Full Length Research Paper

Environmental assessment on sensitive ecosystems in Cham Island, Vietnamin climate change conditions

*Le Phuoc Cuong, Le T. Xuan Thuy, Dinh T. Phuong Anh and Hoang Ngoc An

Faculty of Environment, Danang University of Technology, 54 Nguyen Luong Bang st., Lien Chieu dist., Danang City, Vietnam
*Corresponding author email: lpcuong@dut.udn.vn, le_p_cuong@mail.ru

Abstract

This paper presents the results of research on the state and quality of sea water environment in the fishery area of the community at Cham Island including Bai Lang, Bai Huong, Bai Ong, Bai Bim, and Bai Bac in Tan Hiep commune, Quang Nam Province, Vietnam. Quality of soil environment and sediments are also studied and analyzed through factors such as moisture, humus, and organic matter content. The analysis results show that agricultural land (rice), the hill garden (forest vegetables) and hills (forest vegetables and wild medicinal plants) have poor humus quality (1-2 %), poor nutrient content (total N less than 0.08 %). With the aim of assessing the impact of the current environment on the local people's health, we analyze hair samples of 14 random people on the island at age 18 to 65. The results show that Hg concentration is detected in the relatively stable frequency. If there is no solution for the situation of dynamite fishing and gold mining which kills the coral reefs (due to the high level of mercury in water)in the near future, the health status of the people in Cham Island would be affected adversely.

Keywords: Sea water, sea grasses, soils, human hair, heavy and metals.

INTRODUCTION

Cham Island, Hoi An City, Quang Nam province belongs to the island system along the coast of Vietnam, and has an strategically important position in sovereignty and national security protection and marine economic development. It has the natural area of 1,549 hectares, hilly area accounts for about 90 %; the remaining 10 % is alluvial land, hill foot land, and sand beaches along the east southern side of the island. Ecosystems on the Cham Island include: terrestrial ecosystem, coastal ecosystem, and marine ecosystem. The research results announced 947 species that live in the waters around the island.

The flora is abundant here, especially seafood such as abalone, breast snails and bird nests. Coral reefs have about 135 species. In October 2003, Cham Island Nature Reserve was established to preserve the wildlife on the island. On 29/05/2009, Cham Island was recognized as a UNESCO (United Nations Educational Scientific and Cultural Organization) Biosphere Reserve in the world. Cham Island is a tourist destination attracting large amounts of domestic and foreign tourists. At this time, Cham Island welcomes about 6,000 visitors every month.

Quang Nam is one of the places, which are forecasted to be affected by the global climate change strongly. Cham Island Marine Reserve is forecasted to be flooded in some areas as sea level rise up 0-1 m, and in danger of being strongly affected by the climate change. If the climate change occurs, a number of characterized ecosystems, landscapes, and the biodiversity will be affected or changed. At the same time, the conservation based socio-economic development of the local people will also be seriously affected. The climate change not only affects the natural environment but also leads to socio-economic problems, especially the livelihoods of residents in Cham Island and Hoi An City.

Currently, the forest ecosystem and sea grass ecosystem on the island are in a decline. Organism resources in these ecosystems are affected by the climate change; rapacious exploitation and environmental pollution put the many species at risk of extinction. According to the criteria of the International Union for Conservation of Nature (IUCN) there are about 8 species in danger at different levels, of which 4 species are listed in the Red Book and belong to species in danger of extinction by the IUCN (IUCN 1993). Notably, the species diversity tends to decline which shows the long-term and
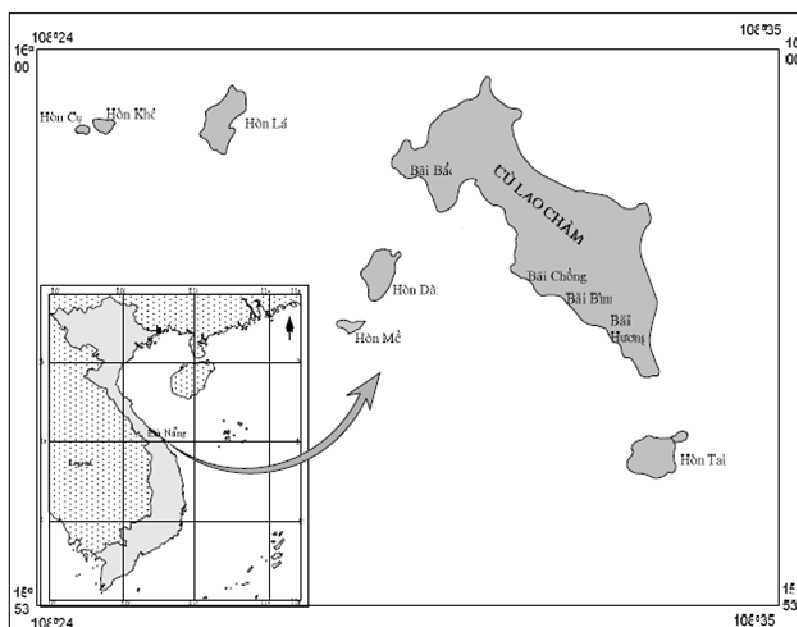
Figure 1. Location of Cham Island (source: Management board of Cham Islands MPA, 2012).

