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Environmental quality assessment of Treis Island, Nicobar, India

Dilip Kumar Jha [1,*], N.V.Vinithkumar [1], Mehmuna Begum [1], Apurba Kumar Das [1], Biraja Kumar Sahu [1], R. Kirubagaran [2]

[1]*Andaman & Nicobar Centre for Ocean Science and Technology (ANCOST), National Institute of Ocean Technology, Dollygunj, Port Blair-774103, Andaman and Nicobar Islands, India.*
[2]*National Institute of Ocean Technology, Ministry of Earth Sciences (Government of India), Pallikaranai, Chennai-600100, Tamil Nadu, India*

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* Corresponding author e-mail: dilipjha75@yahoo.com

Abstract
The physico-chemical, biological and microbiological parameters of surface seawater was studied at Tries Island during a survey in 2009. The physico-chemical parameters like silicate and inorganic phosphate concentration varied significantly from 3.53 to 4.22 and 0.05 to 0.09 µmol/L, respectively at Tries Island. The zooplankton population density ranged from 4696 to 8207 Nos./m^3 and the dominant group was Copepod. The zooplankton biomass also varied significantly from 0.31 to 0.72 ml/m^3. The phytoplankton density and species number also varied significantly from 1020 to 1220 Nos. /L and 25 to 31 numbers, respectively. Soleniae dominated in coastal waters of Treis Island. Chlorophyll-*a*, and phaeophytin concentration varied between 0.12 to 0.24 and 0.06 to 0.27 mg/m^3, respectively. The chlorophyll-*a* concentration variation was significant. Apart from that noise level, soil and plant diversity were also investigated. Soil parameters indicated its fertile nature which is being utilized for horticulture by tribal community living in the neighbouring islands. The present study gives an account of the existing environmental quality in and around the island, providing a baseline scenario to assess the environmental impacts due to developments in the future. This study also provides comparison between populated and unpopulated coastal bay/marine ecosystems.

Keywords: Atmospheric parameters, water quality, soil parameters, Treis Island.

1. Introduction
The Andaman and Nicobar (A&N) Islands are one of the union territories of India, situated in the eastern part of Bay of Bengal. There are 572 islands within the A&N archipelago, which is one of the known biodiversity hotspot of the world. The Andaman group of islands is separated from the Nicobar group of islands by 10 degree channel. Treis Island (area 0.42 km^2) is located north-west of Little Nicobar with diverse types of ecosystems such as sandy beach in the east, rocky coast in the north, reef slope in north-west and dense forest in the centre of island. Its maximum elevation is about 60 m from the mean sea level (MSL). It is an uninhabited island situated (Figure 1) between latitude 7° 27’ 50” to 7° 28’ 20” N and longitude 93° 38’ 10” to 93° 34’ 40” E [1,2]. It is an evergreen forest surrounded by clean oceanic environment. The climate of this island, located 474 km away from Port Blair, is typically equatorial with temperature variation between 25 and 35^{o}C. The average rainfall is about 300-350 cm spreading from May to November with very high percentage of humidity (74.5%). It is bestowed with rich marine and floral biodiversity and has pristine environment due to its remoteness from Port Blair and the mainland. There are 24 islands in the Nicobar group clustered into northern, middle and southern groups, 12 islands being inhabited. The inhabited northern Nicobar group includes Car Nicobar and Battimalv Island, middle group consists of Tillangchong, Chowra, Teressa, Bompoka, Kamorta, Trinket, Katchal and Nancowry Islands, whereas southern Nicobar group consist of Great and Little Nicobar Islands.

