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Assessment of the Ecological Quality Status of Sediment in the Organic Shrimp Farming Ponds Using Azti's Marine Biotic index Based on Marobenthic Communities

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Abstract: Macrobenthic communities (MC) in the Tam Giang's organic shrimp farming ponds (TGOSFP) (located in Tam Giang commune, Nam Can district, Ca Mau province) were explored during three seasons in 2015 (March - dry, July - transitional and November - rain season). The results indicated that the MC have characterized by high density and quite diverse. Further more, the present study is a first attempt to use of AZTI's Marine Biotic Index (AMBI) based on MC for determining the ecological quality status of sediment (EcoQ) in the TGOSFP. The following results were also recorded with an undisturbed and slightly disturbed EcoQ in the TGOSFP and the general EcoQ would likely be improved between three seasons. The success of AMBI for detecting EcoQ in Vietnam is specific to this study, but AMBI was likely to improved, in particular tropical regions.

Keywords: AMBI, Ca Mau province, ecological quality status of sediment, macrobenthic communities, organic shrimp farming ponds.

1. Introduction

Macrobenthic communities are the most frequently used as good biological indicators for sediment condition [1]. Macrobenthic organisms are used because they (i) are sensitive to natural and anthropogenic disturbances [2], (ii) are relatively sedentary residents in soft - bottoms, where contaminants accumulate, therefore unable to avoid a stress in sediment [1], (iii) have diverse taxa with different tolerances to stress, and (iv) availability play a crucial position in nutrients and materials cycling [3]. For assessing EcoQ, a very large variety of benthic biotic indices has already been used around the world such as Biological Monitoring Working Party index - BMWP [4], the Infaunal Trophic Index - ITI [5], the Benthic Index of Biotic Integrity - BIBI [6], the Biotic Index - BI [7], AMBI [8], the Bentix Index - BENTIX [9], the Benthic Quality Index - BQI [10], the Exergy Index - EI

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[11] and the latest is the multivariate AZTI's marine biotic index - MAMBI [12]. Nevertheless, in Vietnam, BMWP is the most commonly used benthic biotic index, whereas the others index may be somewhat little - known [13-15].

Regarding AMBI, it was first developed in European by Borja et al. (2000), which attributes five EcoQ ratings ("Undisturbed", "Slightly disturbed", "Moderately disturbed", "Heavily disturbed" and 'Extremely disturbed" - according to the proportion of pollution tolerance of the species present at the site [8]. More specifically, macrobenthic species are also classified in five ecological groups (EG) based upon different sensitivity levels (from very sensitive to opportunistic): EG1, 2, 3, 4, 5 (increasing levels of disturbance). The assignment of species into one of the five EG based on consensus local expert judgement; therefore, those assignments may be transferable among geographies [1]. AMBI is the most commonly used biotic index along European estuarine and coastal habitats [16] and has had successful application to others regions [17- 20].

The organic shrimp farming ponds in this study are located in Tam Giang commune, Nam Can district, Ca Mau province where has come to be known as the largest shrimp production and farming area in Vietnam [21]. In the past years, because the shrimp farming industry expanded rapidly after the end of the Vietnam war [22] and in particular after the government released the resolution 09/NQ - CP (the year 2000), causing devastated damage to Ca Mau's mangroves [23]. To solve this problem, a model organic shrimp farming system is developed to integrate shrimp aquaculture with mangrove protection. It is a sustainable development of the shrimp farming model in the estuarine and coastal areas, which is based upon the holistic agriculture management, being environmentally friendly and sustaining biodiversity [24]. In recent years, several studies have been carried out but concerned only to survey of the physic - chemical characteristics [25], plankton and meiofauna communities in the organic shrimp farming ponds [26, 27] while lots of information about organic shrimp farming ponds is still unknown in general.

Therefore, the present study have two main aims: (i) to survey of the MC and also (ii) to first application AMBI for determining the EcoQ in the TGOSFP. The results of this study can make a expansion its use to other tropical areas and in order to achieve the sustainable conservation of these tropical ecosystems.

