# Quantitative Estimation Of Seaweeds At Vandalous Bay In East Coast Of Sri Lanka

**Sumuthuni S, Harris JM, Kishoran S, Vinobaba P**

**ABSTRACT:** Phycology is systematic study of macro algae and key discipline to important analysis. Seaweeds are the macroscopic, multicellular algae which are important as primary producers in the ocean. In addition, they have great economical and medicinal importance and also provide shelter and nursery ground for the marine organisms. Records on seaweed research, in Eastern province in Sri Lanka is scares. Hence, the present study was focused on preliminary survey of seaweed species abundance, frequency, cover percentage and the anthropogenic activities that thread their sustainable live span were conducted at Vandalous bay of Sri Lanka in Indian Ocean in order to find out the possible threats. Twenty sampling points were selected including of various micro habitats (coral, rock and sea grass) in Vandalous bay during low tide were used to assess the diversity and distribution of seaweeds quantitatively during the period from January to May 2018. Further, physio-chemical water quality parameters were also measured at the study site such as temperature, dissolved oxygen, turbidity, pH and salinity. Line-transect with intercept quadrate method was used to assess the distribution in upper intertidal zone ranging up to 20 m to collect the seaweed samples on monthly basis. Collected samples were identified using standard seaweeds taxonomic key. The present study revealed 40 species belonging to 27 genera, 20 families, 12 orders and 3 classes out of which 55% were green algae, while red algae and brown algae were recorded as 26% and19% respectively. High abundant species was Halimeda opuntia found in almost all the sampled points in study site, it was large scale (ranging from 1.9-3.9) and restricted to coral region and few of them found in seagrass. The less abundant species was Galaxaura rugose (ranging from 1.2-2.1) and other species were moderately distributed in study site. Further, Halimeda opuntia and Carpopeltis maillardii were highest and lowest frequency ranging respectively at the study side. The former registered from 50% to 100% and the later registered 10%. The identified anthropogenic activities were hotel waste discharge, fishing and tourism. In those activities, fishing was the most dominant while hotel waste elimination and tourism had less influence on seaweeds bed. Cladophoraceae was the most diverse family represented by 5 species. Among the study species, green algae were dominant in which Halimeda opuntia was highly abounded and restricted to coral micro habitats. However, red algae share rocky substrates in addition to the coral micro habitats. Sphacelaria novae-hollandiae (brown alga) which was recorded as a new species in Sri Lanka was also collected in the present study site. Hotel waste discharges and the tourism soon after cessation of civil unrest were identified as major threats. Further, future studies must be directed for long term investigation on seasonality, factor controlling existence and distribution of seaweeds along the Vandalous Bay in East coast.