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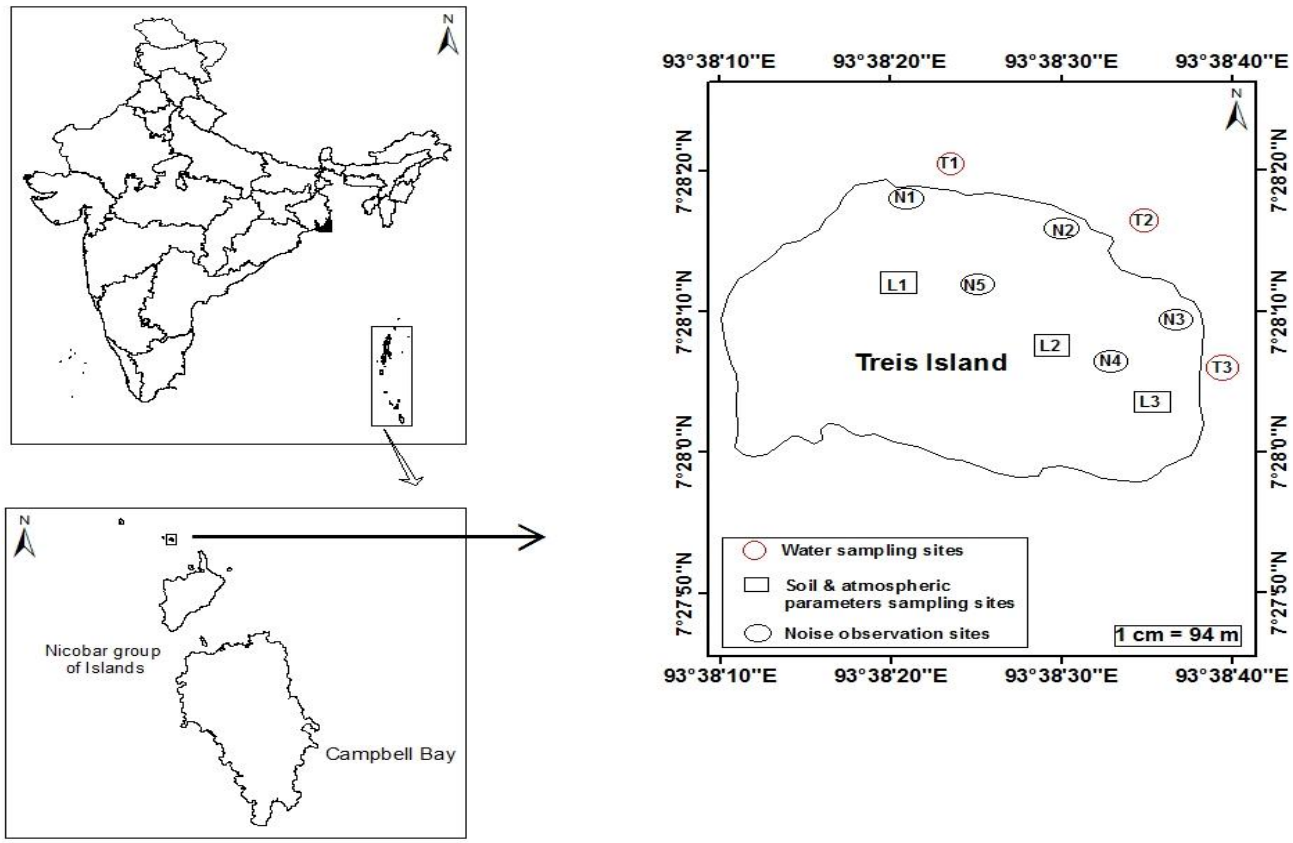

Figure 1 Location map of the study area in Treis Island

Treis Island has oceanic seawater conditions with potential for good fisheries. The nearest inhabited (Nicobari tribes) Island is Pulo Millow Island about 7.5 km away. The main occupations of these tribes are fisheries and horticulture in their surroundings as well as in the neighboring islands. Coconut and banana plants were sighted in Treis Island, which is an indication that tribal people from nearby islands (Pulo Milow, Pulo Panja and Menchal) frequently visit the island for maintaining/collecting their crop yield. In order to assess environmental impacts arising from development activities, it is imperative to measure existing environmental quality in and around the Tries Island. The data on the environmental quality of Tries Island are perhaps little or nil. Hence, a study was undertaken in October 2009, to assess the environmental quality of Tries Island and the data was compared with other populated site (Junglighat Bay). The findings of the study are reported in this paper.

2. Materials and Methods

Surface seawater parameters were studied at three locations, (T1, T2 and T3 indicated in Figure 1) selected around the island. The physico-chemical parameters such as water temperature (WT), salinity, transparency and pH were recorded *in situ* using digital multi-parameter water quality instrument during the survey. Seawater samples (triplicates) were collected using Niskin water samplers and were analyzed onboard in water quality laboratory using standard methods [3] for dissolved oxygen (DO), total suspended solids (TSS), nitrite, nitrate, total nitrogen (TN), ammonia, silicate, inorganic phosphate (IP) and total phosphorus (TP). Similarly, surface zooplankton samples were collected using Hydro-Bios zooplankton net (150 µm mesh size, 0.5 m diameter, 1.8 m length) fitted with Hydro-Bios digital flow meter. Total numbers of organisms were enumerated using Nikon Eclipse microscope (E 600) with a Sedgewick Rafter plankton counting chamber. The zooplankton species were identified following standard keys [4, 5].