2. Materials and methods

2.1. The Tam Giang's organic shrimp farming ponds

Tam Giang is a rural commune (forms a roughly 95.31 km^2) of Nam Can district, Ca Mau province in the Mekong delta region of Vietnam. The commune is one of localities having the large shrimp production and area of organic shrimp farming systems in Nam Can district. Presently, black tiger shrimp (*Penaeus monodon*) is broadly farmed in organic shrimp farming ponds of this commune [25].

2.2. Macrobenthic sampling

In the field, macrobenthic samples were collected in eight organic shrimp farming ponds and coded (TG1, 2, 3, 4, 5, 6, 7, 8) (**Fig. 1**). All ponds were sampled by using a 0.1 m^2 Ponar grab with four replicates per ponds. Biological materials were retained by the sieve with 1 mm mesh and fixed in 10% formaldehyde until it could be sorted and counted under stereo microscope. Samples were identified in the laboratory by using the following literature: [28-32]. Abundances were expressed in inds/0.1 m^2.

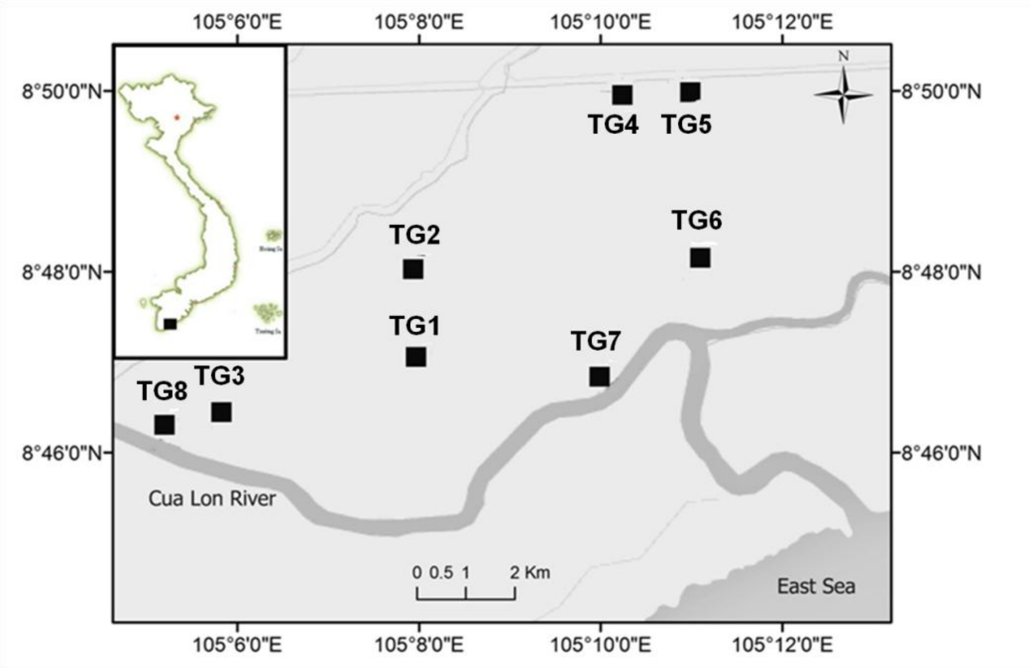

Figure 1. Location map of study area.

2.3. Data analyses

AMBI description

As stated above, AMBI based upon an a priori classification of macrobenthic species in one of five EG depending on their sensitivity to disturbance. The list of EG values is regularly updated and published by the AZTI Laboratory (from http://ambi.azti.es). Grall and Glémarec (1997) [7] had a summary of the characteristics of five EG as follows:

EGI: Including species that are very sensitive to organic matter enrichment and disturbance; present only under pristine conditions. These are carnivores species, some deposit - feeding tubicolous polychaetes. Most have a long generation time.