continuous decrease (by decade) of these ecosystems, especially in the context that the climate change causes significant influence on the lives of communities on the island. The common use of the small capacity fishing ships (80%), the increase of fishing frequency even in the breeding season, and the use rapacious fishing means (3 layer net, thread drawn net), low living quality, and the decrease of organism recourse damage the sensitive ecosystems. Besides, due to the poor management ability and facilities, limited educational level and awareness in the local communities, the environmental and natural resource protection still has limitations, which is the biggest challenge, a threat in the protection of sensitive ecosystems and management of natural resources in this area.

A lack of vitally important elements in drinking water, poor nutrition, diseases and certain harmful pharmaceuticals all may lead to ailments derived from deficiency, excessiveness or an improper balance of microelements within the human body. In order to assess the level of microelements within the human body and other diagnostic biological substrata, such as blood, urine, nails and hair. Hair possesses cumulative characteristics, so its composition reflects general conditions of human health. As a result, hair is a traditional biological material used in ecological and epidemiological surveys.

In Quang Nam, the impact of climate change has occurred quite clearly through the changes of weather and climate over the years. The assessment on environmental status of sensitive ecosystems (sea water, sea grasses, soils and people) in climate change is a very urgent job to have timely interventions for the sustainable economy.

Survey Sites

To assess the current state of environment in Cham Island area, we have conducted surveys to the beaches on Cham island: Bai Bac, Bai Ong, Bai Chong, Bai Bim, Bai Huong, Bai Lang, and conducted the following contents:
(1) Collect information related to water environment in the basin: investigate and interview relevant objects
(2) Survey and identify the location of sea grass beds.
(3) Survey water quality at the beaches: take water samples at different locations and depths.
(4) Analyze the basic parameters of the water environment
(5) Survey the sediment quality at different levels (rice farming area and vegetable growing area) in Bai Lang.
(6) Evaluate accumulation of some toxins (heavy metals) on the human body by analyzing hair samples of the people.

RESULTS AND DISCUSSION

1, Public Consultation (via questionnaires)

+ For seagrass ecosystems:

Through two surveys, 145 people were voluntarily investigated and collected opinions on their knowledge about sea grass, impact of sea grass on the lives of local

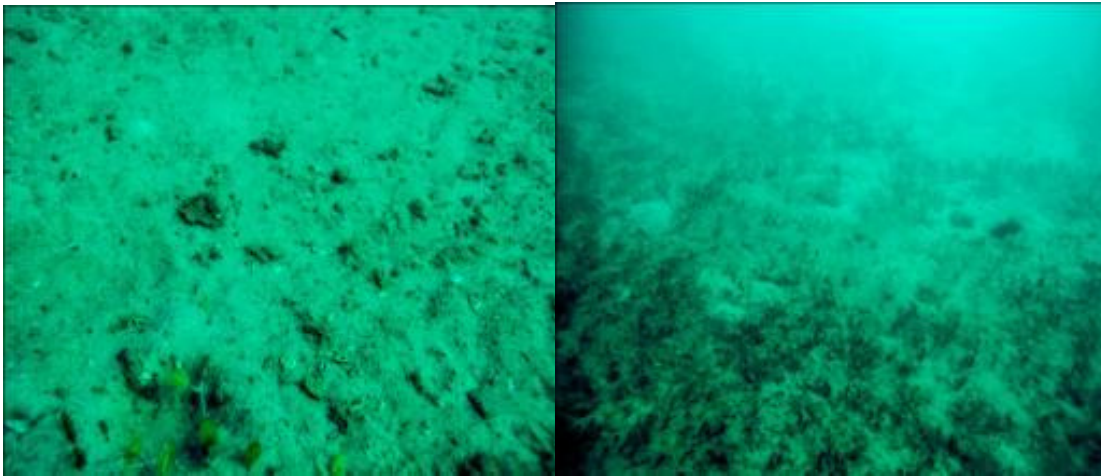**Figure 2.** Research group looking for sea grasses