The phytoplankton samples were preserved with 4% formalin and Lugol's iodine solution. The samples were processed using Utermol's settlement methods [6] and identified up to species level following standard keys [6, 7]. The estimation of chlorophyll-*a* and phaeophytin was carried out by filtering one litre of seawater through APFF (Millipore) filter paper. The pigment was extracted and kept in 90% acetone under dark and refrigerated for 24 hrs. The supernatant of centrifuged extract was used to determine chlorophyll-*a* and phaeophytin following spectrophotometric method [8]. Surface water samples were collected using pre-

sterilized glass bottles for the estimation of total viable count (TVC) and total coliform (TC) population. The membrane filter technique was adopted for studying the microbial population. After the incubation period, bacterial colonies in the plates were counted and results were expressed as Colony Forming Units (CFU) per ml. To test the variations of physico-chemical and biological parameters, one way ANOVA was employed.

Treis Island is an uninhabited island hence it was assumed that there is no known source of air pollution through anthropogenic activities. However, the noise level was measured using the digital sound level meter (Lutron SL-4001) at five locations (N1 to N5 indicated in Figure 1). Similarly, atmospheric temperature (AT) and humidity were also recorded from the same location.

Soil sample collection and plant enumeration using quadrate method were carried out at three locations selected in the island: L1, L2 and L3 (Figure 1). A random quadrate ($15m^2$) method [9] was used to enumerate plant species in the Treis Island. Plants were identified at species level and categorized according to the IUCN classification [10]. All the 25 plant species were compared with regard to its distribution in mainland India and outside of India. Soil samples were collected for the analysis of phosphorus and potassium from three locations. The locations of those sampling points were recorded using GPS (Garmin eTrex vista; ±3 m accuracy) and a digital pH meter was used to record soil pH. The phosphorus and potassium concentrations in the soil samples were determined using spectrophotometer [11] and flame photometer [12], respectively. The percentage composition of sand, silt and clay were used to identify the texture of soil using sedimentology methods [13]. Electrical conductivity of the soil samples was measured by conductivity meter, while the organic carbon was determined by the titration method [14].

3. Results and Discussion

The range and mean values (±SD) of surface seawater for environmental variables (atmospheric, physico-chemical and biological parameters) are presented in Table 1.

Table 1 Environmental parameters in and around Treis Island

Environmental variables			
Atmospheric parameters	**Minimum**	**Maximum**	**Mean (±SD)**
Atmospheric temperature (°C)	30.00	31.70	30.73±0.87
Humidity (%)	69	74.5	72.16±2.84
Physico-chemical parameters			
Water temperature (°C)	29.40	29.80	29.63±0.21
Salinity (PSU)	34.00	34.50	34.33±0.28
pH	8.64	8.65	8.64±0.01
DO (mg/L)	5.35	5.70	5.52±0.18
TSS (mg/L)	33.60	38.40	35.80±2.42
Transparency (m)	15	16	15.5±0.7
Nitrite (µmol/L)	0.44	0.54	0.47±0.06
Nitrate (µmol/L)	0.41	0.62	0.55±0.12
Silicate (µmol/L)	3.53	4.22	3.82±0.36
Inorganic phosphate (µmol/L)	0.05	0.09	0.07±0.02
Total phosphorus (µmol/L)	0.36	0.45	0.39±0.05
Ammonia (µmol/L)	0.25	0.65	0.45±0.28
Total nitrogen (µmol/L)	3.14	4.34	3.59±0.65
Biological parameters			
Chlorophyll *a* (mg/m^3)	0.12	0.24	0.20±0.07
Phaeophytin (mg/m^3)	0.06	0.27	0.16±0.11
Phytoplankton density (Nos./L)	1020.00	1220.00	1093.33±110.15
Phytoplankton species (Nos.)	25.00	31.00	27.67±3.06
Zooplankton biomass (ml/m^3)	0.31	0.72	0.52±0.20
Zooplankton population ($Nos./m^3$)	4696	8207	6792±1852