EGII: Species unconcerned to organic matter enrichment or disturbance, usually present in low densities with non - signifiant fluctuations over time. These are suspension feeders, less selective carnivores and scavengers.

EGIII (intermediate EG): Species are tolerant in excess of organic enrichment, that may present under normal conditions, but their densities are stimulated by slightly unbalanced situations. These include surface deposit - feeding species (eg. tubicolous spionids).

EGIV: Second - order opportunistic species, present under slightly unbalanced conditions. These are mainly small subsurface deposit - feeding polychaetes (eg. cirratulids).

EGV: First - order opportunistic species, capable to resist high disturbance. These include deposit - feeders, which proliferate in high organic matter enrichment sediments.

AMBI values are computed as the sum of products of the proportion of each EG by an arbitrary value (0; 1.5; 3; 4.5; 6) attributed to each EcoQ [18] (Table 1).

AMBI = [(0 x %EGI) + (1.5 x %EGII) + (3 x %EGIII) + (4.5 x %EGIV) + (6 x %EGV)]/100

Table 1. The ecological quality status based on AMBI values

AMBI values	Dominating EG	EcoQ	Indicator
0 < AMBI ≤ 0.2	I	Undisturbed	Normal
0.3 < AMBI ≤ 1.2		Undisturbed	Impoverished
1.3 < AMBI ≤ 3.3	II	Slightly disturbed	Unbalanced
3.4 < AMBI ≤ 4.3		Moderately disturbed	Transitional to pollution
4.4 < AMBI ≤ 5.0	IV - V	Moderately disturbed	Polluted
5.1 < AMBI ≤ 5.5		Heavily disturbed	Transitional to heavy pollution
5.6 < AMBI ≤ 6.0	V	Heavily disturbed	Heavy polluted
AMBI = 6		Extremely disturbed	Azoic

In the present study, the AMBI was computed using the AMBI program (by the latest version 5.0 and list of EG Nov 2014) that freely available online at http://www.azti.es. In case, species not assigned on the list, we convert the species by another closest taxa.

Univariate and statistical methods

Macrobenthic communities data were analysed using PRIMER VI software for calculating several univariate indices: Species richness (S), Shannon index (H'). The software STATISTICA 7.0 was used for analysizing the two - way ANOVA.

3. Results and discussion

3.1. Benthic macroinvertebrates communities

Taxa composition

Overall, 28 macrobenthic species (per 0.1m^2) were recorded in three seasons (**Table 2**). They belonged to five class such as Polychaeta, Oligochaeta, Crustacea, Gastropoda and Bivalvia. Furthermore, MC in the TGOSFP, mainly included of three phylum: Mollusca, Annelida and Arthropoda. Through three seasons, most individuals belong to three dominant classes: Gastropoda, Polychaeta and Crustacea. The high proportion of the Gastropoda in total macrobenthic abundance is the major reason of the dominance of phylum Mollusca.

More specifically, in dry season, Gastropoda was dominant (52% of total abundance) followed by Polychaeta (18%), Crustacea (16%), Bivalvia (8%) and Oligochaeta (6%). For trans season, Gastropoda was also dominant with a greater proportion (77%) than its in dry season followed by Polychaeta (12%), Bivalvia (7%). However, Oligochaeta and Crustacea which were recorded with a very small number of individuals (<3% in total abundance). Further more, in rain season, Gastropoda was considerably dominant than the orther classes (measured at 80%). Next, Polychaeta had a slightly high proportion in total abundance (12%). Other classes were only measured with a small number of individuals (<4%) (**Fig. 2**).

In this study, it is notable in that the Gastropoda species *Sermyla tornatella* was dominant with a large number of individuals during three seasons (50.29% - dry, 75.26% - transitional and 76.33% - rain season of total individuals).