Figure 3. Seagrasses in Bai Bim and Bai Bac

people, and their desires in June and July,2013. Volunteers are living in Bai Lang and Bai Huong of Cham Islands (124 people living by fishing and 21 are not).The research group draws up some conclusions as follows:

a) Most people (133 among 145) feel that the fishery resource is decreasing to exhaustion.

b) 107 people are worried about the current fishing forms, which are uncertain, and unstable, only 38people have the opinion that it is okay with offshore fishing.

c) There are four main forms of fishing (among 124 people, who are living by fishing):Using nets (three-layer net, bar net, ball net, two-layer net, thick net, and high net...) which accounts for 52% (64 people), boat 24% (30 people), fishing 22% (27 people), and diving 6% (7 people).

d) The majority of people living in Cham Island (120 among 124 people)do not aquaculture but catch to exhaustion. Besides, only 2.9% (4 people) of interviewed people have aquaculture experience, however the aquaculture result is not satisfactory because of floods.

e) 57.8% (84 people) of interviewed people want to improve family income by aquaculture production; the remaining 42.2% (61 people) do not.

f) Among the people who do the fishing, 46.5% (58 people) of them have never heard of sea grasses, 28.1%

(35 people) have heard of sea grasses but not sure, and 25.4% (31 people) know about sea grass beds.

g) For information about sea grass beds, 43.9% of people (64) know about it through fishing experience, 13.5%(19 people) through training and advocacy courses, 4.8% (7 people) through radio and newspaper, 37.8% (55 people) do not know about sea grass beds.

h) 39.4% of interviewed people (48) do the fishing in sea grass areas, 27.5% of them (35) do not do the fishing in sea grass areas, and 33.1% (41) of them do not know whether they are fishing in sea grass areas.

i) Among 124 people who do the fishing,54.1% people (67) have the average monthly income under 1 million dong from exploitation activities in sea grass beds, 16.4% of them (20) have the average monthly income from 1 to 3 million dong, 19.7% of them (25) have the average monthly income from 3 to 5 million dong, and 9.8% of them (12) have the average monthly income over 5 million dong.

j) Most people (133 among 145) have the desire to protect sea grass beds in Cham Island.

k) Most people (134 among 145) have the desire to use the resources from the sea grass sustainably.

l) 45.7% of the interviewed people (66) answer that they know the agency which directly manage the sea

Figure 4. Sampling and rapid measurements

Table 1. Results of water quality at the sampling point at Bai Huong

No.	Parameters	Unit	Results of sampling position					VR 10:2008/MONRE
			P.1	P.2	P.3	P.4	P.5	
1	Salinity	$^0/_{00}$	33	33.2	33.1	33.2	33.1	
2	DO	mg/l	6.6	6.3	6.3	6.1	6.4	≥ 5
3	Hardness (CaCO3)	mg/l	130	140	149	145	144	-
4	TSS	mg/l	21	17	18	16	24	50
5	BOD5	mg/l	1.4	1.2	1.6	1.5	1.6	-
6	COD	mg/l	2	1.8	2.1	1.9	2	3
7	$N\text{-}NO_3$	mg/l	0.018	0.016	0.015	0.016	0.019	
8	$P\text{-}PO_4$	mg/l	0.025	0.026	0.022	0.025	0.02	-
9	Pb	mg/l	0.0048	0.0045	0.0046	0.0049	0.0052	0,05
10	As	mg/l	0.0015	0.0016	0.0016	0.0014	0.0012	0,01
11	Hg	mg/l	0.00036	0.00034	0.0004	0.00038	0.00033	0,001