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One-way ANOVA (chlorophyll-a, zooplankton biomass, phytoplankton density, phytoplankton species, silicate and inorganic phosphate) results are given in Table 2.
The silicate and IP concentrations in surface seawater varied significantly ($p<0.05$). The silicate, IP, TP and TN concentrations were 3.53-4.22, 0.05-0.09, 0.36-0.45 and 3.14-4.34 µmol/L, respectively, whereas in the thickly populated Junglighat Bay (Port Blair) these concentrations were 6.69-7.39, 0.36-0.88, 2.18-3.27 and 7.60-37.20 µmol/L, respectively [15], during the same period in 2009. This indicates that nutrient values are within the normal oceanic variation in Treis Island but wide with higher concentration in thickly populated Junglighat Bay. It shows that human settlement around the Junglighat Bay contributes the domestic waste into the bay whereas no such settlement was observed around the Treis Island. The other physico-chemical parameters such as WT, salinity, pH, DO, TSS, transparency, nitrite, nitrate and ammonia did not show any significant variation. The field photographs (Figure 2) illustrate the rocky shore in north (Figure 2a) and sandy in east (Figure 2b) which supports the marine biodiversity around the Treis Island.

Table 2 Analysis of variance (ANOVA) results for the site-wise variability of the nutrients and biological parameters

Parameters	*F* value	*P* value
Chlorophyll *a*	27.23	0.00097
Zooplankton (Biomass)	19.5	0.002
Phytoplankton density	239.57	0.00049
Phytoplankton species	28	0.0114
Silicate	47.16	0.00021
Inorganic phosphate	13	0.0065

Zooplankton population density were 4696 and 8207 nos./m^3 at station T2 and T3, respectively. The mean (±SD) zooplankton population density was 6792 nos./m^3(±1852) at Tries Island. Totally, 11 zooplankton groups were recorded in which Copepod occupied 63% followed by Larvacean 10% in zooplankton composition. The zooplankton density and biomass of Tries Island was comparatively low than the Junglighat Bay [15]. Copepod nauplii dominated the zooplankton composition followed by *Oncaea* spp. at Treis Island whereas Oithona sp. dominated at Junglighat Bay [15]. It is reported that Oithona sp. dominates in the mangrove ecosystem which is having high food availability [16]. The presence of euphausiids and harpacticoid copepods (*Microsetella* spp. and *Macrosetella* spp.) indicated that there is coastal upwelling near these islands [17] which ultimately influences fishery potential in the area. Presence of fisheries resources such as tuna, snapper, mullet, etc. was visually observed during the survey. The group wise percentage composition of zooplankton is given in Figure 3. The ANOVA showed that the zooplankton biomass varied significantly ($p<0.05$) which may be due to different coastal geomorphology around the island.

(a) Rocky coast **(b) Sandy beach**

Figure 2 Field photographs of Treis Island showing (a) Rocky coast and (b) Sandy beach

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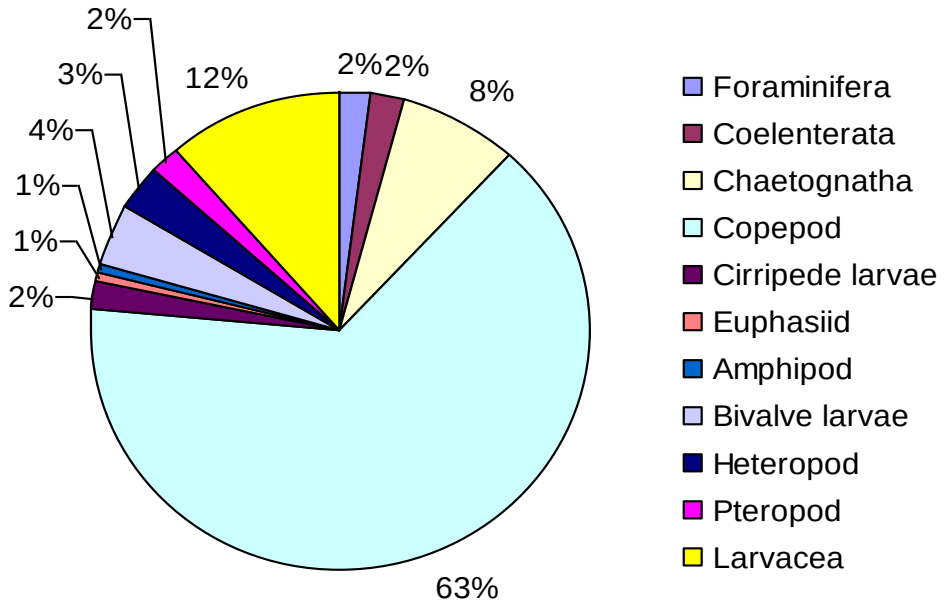