Densities and diversities

In general, average densities (inds/0.1m^2) ranged from 107.3 ± 32.9 to 535 ± 204.9 in dry, 134.7 ± 46.2 to 1,012 ± 424.4 in tranitional and from 163 ± 80.7 to 845.7 ± 465.5 in rain seasons. TG1 was expressed as the highest density during two seasons (except for dry season). By contrast, pond TG7 showed the lowest density through sampling seasons. The MC density was likely to rise in transitional season. The two - way ANOVA analysis based on the the MC density showed significant differences between seasons (p se < 0.01) and ponds (p po < 0.01) as well as between the interaction factors (p se * po = 0.02).

The diversity of MC was measured by the Shannon - Wiener (H') and species richness (S). The H' ranged from 1.53 ± 0.49 to 2.5 ± 0.17 in dry, between 0.63 ± 0.22 - 2.3 ± 0.5 for transitional and between 0.6 ± 0.32 - 2.74 ± 0.09 for rain season (**Fig. 3**). In transitional and rain season, TG1 was the pond that presented a high density whereas the diversity indices (H’) was generally low. In general, values of H' index in dry were higher than its in other seasons. Two – way ANOVA results based on the H' index showed significant differences between ponds, seasons as well as the interaction factors (p se, p po, p se * po < 0.01). The diversity of MC expressed in species richness (S) measured from 5 - 12 species in dry and transitional season, while ranged between 8 to 12 species in rain season (**Fig. 3**). The two - way ANOVA analysis showed no significant differences between seasons (p se = 0.70). Nevertheless, significant differences were observed between ponds (p st < 0.01) and for the interaction terms (p se * po < 0.01).

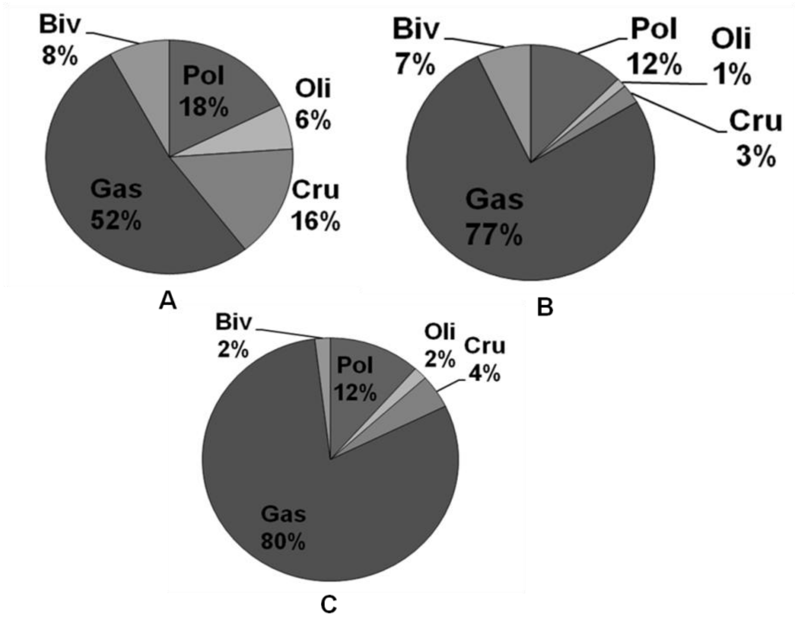

Figure 2. Percentage of macrobenthic classes through three seasons. (A) Dry season, (B) Transitional season, (C) Rain season, (Pol - Polychaeta, Oli - Oligochaeta, Cru - Crustacea, Gas - Gastropoda, Biv - Bivalvia).

3.2. A rich natural food sources in the TGOSFP

This study indicated that the MC in TGOSFP have not been recorded in high density but it has characterized by quite diverse. The density of MC in TGOSFP was higher than the macrobenthic density in the mangrove area of Ximen Island, China (up 340 inds/m^2) [33], in the mangrove of Kachchh – Gujarat, India (424 - 2393 inds/m^2) [34], Northeastern Arabian sea shelf, India (50 - 1437 inds/m^2) [35]. The macrobenthic density in the dry and rain season is comparable with the island of Santa Catarina, South Brazil (up 7,250 inds/m^2) [36], and in Gazi Bay, Kenya (6,025 inds/m^2) [37]. However, these densities we observed were lower than 21,000 to 2.16 x 10^5 inds/m^2 recorded in Schelde eatuary [38].