Note:
+TSS: Total suspended solids
+DO: Dissolved Oxygen
+COD: Chemical Oxygen demand
+BOD: Biological Oxygen demand
+Vietnam Regulations 10:2008/Ministry of Natural Resources and Environment (VR 10:2008/MONRE): National Technical Regulation on coastal water quality applying to the aquaculture and aquatic conservation areas.
Results at the positions are average values of the two samples.

grass beds and sea grass resources in Cham Island, the remaining 54.3% of them (79) do not.

m) 64.5% of interviewed people (80 among 124) would like to join aquaculture in sea grass beds.

n) 64.5% of them (80 among 124) know that if the fishery exploitation in sea grass beds is banned completely, it will affect the economic benefits of their families.

o) 40.8% of them (51 among 124) plan to switch the livelihood in case fishery exploitation in sea grass beds is banned, 42.2% of them (52) do not plan to change the livelihood, and 17% of them (21) still do not have this intention.

+*For forest ecosystems*

Through two surveys to investigate and collect opinions of the local people (40 people, who are living near the forest ecosystems in Bai Lang) on the knowledge about exploitation and utilization of forest products in June and July/ 2013, the group draws up the following conclusions:

a) Most people (38) are exploiting the forest products spontaneously without training or guidance of experts. Specifically, the exploitation occurs in some manners including collecting (16 people), felling (9 people), hunting (13 people) and other forms (collecting from relatives, 2 people).

b) Most people (37) who exploit the forest product in two or more locations with a number of times throughout the year.

c) The forest products include stone crabs, medicinal plants, geckos, and wild vegetables.

d) Although there are many impacts of the climate change, most people (38) answer that their demand for exploiting forest product is higher than the time before
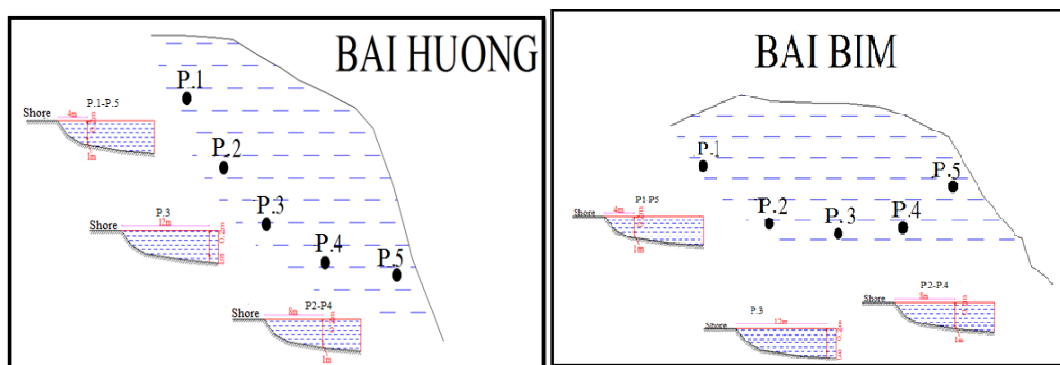
Figure 5. Sampling positions of seawater at Bai Huong and Bai Bim, Cham Island

2012.

e) Based on the experience of the households, the types of forest products which can be cultivated on the island include: rock crabs, geckos, and medicinal plants.

f) Stone crabs, geckos, and medicinal plants are the most valuable forest products in their opinions.

g) The majority of people (38) think that the rapacious exploitation of the people affects the forest products.

h) Most people who exploit the forest products (39) desire to protect the forest and utilize the forest resources in Cham Island sustainably.

i) Currently, there is agency to directly manage the forest and forest resources in Cham Island; however, it has not promoted all capabilities affectively.

j) If the cultivation model of forest products is available, most people (25) desire to participate to increase their income as well as to increase the production of vegetables on Cham Island. However, about 25% of the people (10 people) do not want to participate in the farming model because they do not have cultivation land.

