Hydrographical studies on mangroves ecosystem of the Red Sea Coast of Yemen from Al-Salif to Bab-el-Mandeb Strait

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Abstract

A study was conducted on Hydrographical Studies on Mangroves Ecosystem of the Red Sea Coast of Yemen from Al-Salif to Bab-el-Mandeb Strait, during the months of January, April, August and Octobe,r chosen to represent the four seasons of a full year 2013. Data on temperature, salinity and pH were obtained from the field. Dissolved oxygen was determined in the laboratory by Winkler method. Air temperature varied between (**28.3 - 36.6**) °C, with mean value **31.89**°C; water temperature ranged between (**27.3 - 35.6**)°C with mean value **31.27** °C; salinity ranged between (**42 - 54**) **‰**, with mean value **45.68 ‰**; pH values ranged between (**7.5 - 8.04**), with the mean value **7.74** pH; dissolved oxygen values ranged between (**3.2 - 8.2**) **mg /L**, with the mean value **5.83 mg /L**. This study is baseline data toward future ecological study, conservation and management of the resources of this economically important wetland in Red Sea Coast of Yemen.

Key words: Hydrographical Studies, Mangrove, Red Sea, Yemen.

Introduction

The Red Sea is located in an arid region; the weather is characterized by extremely high temperatures, particularly in summer, increasing from the northern to the southern area. Moreover, the southern part of the Red Sea is considered as one of the hottest regions in the world (22).

These geographic and climatic conditions, leading to a low freshwater input, due to either continental runoff or precipitation, a high evaporation rate, make the Red Sea one of the hottest and saltiest bodies of seawater in the world (5). The climate of the Red Sea is characterized by two distinct seasons, under the influence of the north-east monsoon (winter) and the southwest monsoon (summer), respectively (16).

Mangrove forests are among the most productive and biologically important ecosystems of the world because they provide important and unique ecosystem goods and services to human society and coastal and marine systems (19,15,11). Temperature is a limiting factor in the aquatic environment (18,7). Water temperature is probably the most important environmental variable. It affects metabolic activities, growth, feeding, reproduction, distribution and migratory behaviors of aquatic organisms (13,8,21). It affects solubility of gasses in water, gas solubility decreases with increased temperature (14). Temperature is affected by time of the day; high temperatures may be recorded in daytime and become low at night. It may cause thermal stratification occurring in the oceans.

Hydrogen ion concentration, or pH as one of the vital environmental characteristics, decides the survival, metabolism, physiology and growth of aquatic organisms (20). Recommended optimum range of pH (6.8 - 8.7) for the maximum growth and production of shrimp and carp. pH is influenced by acidity of the bottom sediment and biological activities. High pH may result from high rate of photosynthesis by dense phytoplankton blooms. pH that is higher than7, but lower than 8.5, according to(1). Is ideal for biological productivity, but pH at < 4 is detriment-tal to aquatic life. pH may be affected by total alkalinity and acidity, run off from surrounding rocks and water discharges.

Salinity (S‰) is a dynamic indicator of the nature of the exchange system. It is expressed as the total concentration of electrically charged ions (cations) in water in part per thousand (‰). The cations include CO_3^-, SO_4^{2-}, Cl^- , HCO_3^- , NO_3^- , NH_4^+ , PO_4^{3-} (1,14). It is expressed 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.

The salinity of water within the estuary tells us how much fresh water has been mixed with sea water. Oxygen solubility decreases slightly as salinity increases, but oxygen solubility decreases more as temperature goes up regardless of salinity. The solubility of oxygen in seawater is 21% less than that of freshwater at 32 degrees Fahrenheit and 17 % less than that of freshwater at 100 degrees Fahrenheit. Oxygen solubility in freshwater decreases from 14.6 to 8.24 mg/L as temperature rises from 32 to 100 degrees. This is a 46.3% decrease (14).

On the other hand, oxygen solubility in seawater decreases from 11.5 to 6.75 mg/L for this same temperature increase, a decreased oxygen solubility of 41.3% (14).

The salt concentration directly affects the salinity which impacts circulation with estuaries and coastal regions can derive from or be strongly influenced by the density variation associated with salinity. In effect, dense saline water tends to flow under fresh water. Salinity is an important ecological parameter in its own right; and it is important in some chemical processes.