**Index Terms**: East coast, Estimation, Quantitative, Seaweeds, Species, Vandalous bay

## 1. INTRODUCTION

Coastal region plays a key role to provide valuable ecosystem services to vulnerable shallow habitats such as seaweeds beds and seagrass meadows. Seaweeds or marine benthic algae are multicellular macroscopic, photosynthetic, Eukaryotic plant like organism and usually attached on rock and corals in littoral and sub littoral region [1]. Seaweeds are morphologically distinct from seagrass, which consists blades, bladder and hold fast nearly reassemble the plant structure but not true leaf, stem and root and have much more complicated sex structure that difficult to understand [2] [3]. They fall into three different groups such as Chlorophyta (Green alga), Phaeophyta (Brown alga) and Rhodophyta (Red alga) based on the pigments, and the green colour is due to the predominant pigment called chlorophylls and adapt to survive in intertidal zone. Cell wall components and storage products of these four groups [2]. Blue green and Green algae are mainly in habitat in upper littoral zone, Brown algae in mid part of littoral zone and red algae are lower littoral or deepest part of ocean. Seaweeds are the one of the important primary producers in the ocean, providing shelter, nursery ground for the marine organism and also have great economical, industrial application and as a fertilizer due to non-poisonous algae, and medicinal important but the historical records on seaweed research in Sri Lanka is remarkable interest [4]. Macro algae generally attached on rocky surfaces, coral reefs, seagrass meadows and lagoon. Despite its needs for their firm attachment on substrates, it fails to grow under the unfavorable environmental condition. However, macro algae has high affinity to grow in rocky beaches than sandy beaches and mudflats [5]. Seaweed diversity in the Indian Ocean was abundant during the past 10 decades and provided suitable habitat for their firm growth (6). In spite of Tanzania has high tourism activity, the country relatively belong to high species of seaweeds in Indian Ocean [7]. The first seaweeds collection of Sri Lanka was done by Hermann (1646-1695) following him, Willion Ferguson (1836-1887), William Henry Harvey (1853), Nils Svedelius (1974), Borgesen (1936), Durairatnam (1951-1974) and Coppejans et al (2009). After these persons work only few researchers were worked in north and western coast on Sri Lankan marine algae. The reported marine algae of Sri Lanka consists of 396 species within 147 genera and 56 families [9]. In East coast species distribution is high in Trincomalee district [8]. Further, Vandoulus bay is enclosed by continuous coral reef may having highest seaweed diversity [10]. But recently anthropogenic activities such as tourism, fishing method (Beach seining), deterioration of sea water quality due to direct discharge of waste water, changes in climatic condition and also the predators badly effect on growth of seaweeds. The objectives of the present study were multifold. Taxonomical identification of algal species diversity, distribution and anthropogenic impact at Vandalous Bay in East coast of Sri Lanka and help to understand the ecosystem and providing updated information about seaweeds and major threats to their existence. Seaweed distribution in East coast of Sri Lanka virtually unknown. Since past three decades no serious efforts had been undertaken to expand the diversity and distribution of algae for Sri Lanka. Therefore the present study focused on seaweeds distribution, diversity and potential threats in Vandalous Bay in order to full fill the research gap in East coast of Sri Lanka.

## 2. METHOD

### 2.1 Study period

Survey was carried out during the period of January to May in 2018 on monthly basis in Vandalous Bay.

### 2.2 Sampling procedure

The collection of seaweed samples was done in upper literal zone during low tide (Fig 1). Where the seaweed was discontinuous and also occurs in patches. Seaweed samples were collected at different 20 sampling point inclusive of micro habitats such as coral, rock and seagrass in Vandalous Bay. Collection of alga was carried out along the each point through the line transect with intercept quadrat method. During the sample collection some seaweeds (e.g Padina sp, Halimeda sp, Caulerpa sp) were collected by hand picking while others (e.g Hypnea sp, Enteromorpha sp, Tolypoicladia sp) were collected by scraping from attaching substratum with stain less knife. Collected seaweed samples were preserved in 4% formalin solution (4% formalin with 96% marine water) and transferred to Department of Zoology, Eastern University of Sri Lanka for further identification. Preserved sample also investigated under the stereo microscope (MEIJI TECHNO, Japan) with (x40) magnification. Micro photographs (OPTIKA, Italy) were taken (x400) for the further conformational identification. Photographs of micro habitat of seaweeds were taken immediately at study site using digital camera (Canon EOS 1100D, Japan) for the confirmation of identification. Various method were analyzed to assess the seaweed distribution and diversity qualitatively and quantitatively in present study.

### 2.3 Study area

Study area located in East coast of Sri Lanka (Fig 2). Coordination of the precise study site was marked using hand held Global Positioning System (Gramin, USA). The study site situated between the N 7.91219'' E 81.56979'' and N 7.93746'' E 81.55881'in Sri Lanka. The sampling distance was maintained 20m from the shore line during low tide in upper literal zone. In the study site people have been doing fishing practices and blooming anthropogenic activity. Further study site enriched with coral, seagrass and coastal vegetation.

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*Fig. 1. Upper littoral zone of study site during day time. Where shallow water nature with silt sand texture. Average temperature was 32 Celsius.*