2, Sea water and sea grass quality

+ Sea grass

The research team conducted diving to seek for sea grass beds at the depth from 2m - 8m, 5m - 30m from the shore in: Bai Bac, Bai Ong, Bai Chong, Bai Bim, and Bai Huong.
After conducting the observation, the research team obtained some results as follows:
+ At Bai Huong, Bai Chong, and Bai Ong at the depth of 2m -8m, 5m - 30m away from the shore, the research team did not detect the presence of sea grass beds.
+ At Bai Bim at the depth of 2m - 8m, 5m - 30m from the shore, the research team detected the presence of sea grass beds; however, the sea grasses grow sparsely, in small area of approximately 50m2, about 2cm high and tend to decline Figure 3.
+ At Bai Bac at the depth of 2m - 8m, 5m - 30m from the shore, the research team detected the presence of sea grass beds, the average height is about 4cm, the grasses

grow evenly on fairly large area, approximately 200m2 **Figure 3.**

+ Marine Water Quality

A - Bai Huong

Sampling

Water environment: take samples at various locations and cross sections depending on different depths at the coordinates (Position 1: $N15^0 55'644''$, $E108^0 31'762''$;Position 2: $N15^0 55'548''$, $E108^0 31'830''$; Position 3: $N15^0 55'504''$, $E108^0 31'943''$;Position 4: $N15^0 55'430''$, $E108^0 31'998''$;Position 5: $N15^0 55'379''$, $E108^0 32'041''$).

At each sampling point (Figure 5), the group takes 02 samples, one at 20cm from water surface, and the other at 1m from water surface. Sampling time is from 11:30 am to 03:30 pm on 15/05/2013. The weather condition is sunny with light wind. During the sampling process, there is no interaction.

Through the table of analysis and comparison results with VR 10:2008/MONRE, applying to the aquaculture and of aquatic conservation areas, all parameters are within the permissible limit.

B – Bai Bim

Sampling

The group carried out 2 sampling phases. Samples of phase 1 were taken at various locations and cross sections depending on different depths at the coordinates (P.1: $N15^0 56'309''$, $E108^0 31'024''$;P.2: $N15^0 55'321''$, $E108^0 31'002''$; P.3: $N15^0 56'300''$, $E108^0 31'098''$;P.4: $N15^0 56'303''$, $E108^0 31'139''$; P.5: $N15^0 56'200''$, $E108^0 31'182''$. Samples of phase 2 were taken at the sea grass locations (about 50m from the shore) at the coordinates (P.1:$N15^0 56'285''$, $E108^0 31'022''$; P.2: $N15^0 56'292''$, $E108^0 30'299''$).

At each sampling point, the group takes 02 samples, one at 20cm from water surface, and the other at 1m

Table 2. Results of water quality at the sampling point at Bai Bim, phase 1

No.	Parameters	Unit	Results of sampling position					VR 10:2008 /MONRE
			P.1	P.2	P.3	P.4	P.5	
1	Sanility	$^0/_{00}$	35.5	35.2	35.3	35.2	35.4	
2	DO	mg/l	6.2	6.1	5.8	5.9	6.1	≥ 5
3	Hardness(CaCO3)	mg/l	125	125	130	125	124	-
4	TSS	mg/l	25	30	28	28	29	50
5	BOD5	mg/l	1.2	1.6	1.2	1.4	1.4	-
6	COD	mg/l	2.2	2.5	1.8	2	2	3
7	N-NO$_3$	mg/l	0.024	0.022	0.025	0.022	0.024	-
8	P-PO$_4$	mg/l	0.018	0.019	0.015	0.018	0.016	-
9	Pb	mg/l	0.0042	0.0051	0.0048	0.0045	0.0046	0,05
10	As	mg/l	0.0011	0.0015	0.0013	0.0012	0.0014	0,01
11	Hg	mg/l	0.00026	0.00028	0.00024	0.00025	0.00023	0,001