Figure 3 Group wise percentage composition of zooplankton at Treis Island

Out of 9 families recorded, Soleniae occupied 21% followed by Chaetocereae which formed 20% of phytoplankton composition at Treis Island. The total numbers of phytoplankton species recorded as 25, 27 and 31 in T1, T2 and T3 stations, respectively. *Nitzschia seriata* dominated the phytoplankton composition followed by *Rhizosolenia imbricata* at Treis Island (Figure 4).

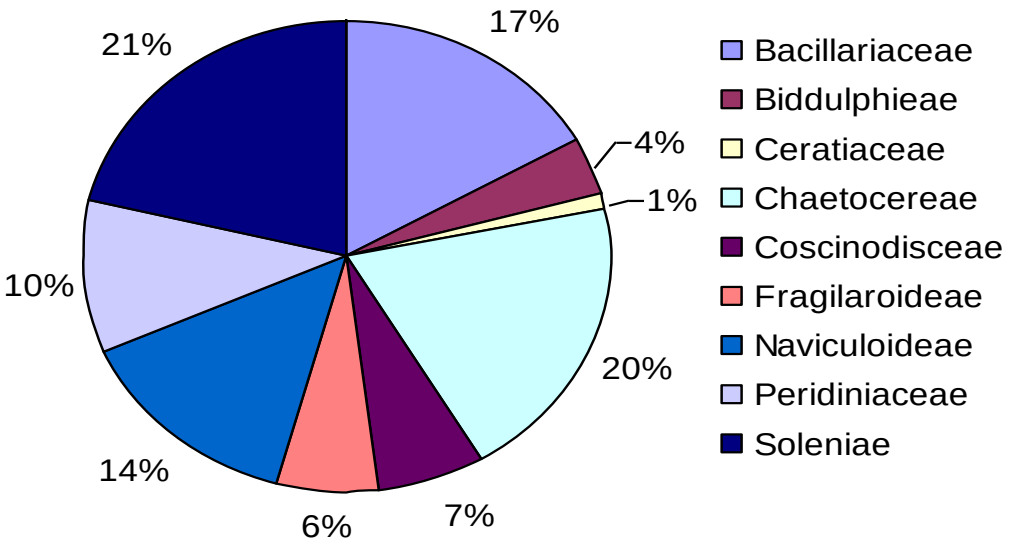

Figure 4 Family wise percentage composition of phytoplankton at Treis Island

The mean phytoplankton density (1093 Nos./L ± 110) and species numbers (28 nos. ±3) varied significantly ($p<0.05$) and was found less compared to thickly populated Junglighat Bay [15]. This may due to high nutrient influx in the thickly populated Junglighat Bay which is surrounded by mangrove vegetation as well as habitation. The coastal geomorphology and nutrient availability plays vital role for the phytoplankton density and diversity. The silicate and IP concentrations directly influenced phytoplankton density and species composition around the sampling stations (Figures 5 & 6). Treis Island endorses the opinion that the silicate concentration is directly related to the population of diatoms [18].

Microbial population like TVC and TC varied between 1 to 1600, 23 to 27 CFU/ml, respectively whereas in the thickly populated Junglighat Bay (Port Blair) it ranged from 8750 to 2278083, 51 to 262 CFU/ml, respectively (NIOT; COMAP REPORT, 2009), during the same period in 2009. This attributes that

microbial population is within the normal oceanic variation in Treis Island whereas due to anthropogenic activities it is higher in thickly populated Junglighat Bay.