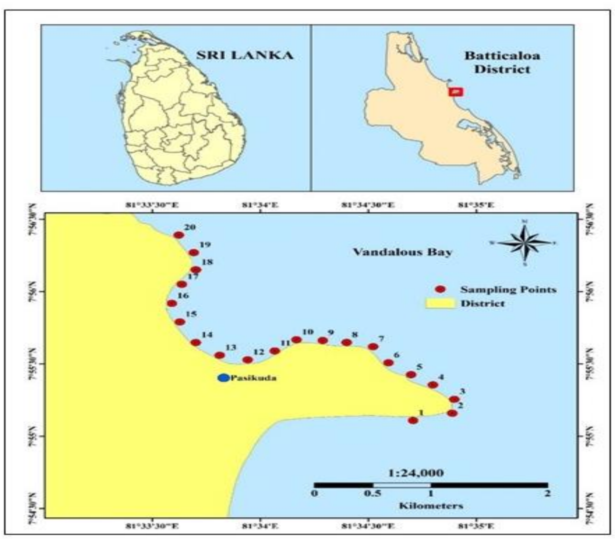


*Fig. 2. Geological map of sampling points points. Total of 4km study site consists 20 sampling points with 200m distance between each points.*

### 2.4 Qualitative assessment

Collected specimens were identified into least taxonomical level with the aid of micro photograph and standard identification key [8] [1].

### 2.5 Quantitative assessment

In order to assess seaweeds quantitatively in Vandalous Bay, Line transect with intercept quadrat method [1] was performed. Line transect was established perpendicular to the coast up to 20m from shoreline at each point by driving steel rods into the substratum at both end of the transect. Ten quadrats were laid down along 20m transect line at random distance. The quadrate (1m2) partitioned into 25 equal small squares in order to estimate the species accurately. The cover value was estimated from the species present within the each small square (20 cm×20cm) through the visual observation as represented by Fig 3. Each small square (20cm×20cm) of a quadrat indicates 4% cover value [11]. If the particular seaweed fully covered in Small Square (20cm×20cm) of a quadrat then the cover considers as 4% while covered half of small square the cover has to be 2%. The cover scale of particular seaweed present in a quadrat estimated by adding the obtained cover value of each small square of a quadrat. Cover scale was determined based on Braun-Blancket method. Similar procedures were repeated for all other nine quadrats. Cover (%) of a species was evaluated by getting summation of cover value of each quadrat sampled subtracting by total number of quadrat (10 times) in 20m line. Likewise cover value was estimated in 20 sampling points.

Abundance (A) of a particular species was calculated from summation of determined cover score subtracting by the number of quadrats at which a species was present while frequency (F) of a species was calculated from number of quadrats in which a species was present subtracting by total quadrats in a line. Similar procedures were repeated to all the species in 20 transect line. Abundance and frequency were calculated using following equation as indicated by 1 and 2. Finally mean of cover value, abundance score and frequency [12] in 20 sampling points considered.

$$A = \sum \frac{S_{ij}}{N_i}$$

$$F = \frac{N_i}{n}$$

Where,

**$S_{ij}$** = Braun-Blanquet score for species i in quadrat j.

**n** = Quadrat number from 1 to n.

**A** = Abundance.

**$N_i$** = Number of quadrats at a site in which species (i) was present.

**F** = Frequency.

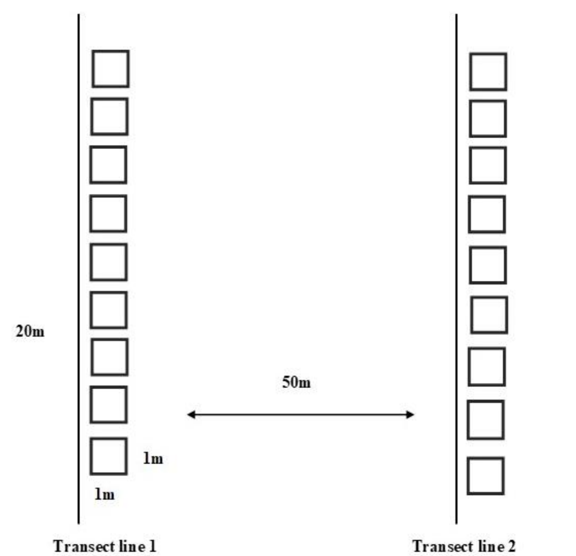


Fig. 3. Two transect line with intercept quadrat in each sampling point. 20m specify the zonation in intertidal zone along with 10 number of intercept quadrat.

