with the diversity of *Sardinella* spp. occurring in the area.

### Related reports

In addition to the biological parameters about the *Sardinella* spp., information pertaining to physical and chemical parameters prevalent in the Gwadar area was also recorded. Temperature of the water was recorded both with the help of mercury thermometer fitted in the water sampler and also by a separate mercury thermometer (range 0-30 °C), but the two method did not show any difference. The chemical factors were determined in the laboratory. The pH of the water sample was observed in the field by Merck's pH paper No.9526 D6100-Drames. salinity, DO was measured by volumetric methods.

### Innovations and breakthroughs

This study aimed to determine common physicochemical parameters of coastal water. Results showed that these parameters of Balochistan coast of Pakistan is not dangerous for marine habitat. The main goals are to reduce the number of pollution incidents in watercourses, eliminate the sources of pollutants, and minimize the consequences of accidental discharges on marine ecosystem.

### Applications

In the developing countries, industries are growing in an unplanned way and domestic wastes are becoming chronic problem. Balochistan coast is facing pollution problem recently. The main causes of water quality degradation in the Balochistan coast are related to land-based activities and pollutants that enter the riverine environment or direct to the coast originate on land from industrial, agricultural, domestic and fishing activities. To save the productivity and other resources of coastal water, it is very essential to study on marine coastal pollution.

### Peer review

In Pakistan, industrial development, intensive tourism, fishing activities and economic growth are all highly influenced by the quality and quantity of coastal waters. Seasonal availability of surface water is highly responsive to the monsoon climate and physiography of Balochistan. In terms of quality, the surface water of the country is vulnerable to pollution from untreated industrial wastes and municipal wastewater, and run off from chemical fertilizers and oil spillage in the coastal area from the operation of sea and ports. The physicochemical properties of water samples from the coast of Balochistan (2004-2006) were presented for the period of three years.

## References

- [1] Odum EP. *Fundamentals of ecology*. Philadelphia: W.B. Saunders Co.; 1971, p. 574.
- [2] Boyd CE. *Water quality in warm water fish ponds*. Alabama: University Press; 1979, p. 59.
- [3] Largler KF, Badach JE, Miller RR, Passimo DRM. *Ichthyology*. New York: John Wiley and Sons Inc.; 1977, p. 506.
- [4] Suski CD, Killen SS, Keiffer JD, Tufts BL. The influence of environmental temperature and oxygen concentration on the recovery of largemouth bass from exercise: implications for live-release angling tournaments. *J Fish Biol* 2006; **68**: 120-136.
- [5] Ramanathan N, Padmavathy P, Francis T, Athithian S, Selvaranjitham N. *Manual on polyculture of tiger shrimp and carps in freshwater*. Thothukudi: Tamil Nadu Veterinary and Animal Sciences University, Fisheries College and Research Institute; 2005, p. 1-161.
- [6] Mukhtar I, Hannan A. Constrains on mangrove forests and conservation projects in Pakistan. *J Coast Conserv* 2012; **16**: 51-62.
- [7] Waqas U, Hasnain SA, Ahmad E, Abbasi M, Pandrani A. Conservation of green turtle (*Chelonia mydas*) at Daran beach, Jiwani, Balochistan. *Pakistan J Zool* 2011; **43**(1): 85-90.
- [8] Khattak MI, Khattak MI, Mohibullah M. Study of heavy metal pollution in mangrove sediments reference to marine environment along the coastal areas of Pakistan. *Pak J Bot* 2012; **44**(1): 373-378.
- [9] Apha. *Standard methods for the examination of water and wastewater: centennial edition*. Washington, D.C.: American Public Health Association; 2005.
- [10] Turkish Environmental Regulations: Water Pollution Control Regulation Law No: 2872, Official Gazette No: 25687. (December 13, 2004).
- [11] Abowei JFN. Salinity, dissolved oxygen, pH and surface water temperature conditions in Nkoro River, Niger Delta, Nigeria. *Adv J Food Sci Technol* 2010; **2**(1): 16-21.
- [12] EPA. *National recommended water quality criteria: 2002*. Washington D.C.: EPA; 2002. [Online] Available from: [http://water.epa.gov/scitech/swguidance/standards/upload/2008\\_04\\_29\\_criteria\\_wqctable\\_nrwqc-2002.pdf](http://water.epa.gov/scitech/swguidance/standards/upload/2008_04_29_criteria_wqctable_nrwqc-2002.pdf) [Accessed on 27th September, 2014]
- [13] Solis NB. Biology and ecology of penaeus monodon. In: *Biology and culture of Penaeus monodon*. Iloilo: SEAFDEC Aquaculture Department; 1988, p. 3-36.
- [14] EPA. *Ambient aquatic life water quality criteria for dissolved oxygen (saltwater): cape cod to cape hatteras*. Washington D.C.: EPA; 2000, p. 55. [Online] Available from: [http://water.epa.gov/scitech/swguidance/standards/upload/2007\\_03\\_01\\_criteria\\_dissolved\\_docriteria.pdf](http://water.epa.gov/scitech/swguidance/standards/upload/2007_03_01_criteria_dissolved_docriteria.pdf) [Accessed on 27th September, 2014]
- [15] Lloyd R. *Pollution and freshwater fish*. Oxford: Fishing News Books; 1992, p. 176.
- [16] Gökkurt O, Bat L, Şahin F. *The investigation of some physico-chemical parameters in the middle Black Sea (Sinop, Turkey)*. VII. İzmir: Ulusal Çevre Mühendisliği Kongresi; 2007. Turkish.
- [17] Bat L, Gökkurt O, Sezgin M, Üstün F, Sahin F. Evaluation of the Black Sea land based sources of pollution the coastal region of Turkey. *Open Mar Biol J* 2009; **3**: 112-124.
- [18] Bat L, Gökkurt Baki O. Seasonal variations of sediment and water quality correlated to land-based pollution sources in the middle of the Black Sea coast, Turkey. *Int J Mar Sci* 2014; **4**: 108-118.
- [19] Gökkurt O. [The effects of potential sewage points to the water quality and the organisms on the coast of Sinop][dissertation]. Samsun: Ondokuz Mayıs University, Institute of Science; 2007. Turkish.
- [20] Gökkurt Baki O. [Coastal management in Sinop Province][dissertation]. Samsun: Ondokuz Mayıs University, Institute of Science; 2011. Turkish.