Table 3. Results of water quality at the sampling point at Bai Bim, phase 2

No.	Parameters	Unit	Results of sampling position		VR 10:2008/MONRE
			P.1	P.2	
1	Sanility	$^0/_{00}$	35.6	35.9	
2	DO	mg/l	5.9	5.5	≥ 5
3	Hardness (CaCO3)	mg/l	120	110	-
4	TSS	mg/l	35	33	50
5	BOD5	mg/l	1.4	1.3	-
6	COD	mg/l	2.2	1.9	3
7	N-NO$_3$	mg/l	0.021	0.022	
8	P-PO$_4$	mg/l	0.012	0.013	-
9	Pb	mg/l	0.0047	0.0044	0,05
10	As	mg/l	0.0011	0.0012	0,01
11	Hg	mg/l	0.0002	0.00019	0,001
12	Cream oil, grease	mg/l	-ND-	-ND-	-ND-
13	Mineral oil	mg/l	0,0009	0,0012	-ND-

-ND-: no detected

from water surface. Sampling time is from 11:30 am to 03:30 pm on 16/05/2013. The weather condition is sunny with light wind. During the sampling process, there is no interaction.

Through the table of analysis and comparison results with VR 10:2008/MONRE, applying to the aquaculture and of aquatic conservation areas, all parameters are within the permissible limit. Except for phase 2, the oil parameters at the 2 positions are beyond the regulation.

The research group carried out water quality analysis at the remaining beaches and the results are as follows: at Bai Ong and Bai Chong, the sea water quality is qualified but at Bai Huong, Bai Bac, and Bai Bim, the oil parameters exceed the criteria.

3. Soil quality

Bai Lang and Bai Huong have largest number of population on Cham Island. To identify the level of soil contamination, and nutrient content in the soil, the group conducted soil analysis at Bai Lang. The soil samples were taken at three different depths corresponding to the intended use of each layer: layer 1 is agricultural land (rice), layer 2 is the hill garden (forest vegetables), and layer 3 is the hilly land (forest vegetables and wild medicinal plants) (Figure 6).

Thus, through the tables of analysis results, layer 2and 3 have lower rate of humus than layer 1, and the nutrient content of layer 2 and 3 is also lower (total N is less than 0.08%) compared with layer 1. On layer 1, the rate of humus and nutrient content are higher than layer 2 and 3 but still at low rate.

4. Assessment on heavy metals accumulated in the local people's hair

To evaluate the possibility of heavy metal accumulation in the people's bodies, we collected and analyzed the concentration of some heavy metals in the hair samples of the local people at the age 18-65 years old of different occupation.
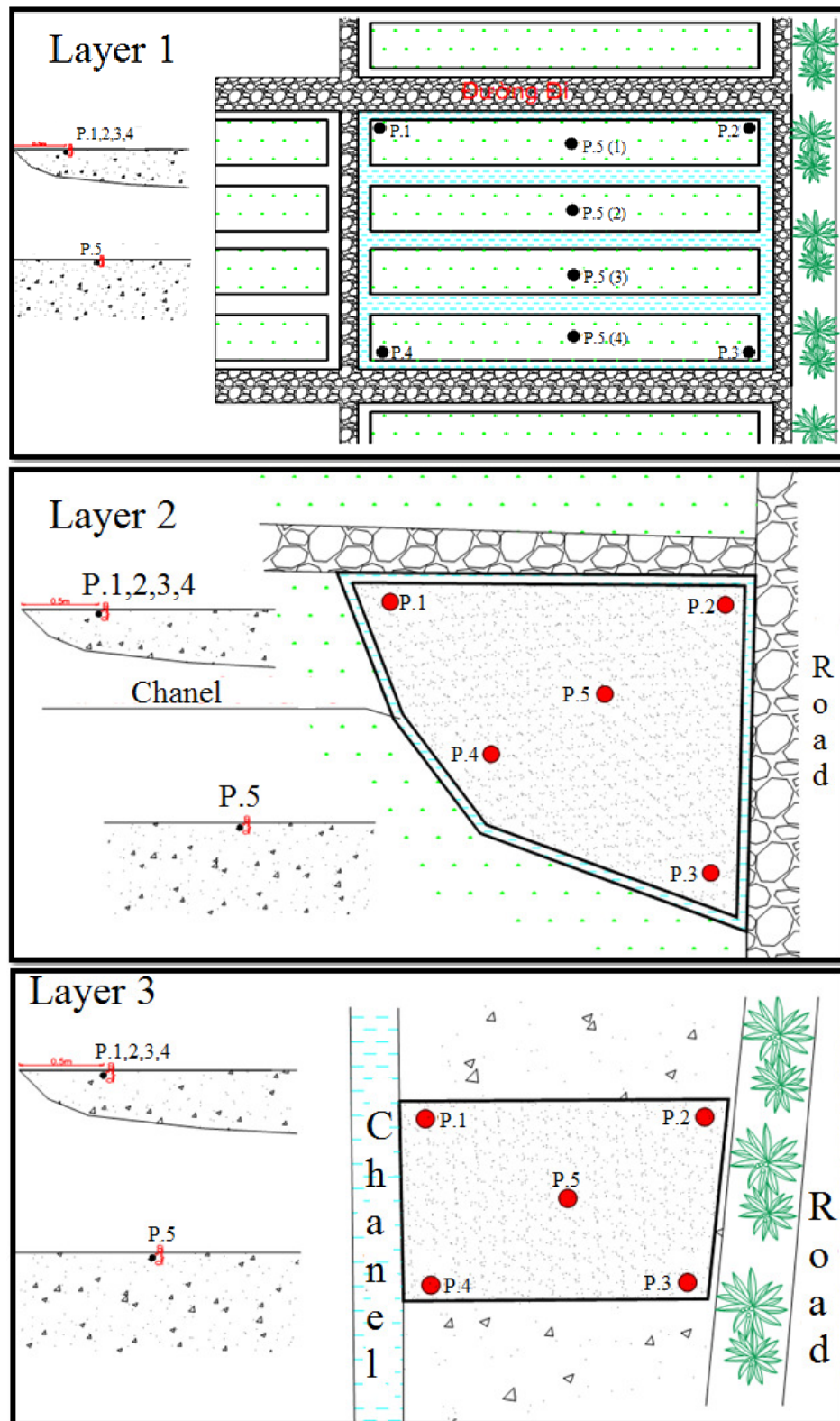
Figure 6. Sampling positions of soil at Bai Lang, Cham Islands