Dissolved oxygen (DO) affects the solubility of availability of nutrients. Its low levels can result in damages to oxidation state of substances from the oxidized to the reduced form; thereby increasing the levels of toxic metabolites. Dissolved carbon dioxide in aquatic environment increases with decreased dissolved oxygen. It is an important parameter in primary production and phytoplankton biomass. Water Acidity increases with increased dissolved carbon dioxide. High rate of dissolved carbon dioxide is detrimental to survival, physiology and metabolic activities of aquatic animals; including fish. Industrial, farming, mining and forestry activities also significantly affect the quality of water (9&14).

Farming increases the concentration of nutrients, pesticides and suspended sediments. Industrial activities also increase concentrations of metals and toxic chemicals, add suspended sediment, increase temperature and lower dissolved oxygen in the water. Each of these effects can have a negative impact on the aquatic ecosystem and/or make water unsuitable for established or potential uses.

The pH of a water body influences the concentration of many metals by altering their availability and toxicity. Metals, such as zinc and cadmium, are most likely to have increased detrimental environmental effects as a result of lowered pH (9). Temperatures, at which environmental samples are collected and at which physico-chemical measurements are made, are important for data correlation and interpretation. For instance, for domestic use, high temperatures may increase the toxicity of many substances such as trace metals in water. In addition to microbial activities within an aquatic medium, temperature and pH are two important factors that govern the methylation of elements such as lead and mercury(23).

The wetlands, including the mangrove swamps of Lagos lagoon, are one of the most productive ecosystems in the world. They are very important economically in fishing, agriculture, husbandry, reed production, ecological tourism, educational and scientific researches. Therefore, the accurate determinations of heavy metals and other physical and chemical parameters in aquatic environment are of ultimate important for controlling their pollution. This study aims at providing additional information to existing data on water quality assessments of this important water body.

Materials and Methods

Study Area:

The Yemen Red Sea coast is ca 760 km in length (12), extending from the Saudi Arabian border in the north, at approx. 16° 22' N to the entrance to the Red Sea at Bab-el-Mandeb in the south, at approx. 12° 30' N. Area of mangrove habitats in Yemen was estimated to be approx. 22.55 km^2 (17). Five selected locations that represent different sectors of mangrove ecosystem of the Red Sea coast of Yemen from Al-Salif in the north at 15° 12' N to Ghorairah in Bab-el-Mandeb Strait in the south at 12° 44' N (Fig. 1).

Sampling was carried out during the months of January, April, August and October, chosen to represent the four seasons of a full year 2013

Selected Locations of these samples were fixed by digital *Garmin eTrex Vista C* GPS.

