Types of Coral Reefs, Ecology and Biodiversity Index from Hadhramout Waters, Gulf of Aden, Yemen

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Abstract

The present study was carried out to identify the types of coral reefs; and to highlight the importance and biodiversity index for these species ecology from Hadhramout waters, Gulf of Aden. Environmental factors were taken only in Burum and Khelf sites: oxygen dissolved, water temperature, pH, salinity, turbidity and sedimentation. Qualitative survey was done at nine sites in the coastal waters: Husihasa, Jelkha, Burum , Khelf, Al-Quran, Ras Qusiayr, Ras Sharma, Ras Baghashawa and Sharma Island during the period from 2015 until 2016. At each site, all scleractinian coral species were observed using scuba dives. The survey of sampling was taken using a 50m belt transect line technique. The results showed that there were no significant differences (P>0.05) between Burum and Khelf site regarding the environmental factors. In Burum site, the maximum value of sedimentation which was sunk on coral reef was 7.89 g compared to 5 g in Khelf site. In all sites, the types of coral reefs found: Turbinaria, Leptoseris, Coscinaraea, Cycloseris (fungia), Acanthastrea, Porites, Parasimplastrea, Montipora, Psmmocora, Anomastraea, Siderastrea, Astreopora, Blastomussa, Favites, Platygyra, Leptoria, Acropora, Goniastrea and Pavona. Generally, the type of Acropora was more available in all sites compared to other type of coral reefs. The biodiversity index was the best in Burum (J= 0.94) followed in Ras Qusair (J= 0.91) compared to other sites. From the results, it can conclude that in general the type of Acropora was more obtainable on the Island of Maqrugha (40%) and Yelkha (27%) compared to other sites.

Keywords: coral reef types, environmental factors, biodiversity index

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أنواع الشعاب المرجانية ، مؤشر البيئة والتنوع البيولوجي من مياه حضرموت ، خليج عدن ، اليمن

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كلية البيئة والأحياء البحرية ، جامعة حضرموت.

** طالب ماجستير في قسم الأحياء البحرية

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الملخص:

أجريت الدراسة الحالية للتعرف على أنواع الشعاب المرجانية، ولإبراز أهمية مؤشر التنوع البيولوجي لبيئة هذه الأنواع من مياه حضرموت وخليج عدن. تم أخذ العوامل البيئية فقط في موقعي بروم والخلف: الأكسجين المذاب ودرجة حرارة الماء ودرجة الحموضة والملوحة والعكارة والترسيب. وتم إجراء مسح نوعي في تسعة مواقع في المياه الساحلية: حصيصة ، جلخة ، بروم ، خلف ، القرن ، رأس قصير ، رأس شرما ، رأس باغشوه وجزيرة شرما خلال الفترة من 2015 حتى 2016. وسجلت في كل الموقع جميع أنواع الشعاب المرجانية الصلبة باستخدام الغطس. وتم أخذ العينات باستخدام تقنية حزام الخط المقطعي بطول 50 م. أظهرت النتائج عدم وجود فروق ذات دلالة إحصائية (P> 0.05) بين موقع بروم وخلف فيما يتعلق بالعوامل البيئية. في موقع بروم كانت أقصى قيمة للترسيب على الشعاب المرجانية 7.89 جرام مقابل 5 جرام في موقع خلف. في جميع المواقع ، تم العثور على أنواع الشعاب المرجانية: Turbinaria، Leptoseris، Coscinaraea، Cycloseris (الفطريات) ، Acanthastrea، Porites، Parasimplastrea، Montipora، Psmmocora، Anomastraea، Siderastrea، Astreopora، Blastomussa، Favoraites، Litropatyra، Pavona. بشكل عام ، كان نوع Acropora متاحًا بشكل أكبر في جميع المواقع مقارنة بالأنواع الأخرى من الشعاب المرجانية. كان مؤشر التنوع البيولوجي الأفضل في بروم (J = 0.94) يليه في رأس قصير (J = 0.91) مقارنة بالمواقع الأخرى. من النتائج يمكن أن نستنتج أن نوع Acropora بشكل عام كان أكثر قابلية للحصول عليه في جزيرة مقدحه (40٪) وجلخه (27٪) مقارنة بالمواقع الأخرى.