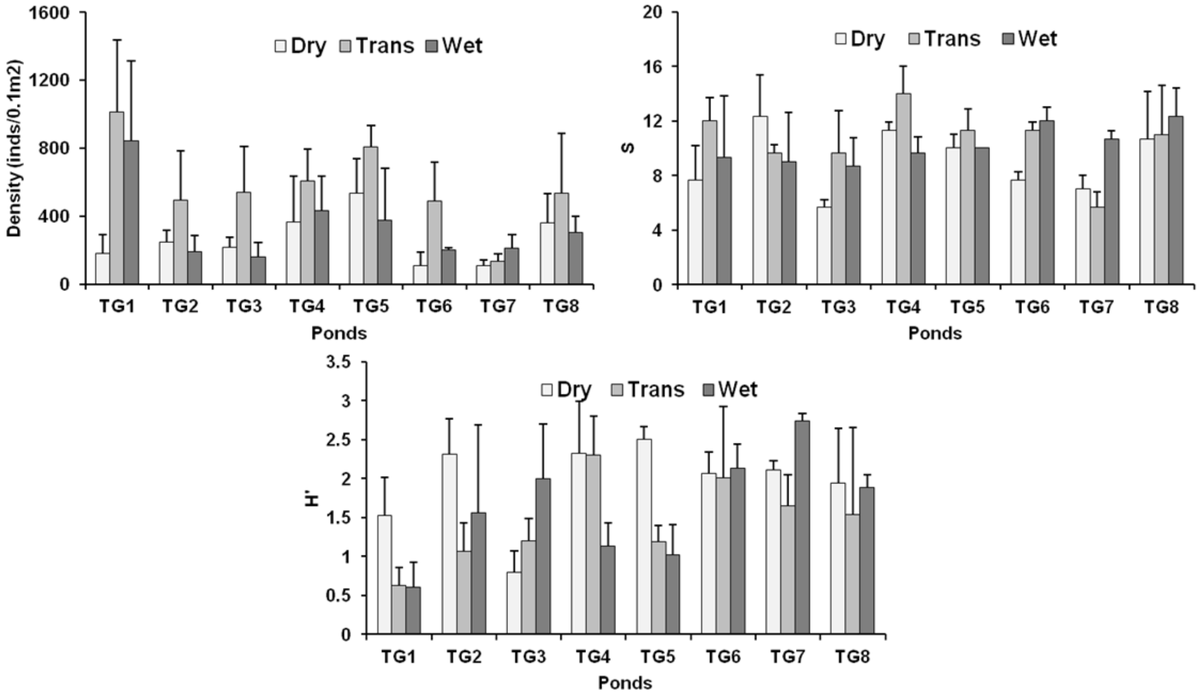

Figure 3. Density and diversity indices (S, H') of macrobenthic species in all ponds of the three seasons (average ± standard deviation)

The macrobenthic diversity (H') was low compared to recently estimates of 4.3 to 5.1 in mangrove area of Tamil Nadu, India [39]. Nevertheless, this range overlapped with the ranges for H' value of MC in the mangrove of Pondicherry, India which measured from 1.8 to 2.83 [40], in Zhanjiang mangrove forest, China (2.06 - 2.36) [41] and from the mangrove of Missionary, Australia (1.18 - 2.38 [42].

Several studies have demonstrated that *Penaeus monodon* is an omnivorous but mostly feeding on macrobenthic organisms. Marte (1980) has warned that the percentage of total food of *Penaeus monodon* includes small Crustacea, Mollusca, fish, Polychaeta (55.08; 31; 5.88; 0.69%, respectively) [43]. From this evidence, it is fair to conclude that MC expressed by high density and diversity. It is a rich natural food resource for *Penaeus monodon* in the TGOSFP.