Sampling and method

The hair samples were voluntarily collected from 14 test subjects, who have been living in Cham Island for 15 to 50 years. The hair sample were cut close to the scalp with stainless steel scissors (that were rinsed with

Table 4. Results of soil samples of layer 1

Samples	Parameters				
	pH$_{KCl}$	Humidity (%)	Humus (%)	N-Total (%)	P-Total (P$_2$O$_5$%)
1	4.2	56.8	1.43	0.095	0.13
2	4.1	60.7	1.38	0.11	0.11
3	3.9	58.5	1.65	0.088	0.097
4	4.2	56.5	1.18	0.09	0.12
5	4.3	61.8	1.25	0. 11	0.12

Table 5. Results of soil samples of layer 2

Samples	Parameters				
	pH$_{KCl}$	Humidity (%)	Humus (%)	N-Total (%)	P-Total (P$_2$O$_5$%)
1	5.1	21.5	0.74	0.068	0.095
2	4.8	20.6	0.82	0.075	0.088
3	4.9	25.8	0.85	0.066	0.11
4	4.8	23.6	0.88	0.074	0.11
5	4.8	24.5	0.83	0.072	0.098

Table 6. Results of soil samples of layer 3

Samples	Parameters				
	pH$_{KCl}$	Humidity (%)	Humus (%)	N-Total (%)	P-Total (P$_2$O$_5$%)
1	5	19.5	0.37	0.042	0.06
2	5.2	18.8	0.28	0.039	0.054
3	4.8	20.5	0.33	0.036	0.066
4	5.1	19.9	0.29	0.033	0.062
5	4.9	20	0.29	0.031	0.057

acetone before use) and were placed into identified paper envelopes for further analysis

To achieve reproducible results, the sample selection was executed on the occipital lobe of the test subject's head on a similar spot from the hair baseline, in the amount of no less than 200 - 250 mg, respectively. The hair was then put into a Petri dish and rinsed in 20 ml of acetone, then rinsed twice in 40 ml of bid stilled water, and then once more in 20 ml of acetone. After rinsing, the hair was dried under a temperature of 80℃ until its mass became constant. In order to find chemical elements, each hair sample, weighing approximately 200 mg, was placed into a high-pressure reservoir DAP-60+ (BERGHOF) made from TFM. The reservoir was filled with 50 ml of 65% HNO$_3$ and airproofed with a tip with a special impermeable edge. The pressure reservoirs with hair were then subjected to hydrolysis in the speed wave MWS-3+ microwave system (Germany) with a suitable temperature program.