الكلمات المفتاحية: أنواع الشعاب المرجانية ، العوامل البيئية ، مؤشر التنوع البيولوجي

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Introduction

Coral reef is one of the most biologically diverse ecosystems on Earth and very complex ecological system. However, coral reef ecosystems are in decline due to multiple and interrelated factors, which leading to extinct of many coral species around the word. In generally, biodiversity is defined as the variability of genes, species, and ecosystems in a known area; it is considered the whole life in a specific area (Newmark & William D. , 2002) . (Hooper, et al., 2005) highlighted that there are relationships between biodiversity and ecosystem processes, which is valuable to consider biodiversity in management plans. It is known that coral biodiversity is declining in many ecosystems throughout the world. For example, in tropical forests alone researcher is believed that the species may be losing at a rate of two to five species per hour (Singh, 2002).

Coral reefs are considered resources for thousands of years and contribution with economic value. Millions of people are dependent upon coral ecosystems for protein and other resources. (Veron, et al., 2009) highlighted that coral ecosystems are provided with value between $172 billion and $375 billion annually. Consequently, it is important to protect and conserve biodiversity on coral reefs in order to sustainable coral reefs ecosystem provide. Coral reefs are one of the most important ecological marine for fish, algae and crustacean. It is known that a little literature studies about coral reefs in Gulf of Aden; and according to our information, the present study is the first study on these species from Hadhramout waters, Gulf of Aden, Yemen. Therefore the present study was conducted to identify the types of coral reefs; and to highlight the importance and biodiversity index for these species ecology in order to know their environmental condition leading the management strategies of coral reefs ecology.

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Material and Methodology

Study area

In the present study a qualitative survey was carried out at nine sites in the coastal waters of Hadhramout. The first site is called Husihasa, which is located at latitude 14° 15 .627' N and longitude 48° 54 .228' E. The second site is named Jelkha located at latitude 14° 15 .627' N and longitude 48° 54 .228' E. The third site is Burum located at latitude 14° 35 .735' N and longitude was 48° 49 .845' E; the fourth site is Khelf located at latitude 14° 31 .198' N and longitude 49° 09 .986' E. The fifth site is Al-Quran located at latitude 14° 50.872' N and 50° 00.818' E; the sixth site is Sharma Island located at latitude 14° 49.196' N and longitude 50° 00.904' E. The seventh site is Ras Sharma located at latitude 14° 49.703' N and longitude 50° 01.328' E; the eight site is Ras Baghashawa located at latitude 14° 51.828' N and longitude 50° 11.911' E and the ninth site is Ras Qusiayr located at latitude 14° 45.120' N and longitude 50° 19.592' E . Geographical located of sites were determined using a hand held global position system, GPS (Type: Garmin, Model: ETrex Vista C).

Sampling Method

Sampling was taken placed at nine different sites during the period from 2015 until 2016. At each site, all scleractinian coral species were observed using SCUBA dives. These coral were found at depths between 1m until 13m, taking photograph and recorded underwater. Then, digital images (Sony camera, w630 -16 megabexel 16 and Sealife camera, 14 megabexel) recorders were analyzed per each site using atlas references in order to identify the coral species (Obura, 2015)

The sampling survey was taken as follows: a 50m belt transects line in length was set horizontal to the shoreline. Both ends of the line were held in place with 0.5m wooden pegs. On side of this line, another transect line was set running parallel to it at a distance of 5m between the lines. Stretch the transect line tightly and close to the bottom (0-15cm), then moving slowly along the transect line in order to record the case condition of coral. The coral

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found on both sides of line, about 0.5 m, were defined and counted (Hill & Wilkinson, 2004)

Environmental Factors

Environmental Factors was taken only in Khelf site and Burum sites. All fieldwork measurements were carried out underwater using snorkeling diving for: dissolved oxygen and pH were measured using portable device during the period of experiment. Water temperature was measured using thermometers. These were put inside a piece of iron bar and then fixed among coral colonies. Reading of temperature of seawater was taken twice a month at surface and bottom. Salinity of seawater was measured monthly at surface and bottom using a hand-held salinity refract meter (WTW 720 COND). Three sediment traps was set-up at a suitable depth of each site. These traps comprised plastic tubes with an internal diameter of 5.5cm. They were holding with rubber bands to vertical plastic box driven into the coral rock. The traps were collected monthly. Any macroscopic organisms in sedimentation were removals and at that time the sediments were washed with distilled water. The sediments which collected from the 3 traps were combined and dried at 60^{o}C for 48 hours. After that the sediments were weighed to the nearest 0.1mg on a KERN 120A balance. Rate of sedimentation was calculated according to the following formula: (Hallockp, 2001)

$$\text{Rate of deposit sediments} = \frac{\text{Dry weight of sample}}{\text{area of trap aperture}} \div Time = \text{mg/cm2/d}$$

Turbidity or visibility was determined using horizontal Sec-chi disc reading monthly at depth of 4 or 6 meters.