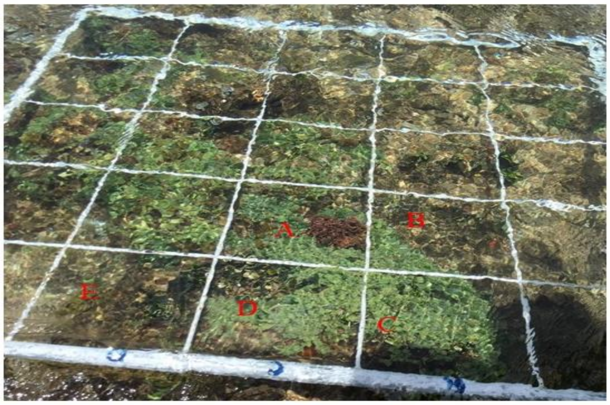


*Fig. 4. Cover value from the visual observation of Caulerpa racemose A=4%, B=1%, C=4%, D=3% and E=O%. Cover value was estimated by visual observation based on Broun-*

### 2.6 Statistical analysis

Differences in total abundance, frequency and cover of seaweeds (green, brown and red algae) at the present study site were determine using mixed-effects models, with habitat (seaweed) as fixed factor, site as a random factor and coral cover and seagrass bed as a covariate, because their cover was high around the seaweed beds during the survey. All the data were under gone to normality checking and transformed while needed (Fig 5).

## 3. RESULTS

### 3.1 Taxonomical analysis

A total of 40 species belong to the 28 genera, 20 families, 12 orders and 3 classes of seaweed were identified from the study site; 17 species of Chlorophyta, 7 species of Phaeophyta and 16 species of Rhodophyta (Table 1). Those consists 6 families such as Halimedaceae, Caulerpaceae, Cladophoraceae, Udoteaceae, Siphonocladaceae, Bryopsidaceae, 4 families such as Dictyotaceae, Sargassaceae, Ralfsiaceae, Sphaceloriaceae and 10 families such as Ceramiaceae, Gracilariaceae, Rhizophyllidaceae, Rhodymeniales, Dasyaceae, Galaxauraceae, Halymeniaceae, Cystocloniaceae, Champiaceae and Delesseeriaceae are respectively. In green algae Caulerpaceae was diverse family which consists Cladophora branchiona, C.colabensis, C.herpestica, C.saracenia and Enteromorpha clathrate whereas brown and red algae consists Sargassum crassifolium, Sargassum cristaefoliu, Sphacelaria nove-hollandia, Padina boergensenii, Padina minor, Dictyota sp, Ralfsia ceylanica and ceramiaceae includes Ceramium marshallense, Ceramium nodulosm and Centroceras clavulatum respectively. During the survey new species to Sri Lanka was identified named Sphacelaria nove-hollandia already identified in other parts of the country by previous researchers. Despite seaweeds diverse nature, some anthropogenic activities were identified at study site as major influences to seaweeds existence.

### 3.2 Braun-Blancket analysis

Through the visual observation by using Braun-Blancket method the green algae was highest cover while red and brown algae were 26% and 19% respectively. Based on the findings, high abundant species was Halimeda opuntia found in almost all the sampled points in study site. It was large scale (ranging from 1.9-3.9) and restricted to coral region and few of them found in seagrass. Brown and red alga were distributed both rock and coral region (Fig 7). The less abundant species was Galaxaura rugose (ranging from 1.2-2.1) and other species were moderately distributed in study site. Further, Halimeda opuntia and Carpopeltis maillardii were highest and lowest frequency ranging at the study side. The former registered from 50% to 100% and the later registered 10%. Species distribution was absence up to 20m in sampling points near the hotels and Pasikuda and also physio-chemical parameters were fluctuate than optimum level. Further, according to the histogram from the mixed effect model green algae had high cover value, abundance and frequency when compare to brown and red algae at 25th and 75th percentiles, error bars shows the 95% confidence intervals of the median values and closed symbols indicate outlier.