3.3. Assessment of EcoQ in TGOSFP by using AMBI

Classification of macrobenthic species in EG

Among all the macrobenthic species identified (28 species), the majority (fourteen species - 50% in total) were ascribed an EG based upon the classification supplied in the AZTI database by closet species. Eleven species (39.3%) were available in the AZTI database. Only one species (3.5%) was classified based on the AZTI classification for higher taxa (Family) (*Tegillarca granosa* converted to Arcidae). Finally, due to the lack of ecological information about species that lived in tropical areas, two species (7.2%) were not classified in any EG (*Grandidierella bonnieri* and *Longiflagrum amphibium*) (denominated as "N.A") (**Table 2**).

Table 2. List of taxa and species together with their EG

STT	Taxa	Species	Seasons sampling			EG proposed by AZTI web list or for closest taxa
			Dry	Trans.	Rain	
1	Pol	*Nereis zonata*	x	x	x	III
2	Pol	*Nereis pachychaeta*	x	x	x	III (for *Nereis* sp.)
3	Pol	*Nereis kauderni*	x	x	x	III (for *Nereis* sp.)
4	Pol	*Nereis unifasciata*	x	x	x	III (for *Nereis* sp.)
5	Pol	*Perinereis cultrifera*	x	x	x	III
6	Pol	*Nereis* sp.	x	-	-	III (for *Nereis* sp.)
7	Pol	*Branchiomma* sp.	-	x	x	I (for *Branchiomma* sp.)
8	Pol	*Spionidae* sp.	x	x	x	III (for *Spio* sp.)
9	Pol	*Minuspio cirrifera*	x	x	x	IV
10	Pol	*Nephtys polybranchia*	x	x	x	II
11	Pol	*Nephtys hombergii*	x	x	x	II
12	Pol	*Capitella capitata*	x	x	x	V
13	Pol	*Lumbriconereis pseudobifilaris*	-	x	x	II (for *Lumbriconereis* sp.)
14	Oli	*Lumbriculus variegatus*	x	x	x	V
15	Cus	*Grandidierella bonnieri*	x	x	x	N.A
16	Cus	*Gammarus pulex*	x	x	x	I (for *Gammarus* sp.)
17	Cus	*Longiflagrum amphibium*	x	x	x	N.A
18	Cus	*Gammaropsis thompsoni*	x	x	x	II
19	Cus	*Neomysis* sp.	-	x	x	II (for *Neomysis* sp.)
20	Gas	*Sermyla tornatella*	x	x	x	I (for *Sermyla riqueti*)
21	Gas	*Cerithium lutosum*	x	x	x	II (for *Cerithium* sp.)
22	Gas	*Cerithidea cingulata*	x	x	x	I
23	Gas	*Acteocina infrequens*	x	x	x	II (for *Acteocina* sp.)
24	Gas	*Neritina violace*	-	x	x	I (for *Neritina* sp.)
25	Gas	*Stenothyra glabra*	-	-	x	I
26	Biv	*Amygdalum watsoni*	x	x	x	III (for *Amygdalum* sp.)
27	Biv	*Solen strictus*	-	x	x	II
28	Biv	*Tegillarca granosa*	-	-	x	I (for Arcidae)

(-/x means absent/present of taxa, N.A - not assigned, Pol - Polychaeta, Oli - Oligochaeta, Cru - Crustacea, Gas - Gastropoda, Biv - Bivalvia)

The ecological quality status of sediment in the TGOSFP

Overall, AMBI produced very low values and no values reached the threshold of 3.4 (assigned to moderate disturbed) as well as individuals from EGI was the dominant group at all seasons, indicating a high or good ecological status for the TGOSFP during three seasons.

TG1, 3, 7 have been classified as undisturbed in dry, transitional, as well as in rain season. TG2, 4, 5, 6, 8 were classified as slightly disturbed in dry season; however, it improved a little and was classified as undisturbed in transitional season (except for TG4, 6 were still identified as slightly disturbed). In rain season, all ponds were classified as undisturbed, except for TG6 was measured as a slightly disturbance over the three seasons (**Table 3**).