Statistical Analysis

All statistical analysis was performed using the SPSS software packages, version 23. The environmental factors were analyzed and tested for differences between group means of oxygen dissolved, water temperature, pH, salinity, turbidity and sedimentation for significance ($P<0.05$) using T-test technique. Biodiversity index of Scleractinian corals in different sites were analyzed using Microsoft Excel 2010.

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Results

In the present study the environmental factors: temperature, pH, salinity, dissolved oxygen, turbidity and sedimentation which were taken during March 2015 to February 2016 from two sites Kalf and Burum site of Hadhramout waters, Gulf of Aden. These environmental factors which surrounding the coral reef were used as indicator on health case of coral in the study area.

Chemical Environment Factors

In Khelf site**,** data for the mean of chemical environment factors: the minimum value of surface dissolved oxygen was 4.56 mg/l, whereas the maximum value was 7.1 mg/l. But, the minimum value of bottom dissolved oxygen was 4.02 mg/l, whereas the maximum value was 6.6 mg/l. On the other hand, the minimum value of surface pH was 7.35, whereas the maximum value was 8.28. However, the minimum value of bottom pH was 7.35, whereas the maximum value was 8.25.

In Burum site**,** data for the mean of chemical environment factors: the minimum value of surface dissolved oxygen was 4.47 mg/l and the maximum value was 7.22 mg/l. But, the minimum value of bottom dissolved oxygen was 4.01 mg/l and the maximum value was 7.3 mg/l. On the other hand, the minimum value of surface pH was 7.69 and the maximum value was 8.32. However, the minimum value of bottom pH was 7.79, whereas the maximum value was 8.31. The statistical analysis between Khelf and Burum site regarding the chemical environment factors shown that there were no significant differences ($P>0.05$), when independent T-Test technique was used.

Physical Environment Factors

In Khelf site, data for the mean of physical environment factors: the minimum value of surface water temperature was 22.6, whereas the maximum value was 28.5. But, the minimum value of bottom water temperature was 22.8 and the maximum value was 28.2. The minimum value of surface salinity was 34.6, whereas the maximum value was 36. The minimum value of bottom salinity was 34.6 and the maximum value was 36.2.

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The minimum value of surface turbidity was 0.74, whereas the maximum value was 11.56. However, the minimum value of bottom turbidity was 0.66 and the maximum value was 7.71. Besides, the minimum value of sedimentation which was sunk on coral reef was 2.87 g, whereas the maximum value was 5.12 g (mean: 3.94).

In Burum site**,** data for the mean of physical environment factors: the minimum value of surface water temperature was 23.2, whereas the maximum value was 28.8. But, the minimum value of bottom water temperature was 21.4 and the maximum value was 28.7. The minimum value of surface salinity was 34.5, whereas the maximum value was 36. The minimum value of bottom salinity was 34.4 and the maximum value was 36.1. The minimum value of surface turbidity was 1.58, whereas the maximum value was 7.62. However, the minimum value of bottom turbidity was 1.43 and the maximum value was 7.3. Besides, the minimum value of sedimentation which sinks on coral reef was 3.45 g , whereas the maximum value was 7.89 g, the (mean: 5.35g).

The statistical analysis between Burum and Khelf site regarding the physical environment factors shown that there were no significant differences ($P>0.05$), when independent T-Test technique was used.

Distribution Patterns of Scleractinian Coral

Data for distribution patterns of Scleractinian corals in different sites: Ras Qusair, Ras Baghashawa, Ras Sharma and Maqrugha Island as follows. The present of some genus of coral was the following: In Ras Qusair, the percentage of *Acropora* was the highest (28%), whereas the Leptoseris was the lowest (3%). Also, in Ras Baghashawa, the highest percentage was 48 % of Acropora, whereas the lowest was 2% of *Parasimplastrea and Pavona*. In Ras Sharma, the highest percentage was 28% related *Anomastraea*, whereas the lowest was 2% linked Pavona. Besides, on the Island of Maqrugha the highest percentage was 25% connected *Acropora*, whereas the lowest was 1% related the types of *Turbinaria*, *Parasimplastrea*, *Psmmocora* and *Blastomussa*. Generally, the type of *Acropora* was more available on the Island of Maqrugha (40%) compared to other sites. The biodiversity index

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was the best in Ras Qusair (J= 0.91) compared to other sites as shown in Table 1.