***Table.1. Taxonomical identification of seaweeds at study site.***

| No | Class | Division/Family | Species |
|---|---|---|---|
| | Chlorophyta | | |
| 1 | | Halimedaceae | *Halimeda opuntia* |
| 2 | | | *Halimeda gracilis* |
| 3 | | | *Halimeda macroloba* |
| 4 | | Caulerpaceae | *Caulerpa racemosa* |
| 5 | | | *Caulerpa racemosa var* |
| 6 | | | *Caulerpa racemose var cylindracea* |
| 7 | | | *Caulerpa sertularioides* |
| 8 | | Cladophoraceae | *Cladophora herpistica* |
| 9 | | | *Cladophora saracenia* |
| 10 | | | *Cladophora colabensis* |
| 11 | | | *Enteromorpha clathrata* |
| 12 | | | *Chetomorpha branchiona* |
| 13 | | Udoteaceae | *Chlorodesmis sp* |
| 14 | | | *Avrainvillea erecta* |
| 15 | | Siphonocladaceae | *Boodlea composite* |
| 16 | | | *Dictyophaeria versluysii* |
| 17 | | Bryopsidaceae | *Bryopsis pennata* |
| | Phaeophyta | | |
| 18 | | Dictyotaceae | *Padina minor* |
| 19 | | | *Padina boergensenii* |
| 20 | | | *Dictyota sp* |
| 21 | | Sargassaceae | *Sargassum cristaefolium* |
| 22 | | | *Sargassum crassifolium* |
| 23 | | Ralfsiaceae | *Ralfsia ceylanica* |
| 24 | | Sphaceloriaceae | *Sphacelaria novae-hollandia* |
| | Rhodophyta | | |
| 25 | | Ceramiacea | *Ceramium nodulosum* |
| 26 | | | *Ceramium marshallense* |
| 27 | | | *Centrocerus clavulatum* |
| 28 | | Gracilariaceae | *Gracilaria salicorna* |
| 29 | | | *Gracilaria corticata* |
| 30 | | Rhizophyllidaceae | *Portieria hornemannii* |
| 31 | | Rhodymeniales | *Tolypoicladia calodictyo* |
| 32 | | | *Leveillea jungermannioides* |
| 33 | | Dasyaceae | *Heterosiphonia crispella* |
| 34 | | Galaxauraceae | *Acanthophora muscoides* |
| 35 | | | *Galaxaura rugose* |
| 36 | | Halymeniaceae | *Carpopeltis maillardii* |
| 37 | | Cystocloniaceae | *Hypnea pannosa* |
| 38 | | | *Hypnea spinella* |
| 39 | | Champiaceae | *Chylocladia verticillata* |
| 40 | | Delesseeriaceae | *Taenioma perpusillum* |

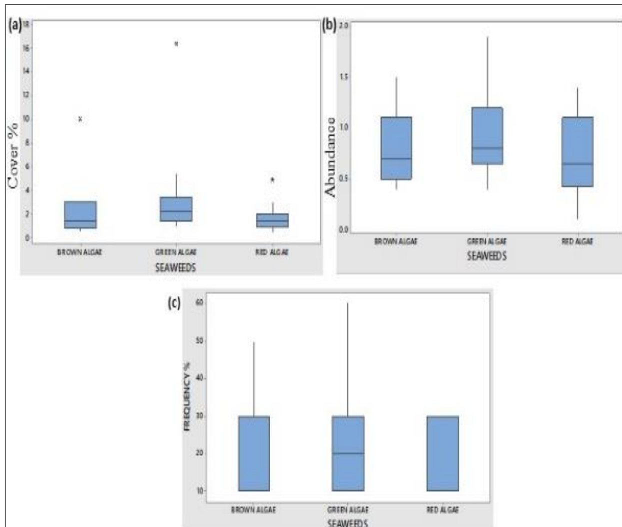


***Fig. 5. Box plots showing (a) cover percentage (b) abundance and (c) frequency percentage of green, brown and red algae at the study site. Horizontal lines indicate median values, boxes indicate 25th and 75th***


*Fig. 6. a- Sphacelaria novae-hollandiae attached on rock substratum, b - Scale C- microscopic view of thallus (x40). (New species to Sri Lanka (Coppejans et al., 2009)).*