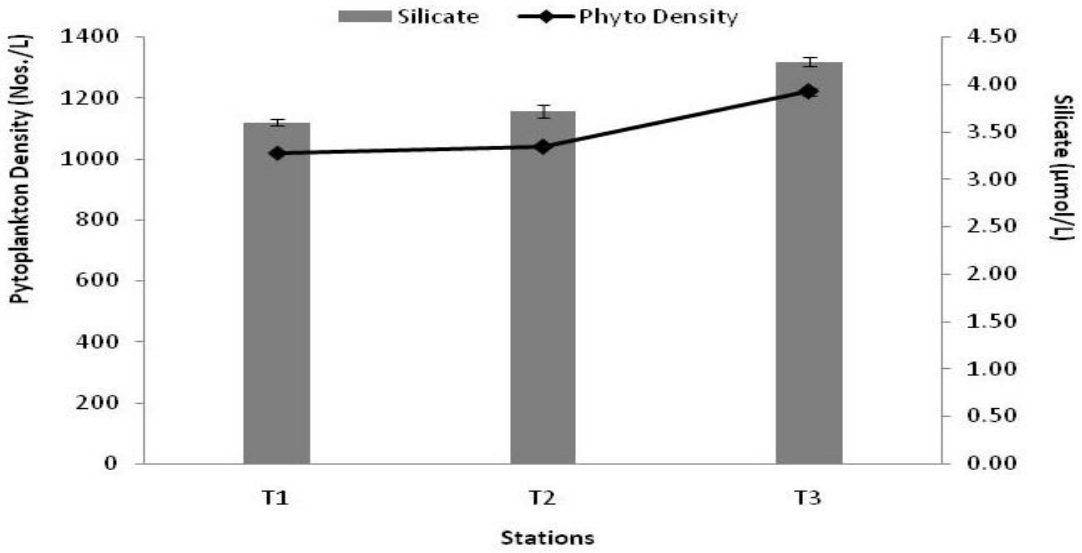

Figure 5 Silicate and phytoplankton density variation

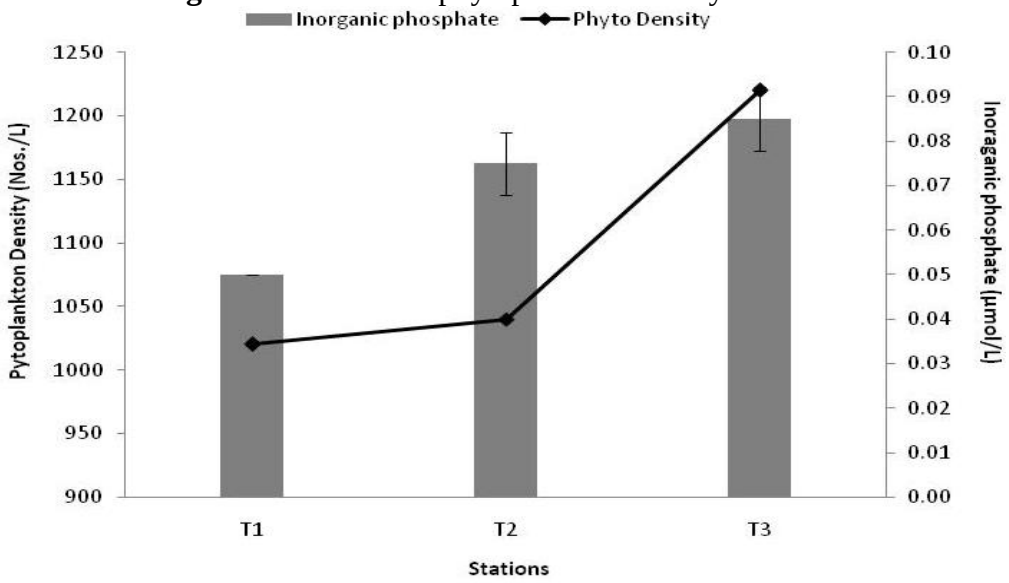

Figure 6 Inorganic phosphate and phytoplankton density variation

The AT and humidity values were recorded between 30 to 31.7 °C, 69 to 74.5 %, respectively, around Treis Island. The noise level recorded (30-52 dBA) in the island was mainly attributable to natural phenomena, such as wave breaking sound near beach, rustling of leaves and chirping of birds in the forest.

Soil texture was clay loamy with considerable quantity of potassium oxide (17.5 - 25.0 kg/ha) and phosphorous pentaoxide (1.6 - 5.2 kg/ha), which indicates its fertile nature. The mean of soil pH, electrical conductivity, organic carbon were recorded 5.2 ± 0.0, 1.0 mmohs/cm ± 0.61 and 0.23 % ± 0.07 respectively during the study period. During the study, 25 plant species were identified and presented as a checklist in Table 3.