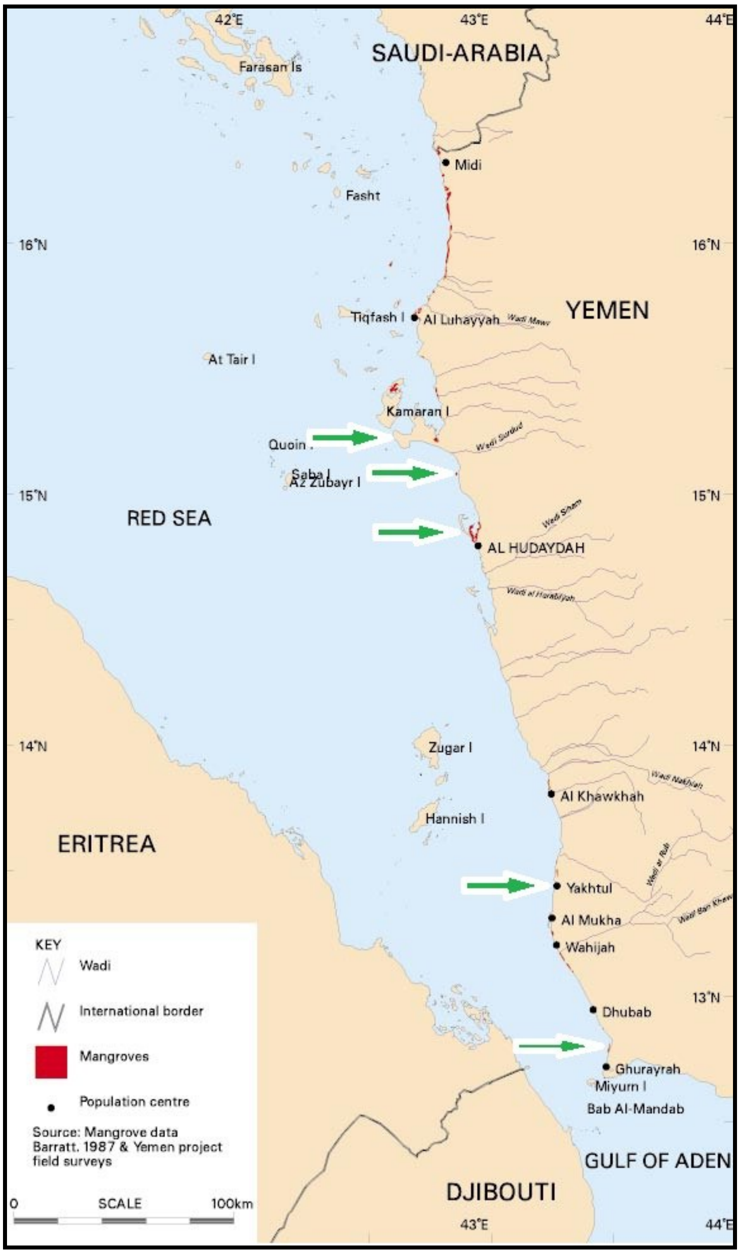

Fig. 1. Distribution of mangrove habitats along the Red Sea coastal zone of Yemen. Arrows indicate locations of Study Area (6)

Sample collection and analysis:

All the analyses were based on standard methods as appropriate to each water quality parameter, as prescribed in the (4). The equipments used in the experiments were included:

The air and water temperatures were measured at the sampling sites with a mercury thermometer calibrated to 0.1 °C. 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 four to five minutes. For water temperature, the thermometer was immersed in water 6 cm below the water surface and left to stabilize for about five minutes. The average values temperatures were recorded in °C.

The pH was determined with a pocket pH-meter Ezodo model 5O11A with range (0.00–14.00) pH and Accuracy ± 0.02. The electrodes were immersed in water samples, stir gently and wait until the display stabilized Standardization was done, using buffer solutions of pH values of 4, 7, and 9.

Fixing of dissolved oxygen was carried out in the field. 1000 ml. of water was measured into a clean oxygen bottle and flushed several times until all air bubbles escaped. 2 ml of Winkler's solution I ($MnSO_4$ solution) and another 2 ml of Winkler's solution II (KI + NaOH solution) were added to the bottle using a pipette.

The bottle was closed and thoroughly shaken to ensure proper mixing. A brown precipitate forms at the bottom of the bottle after this process. The bottle was then stored in a wooden box out of direct sun light and transported to the laboratory for further analysis.

Salinity was measured with a hand-held *refracto-meter* (*ATAGO*, Japan), with range: (*0 – 100*)‰.

Results and Discussion

The results of Hydrographical Studies from the five locations that represent different sectors of mangrove ecosystem along the Red Sea coastal zone of Yemen from Al-Salif to Bab-el-Mandeb Strait are presented in Table 1and 2.

Air temperature:

It ranged from (**28.3- 36.6**) °C with mean value of **31.89** °C. The minimum value is at Ghorairah in October, while the maximum value was at Al-Hodeidah in August. Air temperature showed seasonal variations due to climatic conditions. It is clear that the seasonal variations of air temperature followed the weathering area.

Water temperature:

Surface water temperature ranged from **27.3 - 35.6**°C, with mean value of **31.27** °C. The minimum value is at Al-Salif in January, while maximum value is at Al-Salif in August. It is clear that the variations of water temperature followed those of the air.

Variations of water temperatures in different season are mostly controlled by heating effect of the sun in these coastal water. Generally, the variations reflecte the conditions of the warm subtropical zone of the southern Red Sea.