In the hair samples, concentration of 7 chemical elements (Hg, Zn, Cu, Pb, Cd, As, Cr) was calculated with the help of atomic emission spec- trometry with inductively coupled argon plasma iCAP 6300 DUO (Thermo Scientific, USA). The calibration curves that connect the analyte concentration in plasma with the instrumental response were linear in the range of five exponents of concentration value. For investigated elements, the limits of determining are 1 - 100 µg·l^{-1}, respectively.

The measurements were executed five separate times, after which the results were averaged out. The relative measurement error, consisting of accidental errors during the dissolving phase and choice errors, was no more than 10%. The correlation parameter for each element was no worse than 0.98.

The analysis was executed in axial mode. The capillary flushing time before analysis was 30 seconds. The pump velocity during flushing was 100 (rev·min^{-1}), during analysis was 50 (rev·min^{-1}), respectively. The flow of argon in the pulverizer and in the secondary flow was 0.7 l·min^{-1} and 0.5 l·min^{-1}, respectively. The power of plasma was 1150 W. Signal integration was executed during a 15-second period. Statistical processing of re-salts was made using Microsoft Excel under P < 0.05.

According to the analysis result of heavy metals and macro elements in human hair (Table 7) and based on the standard results of the WHO analysis which was conducted on 2838 healthy people at the age 18 to 65, the concentration of heavy metals with high toxic properties (Hg, Cd, Pb, and As) rests at a safe level. The macro element Zn is relatively high compared to the standard, but still within the allowable range. The reason is that the local people usually use seafood. Other parameters such as Cu and Cr are within the safe limit allowed by the WHO.

Table 7. Results of metal accumulation in human hair, who is living in Cham Island

Volunteers	Result						
	Hg (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	As (mg/kg)	Cr (mg/kg)
1.Duong La	0,029	165,72	10,53	0,55	0,027	0,018	0,37
2.Huynh Thanh	0,044	170,42	11,82	0,49	0,052	0,022	0,46
3.Dinh Hong	0,052	188,63	11,4	0,47	0,033	0,0054	0,52
4.Nguyen Thi Loi	0,037	159,64	12,82	0,52	0,038	0,021	0,64
5.Tran Quoc Khanh	0,039	166,88	9,36	0,55	0,025	0,036	0,38
6.Nguyen Em	0,046	190,03	9,42	0,62	0,028	0,087	0,39
7.Tran Van Trau	0,055	169,59	12,5	0,72	0,031	0,012	0,44
8.Nguyen Na	0,038	182,87	10,8	0.68	0,045	0,0095	0,53
9.Duong Thi Bich Lien	0,075	180,05	11,54	0.66	0,052	0,028	0,51
10.Le Thi Nga	0,048	178,75	10,71	0,83	0,038	0,019	0,43
11.Le Van Muoi	0,065	184,96	9,82	0,77	0,037	0,073	0,38
12.Duong T.Thu Dong	0,072	192,29	10,48	0,92	0,029	0,048	0,57
13.Tran Cong Thanh	0,037	187,72	11,25	0,64	0,044	0,027	0,61
14.Dinh Sy Cong	0,042	168,95	9,58	0,88	0,038	0,032	0,42

CONCLUSION

Our study presented the actual states and quality of sea water, sea grasses, soil (3 layers) in Cham Island including Bai Lang, Bai Huong, Bai Ong, Bai Bim and Bai Bac. Through the analysis results, we may be given the comments that we need to improve the quality of soil environment to gain the content of humus and the nutrients with the purpose of improving quality of agricultural products in Cham Island.

During the testing phase, we developed ecological analysis method for chemical elements to monitor the human hair of Cham Island's people. In general, the health status of fishermen in Cham Island has not been affected by the environmental factors. Parameters of toxic heavy metals in human hair are within a safe threshold. However, the level of Hg was detected in the relatively stable frequency. If there is no solution for the situation of dynamite fishing and gold mining in Bong Mieu which kills coral reefs (due to the high level of mercury in water)in the near future, the health status of the people in Cham Island would be affected adversely.

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