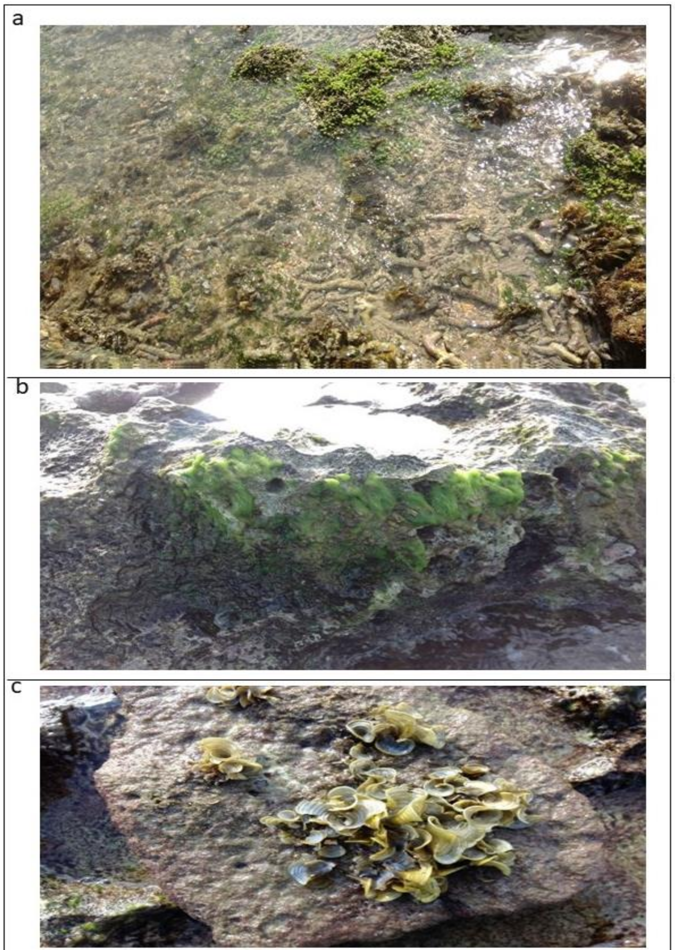


*Fig. 7. Different micro habitat of seaweeds at study site. Halimeda sp mostly attached on dead coral and live coral while Padina sp and Gracillaria sp attached on rocky substrates.*

#### 3.3 Invertebrates

During the identification of macro algae numerous invertebrates were identified such as crab, star fish, sea cucumber (Holothuria atra), isopods and Neres sp(Fig 8). Mostly Nereis sp species were associated with green algae whereas sea cucumber and isopods were associated with Padina sp, sea grass meadows and Gracilaria sp.

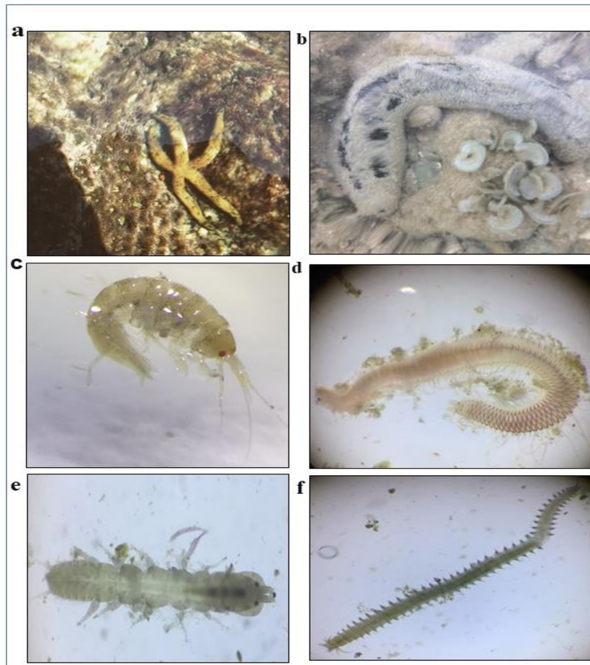


*Fig. 8. Key invertebrate predators at study site (a-star fish, b-sea cucumber (Holothuria atra), c&e isopods and d&f Nereis sp). View of c, d, e & f specimens were observed under stereo microscope (X40.)*