Salinity (‰=ppt):

It ranged from **42 - 54 ‰**, with mean value of **31.9‰**. The minimum value is at Al-Hodeidah in January, while maximum value is at Al-Salif in August.

These variations may be mainly due to local hydrographic condition, for example, semi-isolated, intensive evaporation and restricted circulation (2).

Table .1: The results of Air and Water temperature during the Months of January, April, August and October 2013, in Mangrove ecosystem of the Red Sea coast of Yemen from Al-Salif to Bab-el-Mandeb Strait

Location	Latitude (N) Longitude (E)	Months	Air temp.°C	Water temp. °C
Al-Salif	15° 12' 35.9" N 42° 46' 16.1" E	January	28.5	27.3
		April	30.2	33.1
		August	36.3	35.6
		October	29.1	28.2
Al-Urj	15° 05' 51.6" N 42° 52' 16.7" E	January	29	28.6
		April	31.2	32.3
		August	34.1	33.2
		October	30.4	28.4
Al-Hodeidah	14° 52' 02.7" N 42° 57' 10.0" E	January	30.6	29.1
		April	33.7	34.2
		August	36.6	34.4
		October	31.2	29.6
Yakhtol	13° 31' 03.0" N 43° 15' 55.7" E	January	30.4	28.5
		April	34	34.7
		August	35.5	34.2
		October	30.1	29.5
Ghorairah	12° 44' 33.9" N 43° 28' 22.3" E	January	29.3	27.5
		April	33.5	35.2
		August	35.8	34.4
		October	28.2	27.4
Mean			31.89	31.27
Range			28.2 - 36.6	27.3 - 35.6
±SD			2.77	3.07

Hydrogen ion concentration (pH) variations:

It ranged from **7.5 - 8.04** with the mean value **7.74.** The minimum value is at Al-Salif in October, while maximum value is at Al-Salif in January.

The general pattern of the surface horizontal distribution of pH gave local variations mainly due to the climatic conditions and consequently water temperature, as well as dissolved oxygen content and biological activity (10,3)

Dissolved oxygen (DO):

The values ranged from **3.2 - 8.2 mg /L**, with the mean value **5.83 mg /L**. The minimum value is at Al-Urj in October, while maximum value is at Al-Salif in April. These fluctuations may be attributed to several hydrogra-phical and biological conditions prevailing at various locations.

Table .2: The results of Salinity, pH, Dissolved oxygen during the months of January, April, August and October 2013, in Mangrove ecosystem of the Red Sea coast of Yemen from Al-Salif to Bab-el-Mandeb Strait

Location	Months	Salinity (‰=ppt)	pH	Dissolved O_2(mg/L)
Al-Salif	January	46	8.04	7.4
	April	50	7.85	8.2
	August	54	7.70	6.2
	October	48	7.50	6.8
Al-Urj	January	43	7.60	4.6
	April	45	7.65	5.1
	August	47	7.54	3.8
	October	44	7.83	3.2
Al-Hodeidah	January	42	7.68	5.8
	April	43	7.75	7.7
	August	44	7.64	5.1
	October	43	7.54	5.3
Yakhtol	January	45	7.98	5.9
	April	47	7.82	6.8
	August	48	7.88	5.4
	October	45	7.63	5.7
Ghorairah	January	44	8.01	6.3
	April	45	7.58	7.1
	August	46	7.76	5.4
	October	44.5	7.73	4.8
Mean		45.68	7.74	5.83
Range		42 - 54	7.5-8.04	3.2-8.2
±SD		2.80	0.16	1.27