Table 1: Biodiversity index of Scleractinian corals in different sites: Ras Qusair, Ras Baghashawa, Ras Sharma and Maqrugha Island

Sites / Biodiversity Index	Ras Qusair	Ras Baghashawa	Ras Sharma	Maqrugha Island
H	0.8724	0.7125	0.8321	0.831
J	0.9142	0.7467	0.8720	0.8708

On the other hand, data regarding the distribution patterns of Scleractinian corals in different sites: Al-Quran, Khalf, Burum, Yelkha and Husihasa as follows. The present of some types of coral was the following: in Al-Quran, the percentage of *Acropora* was the highest (43%), whereas the lowest was 2% for *Parasimplastrea* and *Siderastrea*. Also, in Khalf, the highest percentage was 34 % of *Acropora*, whereas the lowest was 3% related *Porites, Montipora, Montipora* and *Psmmocora*. In Burum, the highest percentage was 17% related *Pavona*, whereas the lowest was 2% linked *Acanthastrea* and *Favites*. In Yelkha the highest percentage was 51% connected *Acropora*, whereas the lowest was 1% related the types of *Astreopora*. Besides, in Husihasa the highest percentage was 34 % linked *Acropora*, whereas the lowest was 1% connected *Coscinaraea*, *Astreopora*, *Platygyra* and *Goniastrea*. Moreover, the type of *Acropora* was more found in Yelkha (27%) compared to other sites. The biodiversity index was the best in Burum (J= 0.94) compared to other sites as shown in Table 2.

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Table 2: Biodiversity index of Scleractinian corals in different sites: Al-Quran, Khalf, Burum, Yelkha and Husihasa

Sites / Biodiversity Index	Al-Quran	Khalf	Burum	Yelkha	Husihasa
H	0.7325	0.8545	0.9438	0.6849	0.739
J	0.7325	0.8545	0.9438	0.6849	0.739

Discussion

It is known that the environmental factors which surrounding the coral reef were used as indicator on health case of corals reefs. In the present study, the mean of chemical environment factors at Khelf site and Burum sites were shown the value of dissolved oxygen at surface water was higher; than the value of dissolved oxygen at bottom water. The statistical analysis between Khelf and Burum site regarding the surface dissolved oxygen and bottom dissolved oxygen show that there were no significant differences ($P>0.05$). These explanations probably indicate that the concentration of dissolved oxygen was high at surface water because of the upper layers of water connected directly with oxygen of atmosphere; as well as the phytoplankton produces oxygen at this layer compared to bottom water; in which biological process of analysis organic materials with bacteria leading to reduce concentration of dissolved oxygen as supported by (Horne & Goldman, 1994); (Wetzel, 1983); (Hach, 2007) reported that oxygen changes with depth due to bacteria which analyze the organic materials that sink to the bottom and use up oxygen. Also, (Mesner & Geiger, 2010) that bacteria decay organic waste in water, requiring more oxygen.

For the value of pH at surface water was higher than the value of pH at bottom water at both Khelf sites and Burum site. The statistical analysis between Khelf and Burum site regarding the surface pH and bottom pH were shown no significant differences ($P>0.05$). These explanations probably

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indicate that no changing in pH values due to ability of water to resistance of changing value of pH (Kleypas, Buddemeier, Archer, Gattuso, Langdon, & Opdyke, 1999) ; (Cohen, McCorkle, de Putron, Gaetani, & RoseK, 2009) reported that the ability of corals to secrete their skeletons, which use to settled coral larvae, was upset when pH was low.

Data for the mean of physical environment factors at Khelf site and Burum sites were shown that the value of water temperature, salinity and turbidity at surface water was higher- than the value of them at bottom water. Also, at Khelf site and Burum sites, the mean value of sedimentation which was sunk on coral reef was 3.94 g and 5.35 g, respectively. The statistical analysis between Burum and Khelf site regarding the physical environment factors were shown that there were no significant differences ($P>0.05$). These observations probably indicate that no changing in the physical environment factor values; as well as no effects were observed on coral reefs in these area owing to similar the geographic region of both sites as supported by (Mesner & Geiger, 2010) reported that dissolved oxygen affects with changing water temperature and saltiness. (Veron J. , 2000) mentioned that temperature, salinity and sediment load are affected on coral biodiversity. (Baker, Glynn, & Riegl, 2008) declared that climate change such as rising temperature related to mass coral bleaching and coral mortality. Also, (Sammarcos, 1996) stated that corals have a range of temperatures within 22 to 28^{o}C in order to survive, grow and reproduce, but above or below this range the coral could be bleached. He also said that increasing sedimentation on reef cause negative reef growth.