Among them, *Pandanus andamanensium* and *Tabernaemontana crispa* are found to be endemic to A&N Islands. The study also reveals the presence of medicinal plants such as *Pongamia pinnata* (oil from seed is used for skin disease and ulcers), *Tinospora cordifolia* (used for treatment of asthma, diarrhoea, dysentery, jaundice, malaria and skin diseases) and *Pandanus andamanensium* (extract is used for hair tonic

and external abscess) in the Treis Island. These medicinal plants are widely used for traditional treatment by the Nicobari tribes [19].

Table 3 Checklist of flora of Treis Island

Sl. No.	Name of the taxa	Family	Habit	A	N	M	O
1.	*Cocos nucifera* Linn.	Arecaceae	Tree	+	+	+	+
2.	*Cyperus kyllingia* Endl.	Cyperaceae	Perennial herb	+	+	+	+
3.	*Acrostichum speciosum* Willd.	Pteridaceae	Terrestrial shrub	+	+	+	+
4.	*Semecarpus anacardium* Linn.	Anacardiaceae	Tree	+	+	-	+
5.	*Pongamia pinnata* (L.) Pierre.	Fabaceae	Tree	+	+	+	+
6.	*Cayratia trifolia* (L.) Domin.	Vitaceae	Climber	+	+	+	+
7.	*Pandanus andamanensium* Kurz.	Pandanaceae	Tree	+	+	-	-
8.	*Areca catechu* Linn.	Arecaceae	Tree	+	+	+	+
9.	*Tabernaemontana crispa* Roxb.	Apocynaceae	Shrub/ Small tree	+	+	-	-
10.	*Oplismenus compositus* (L.) P.Beauv.	Poaceae	Decumbent herb	+	+	+	+
11.	*Flagellaria indica* Linn.	Flagellariaceae	Robust perennial climber	+	+	+	+
12.	*Leea indica* (Burm.f.) Merr.	Leeaceae	Shrub/ small tree	+	+	+	+
13.	*Cyperus esculantus* Linn.	Cyperaceae	Perennial tufted sedge	+	+	+	+
14.	*Dracaena angustifolia* Roxb.	Liliaceae	Shrub/small tree	+	+	+	+
15.	*Morinda citrifolia* Linn.	Rubiaceae	Tree	+	+	+	+
16.	*Ficus hispida* L.f.	Moraceae	Tree	+	+	+	+
17.	*Lygodium circinnatum* (Burm. f.) Sw.	Lygodiaceae	Terrestrial herb	+	+	+	+
18.	*Ipomoea pes-caprae* (L.) R.Br.	Convolvulaceae	Prostrate herb	+	+	+	+
19.	*Rhaphidophora eximia* Schott.	Araceae	Epiphytic herb	+	+	+	+
20.	*Luffa cylindrica* Mill.	Cucurbitaceae	Climber	+	+	+	+
21.	*Areca triandra* Roxb.	Arecaceae	Tree	+	+	-	+
22.	*Tinospora cordifolia* Miers.	Menispermaceae	Climber	+	+	+	+
23.	*Cyperus difformis* Linn.	Cyperaceae	Perennial sedge	+	+	+	+
24.	*Macaranga tanarius* Muell. Arg.	Euphorbiaceae	Tree	+	+	-	+
25.	*Antiaris toxicaria* Leschen.	Moraceae	Tree	+	+	-	+

A: Andaman groups of Islands; N: Nicobar groups of Islands; M: Main land India; O: Outside India; +: Present; - : Absent

Conclusion

The environmental quality of Treis Island with respect to soil, noise and water shows a relatively pristine environment. However, some of the medicinal and endemic plants were recorded which is being used by tribal community for treatment purpose. The measured noise levels were observed to be in the range of 30-52 dBA at Treis Island. The higher noise levels were observed at sea shore. The seawater quality in Treis Island was assessed through physico-chemical, biological and bacteriological parameters of surface waters. The values of all the nutrients parameters were very less when compared with other site (Junglighat Bay). Bacteriological studies reveal that the surface waters had very less bacterial count compared with other site (Junglighat Bay). This study reveals that this type of site can be taken as reference point or standard for comparative study purposes.

The present study is the first attempt to develop a database of physico-chemical, biological, bacteriological, noise level, soil parameters and coastal plants of Treis Island. Regular sampling in Treis Island will provide details on coastal water quality of pristine marine environment in relation to biodiversity and environmental status.

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