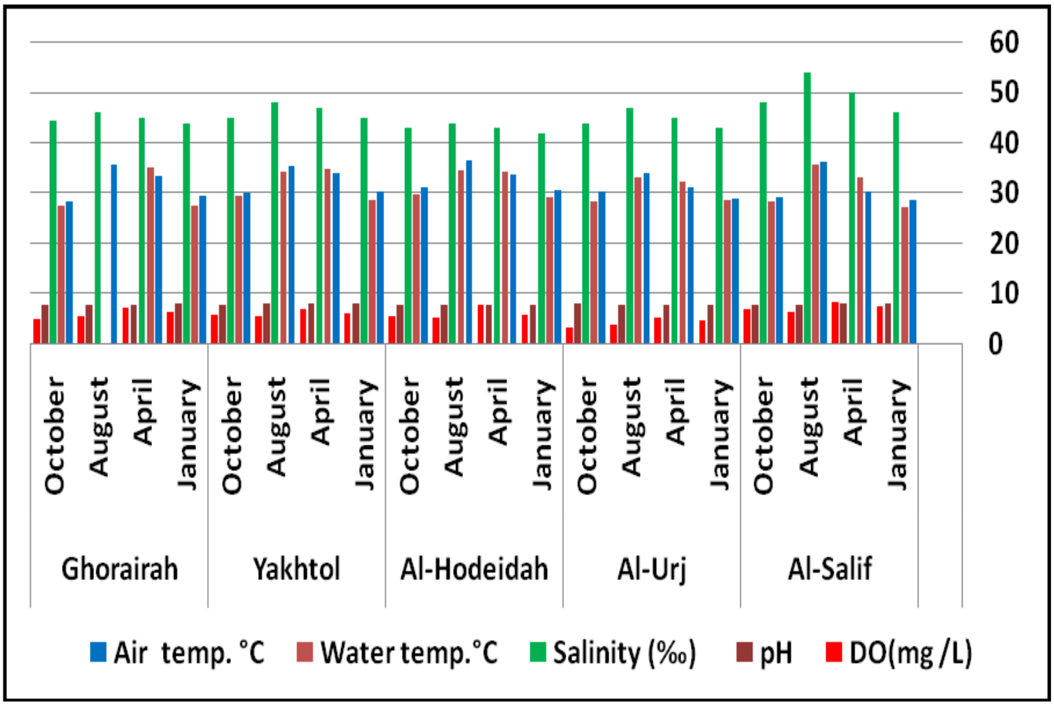

Fig 2: The results of Air and Water temperature, Salinity, pH, Dissolved oxygen in the study area

Conclusion

The main conclusion of the present study is that the hydrographical parameters, like air and water temperature, salinity, PH, and dissolved oxygen, should be monitored so that a better appraisal of the survey data could be made. The difference between the values may be mainly due to local hydrographical condition; for example, semi-isolated shores, intensive evaporation, restricted circulation, and several biological conditions prevailing at various locations.

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الدراسات الهيدروغرافية على النظام الإيكولوجي لأشجار المانجروف للساحل البحر الأحمر اليمني من الصليف إلى مضيق باب المندب

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الملخص

تختص الدراسة الحالية هيدروغرافية المياه في النظام الإيكولوجي لأشجار المانجروف للساحل البحر الأحمر اليمني من الصليف إلى مضيق باب المندب، خلال أشهر يناير، إبريل، أغسطس وأكتوبر لتمثيل الفصول الأربعة لعام 2013. البيانات عن درجة الحرارة، الملوحة ودرجة الحموضة تم الحصول عليها من الحقل. الأكسجين الذائب تم تحديده في المختبر باستخدام طريقة وينكلر. درجة حرارة الهواء تباينت بين (**28,3- 36,6**) درجة مئوية، مع قيمة متوسطة **31,89** درجة مئوية، وتراوحت درجة حرارة المياه ما بين (**27,3- 35,6**) درجة مئوية، مع قيمة متوسطة **31,27** درجة مئوية، وتراوحت نسبة الملوحة ما بين (42– **54**)‰ ، بمتوسط قيمة **45,68‰**؛ وتراوحت قيم درجة الحموضة بين (**7,5 – 8,04**) مع متوسط قيمة **7,74** درجة الحموضة؛ وتراوحت قيم الأكسجين الذائب بين (**8,2**–3,2) ملغم/لتر، مع قيمة متوسطة **5,85** ملغم /لتر. هذه الدراسة وإدارتها تعد بيانات أساسية نحو الدراسات الإيكولوجية المستقبلية، وحفظ موارد هذه الأراضي الرطبة ذات الأهمية الاقتصادية في ساحل البحر الأحمر اليمني.

الكلمات المفتاحية : الدراسات الهيدروغرافية، المانجروف، البحر الأحمر، اليمن.