### 4. Discussion

Vandalous bay have coral and rocky nature with suitable environmental condition which favor for growing of seaweed. Therefore it is certainly true that attachment substratum essential for their sustainable growth [8]. Based on the findings, Chlorophyta was the dominant algae capered to Phaeophyta and Rhodophyta in littoral zone [8]. This is clearly denote that littoral zone facilitates the growth of green algae due to the optimum sun light [1]. Hence Halimeda opuntia was registered in higher abundance, cover and frequency due to the coral nature geographical landscape in all 20 sampling site except certain points [10]. This means that the study site enriched with coral ecosystem and support their massive growth. Because cell wall of Halimeda opuntia is made by calcium carbonate that extracted from dead coral from its existing environment [13]. This indicates indirectly about the healthiness of coral ecosystem hence Halimeda opuntia is used as bio indicator to monitor the coral ecosystem [14]. However, dissociation of Halimeda opuntia after its life span it involves in turning the soil structure and texture that prevent from sea erosion and conserve the coastal community from flood in long term view [5]. In spite of lowest abundance, cover and frequency of brown algae, Padina minor was registered second ranked patches in study site due to the rocky nature. This is clearly that reflecting the high nutrients cycle is circulated in littoral zone. Because nutrients and minerals importance for surviving of seaweed and associated fauna [1]. However, species diversity of red algae was highest in study site while it was lower in abundance, frequency and cover. This is because of its growth pattern is highly adapted to deepest area in ocean. These finding clearly figure out high distribution of seaweed noted in Vandalous Bay in East coast. Littoral zone mostly suitable for green algal growth due to the direct sunlight penetration [15]. Further its adaptive thin morphological characters and anatomical structure and its genetic traits are the reason for their dominant [16]. The primary seaweeds habitats were identified during the survey consists of monospecific beds of Enteromorpa clathrate and Gracilaria salicoenia, some species were smallest and mixed species (Padina sp and Caulerpa sp) and few others attached on other seaweeds (Ceramium attached on Caulerpa racemose). In addition to that rock, corals and seagrass were the identified micro habitat where most of the Bryopsidales associated with coral while Dictyotales and Ceramiales attached with rock and seagrass respectively. This is further confirm that attachment substratum supports their life span [8]. Economically important seaweeds were identified at study site such as Gracilaria sp and Caulerpa sp which are used to make agar, jelly production, fertilizer for plant and pharmaceutical production. Therefore the present study emphasis the idea of seaweed farming in order to provide livelihood option and increase the coastal community income who lives around. Because seedlings for the farming easily could take from wild system without damaging them. Not only that, Gracilaria sp contain high protein constituents therefore it can be used as alternative protein source in order to prevent the food scarcity for upcoming generation in the world [10]. Fish associated with seaweeds always would be siganidae family fish species. It will give additional income if the initiate the farming of economically important macro algae. The considerable sampling points where totally seaweeds were absent due to the tourism activity. In that points totally attachment substratum were absence. This vividly illustrates anthropogenic stressors that result in changes in seaweeds assemblages including silt deposition and habitat alteration [17]. Therefore stressed macro algae difficult to retain the important environmental factors for their healthy successful growth [18] [19] [20]. In addition to that physiochemical parameters are played key role in survival of seaweeds. Specifically turbidity always would consider for surviving rate of macro algae [8] [21]. In study site specific sampling points had high turbidity when compared to other sampling points due to the siltation. But this region is highly disturbed by the tourist activities (boating and snorkeling). Apart from that plenty of hotels were formed along that points where effluent directly discharged into the marine and it could disturb the growth of algal mat [9]. In future this may be going to lead to the threats to existence of seaweed species. Therefore further consideration and necessary activities are very important to maintain the distribution of seaweed in these places and further proper awareness necessary to the fisheries folk and people about the value of seaweed and their benefits. In future long term studies are necessary to show the annual species distribution of seaweeds species.

## 5. CONCLUSION

Present study concluded that Vandalous Bay consists 40 seaweed species. Among three phylum Chlorophyta (55%) was dominant over Rhodophyta (26%) and Phaeophyta (19%) in Upper intertidal zone. Halimeda opuntia was registered as dominant species in terms of cover, abundance and frequency while Gracilaria salicornia and Padina mior were respectively in Rhodophyta and Phaeophyta.

**Major threats identified during survey as follow,**

- Tourism (bathing and snorkelling)
- Fishing activity (bycatch)
- Hotel waste discharge

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