In the present study, data for distribution patterns of Scleractinian corals (*Turbinaria, Leptoseris, Porites, Parasimplastrea, Montipora, Psmmocora, Anomastraea, Siderastrea, Blastomussa, Favites, Platygyra, Leptoria, Acropora, Goniastrea and Pavona*) in different sites: Ras Qusair, Ras Baghashawa, Ras Sharma and Maqrugha Island showed that in generally the type of *Acropora* was more available on the Island of Maqrugha site (40%) compared to other sites. There was a biodiversity at these sites; the best biodiversity index was in Ras Qusair site (J= 0.91) compared to other sites (Table 1). These observations probably indicate that genus of *Acropora* is more resistance to its surrounding environmental changes than other genus;

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as well as Maqrugha Island site may be more suitable environment to grow *Acropora* compared to other sites as supported by (Alvarez-Filip, Oliver, McClanahan , & Coˆte´, 2012) who mentioned that some coral reef such as *Pocillopora* has characterized of competitive taxon to dominant in its surrounding environment. (Roik, Roder, Ro¨thig, & Voolstra, 2016) reported that *Acropora* is most marked in benthic abundance of the corals. (Roik, Roder, Ro¨thig, & Voolstra, 2016) stated that *Porites, Acropora*, and *Pocillopora* were abundances when environment of calcareous crusts were obtainable. Also, (Gilmour, 1999) and (Cooper, Uthicke, Humphrey, & Fabricius, 2007) mentioned that low present of corals could be related to increasing sedimentation or other coastal disturbances. (Nugues & Roberts, 2003); (Boyer & Bricen˜ o, 2006); (Fabricius, De'ath, McCook, Turak, & Williams, 2005) and (Fabricius K. , 2005) highlighted that coral recruitment could be lower in inshore habitats owing to change in the following: temperature, salinity, nutrients, sedimentation and turbidity. (Yee, Santavy, & Barron, 2008) reported that temperature-induced leading to mass bleaching of coral.

On the other hand, data regarding the distribution patterns of Scleractinian corals (*Turbinaria, Leptoseris, Porites, Parasimplastrea, Montipora, Psmmocora, Anomastraea, Siderastrea, Blastomussa, Favites, Platygyra, Leptoria, Acropora, Goniastrea and Pavona*) in different sites: Al-Quran, Khelf , Burum , Yelkha and Husihasa (Table 2) showed that in generally the type of *Acropora* was more presented in Yelkha site (27%) compared to other sites. There was a biodiversity at these sites, whereas the best biodiversity index was in Burum site (J= 0.94) compared to other sites (Table 2). These observations probably indicate that genus of *Acropora* is more resistance to its surrounding environmental changes than other genus; as well as in Yelkha site may be more suitable environment to grow *Acropora* compared to other sites as supported by (Alvarez-Filip, Oliver, McClanahan , & Coˆte´, 2012) , (Roik, Roder, Ro¨thig, & Voolstra, 2016), (Gilmour, 1999) and (Cooper, Uthicke, Humphrey, & Fabricius, 2007) as mentioned above.

From the present study, it can conclude that in general there is no different can be mentioned between Khelf and Burum site regarding chemical environment factors and physical environment factors. Also, the value of

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dissolved oxygen, pH, water temperature, salinity and turbidity at surface water is higher; than the value of them at bottom water in both sites Kalf and Burum site. In addition, it can conclude that in general the type of *Acropora* was more obtainable on the Island of Maqrugha site (40%) and followed by Yelkha site (27%) compared to other sites (Ras Qusair, Ras Baghashawa, Ras Sharma Al-Quran, Khalf, Burum, Yelkha and Husihasa). The biodiversity index was the best in Burum site (J= 0.94) and followed by Ras Qusair site (J= 0.91) compared to other sites. It could be recommended that future studies should be taken in account and make artificial corals in places which have problems.

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