Table 3. Values of AMBI, percentages of each EG and ecological quality status of sediment from each ponds in TGOSFP during three seasons

Seasons	Ponds	Percentages of each EG					AMBI	Disturbance Clasification
		I	II	III	IV	V		
Dry season	TG1	89.6	0.5	7.30	0.0	2.7	0.57±0.52	U
	TG2	46.4	3.5	46.4	0.1	3.6	1.53±0.74	S
	TG3	89.6	1.1	9.0	0.0	0.3	0.32±0.10	U
	TG4	61.8	1.8	33.3	0.0	3.1	1.81±1.00	S
	TG5	41.6	0.9	51.3	0.0	6.3	2.29±1.11	S
	TG6	47.3	1.4	29.5	0.0	21.9	2.84±1.50	S
	TG7	71.2	13	9.60	0.0	6.2	0.78±0.35	U
	TG8	60.4	2.9	18.6	0.0	18.1	2.10±0.43	S
Transitional season	TG1	94.5	0.3	5.10	0.0	0.1	0.18±0.09	U
	TG2	86.4	1.1	11.9	0.0	0.5	0.48±0.19	U
	TG3	81.6	1.3	15.2	0.0	1.8	0.57±0.17	U
	TG4	48.0	1.2	47.9	1.6	1.2	1.73±0.60	S
	TG5	82.2	0.5	16.9	0.1	0.3	0.54±0.08	U
	TG6	61.5	0.9	35.2	0.2	2.2	1.36±0.79	S
	TG7	71.8	12.4	11.9	0.0	4.0	0.83±0.39	U
	TG8	76.7	2.7	15.2	0.3	5.0	0.87±0.92	U
Rain season	TG1	92.8	0.5	6.40	0.1	0.3	0.29±0.19	U
	TG2	78.7	1.8	15.6	0.2	3.8	1.04±1.06	U
	TG3	80.3	3.4	12.8	0.0	3.6	0.88±0.61	U
	TG4	85.6	2.3	11.7	0.0	0.4	0.46±0.18	U
	TG5	90.1	0.4	9.40	0.0	0.2	0.38±0.19	U
	TG6	53.3	1.0	19.6	24.2	1.9	1.80±0.37	S
	TG7	68.3	17.9	7.30	6.5	0.0	0.78±0.15	U
	TG8	69.2	0.7	19.3	0.8	10	1.18±0.33	U

(U: Undisturbed, S: Slightly disturbed)

3.4. AMBI has been widely accepted for sediment condition monitoring among different geographical regions

The AMBI was primarily created to determine the EcoQ of European coastal areas [16]. Nowadays, it is being used commonly as a biotic index in the WFD (European Water Framework Directive) [12]. Many studies have been applied successfully this index for assessing the EcoQ under different impact sources within European. However, AMBI has only seldom been used outside European (**Table 4**). To our knowledge, the present study is a first attempt to use AMBI in tropical habitats of the Southeast Asia regions.

Table 4. AMBI has been widely used in different geographic regions

Regions	Locations	References
Europe	Plentzia (Spain) and Tallinn (Estonia)	[44]
	Bay of Seine and the Seine estuary	[3]
	Brittany (France)	[45]
	Basque Country (Spain)	[45]
	Mondego estuary (Portugal)	[11]
	Huelva (Spain)	[45]
	Almer´ıa and Murcia (Spain)	[45]
	Adriatic Sea (Italy)	[46]
	Port of Trieste (Italy)	[47]
	Saronikos Gulf (Greece)	[45]
	North Sea (Netherlands)	[45]
Tropical areas	TGOSFP	This contribution
	Along coastline of Pernambuco (Brazil)	[48]
	Northwest and the East coast of Reunion Island (Southwest Indian Ocean)	[18]
South America Atlantic	South - eastern Brazilian coast Uruguayan coastal zone	[49]
North America	Southern California marine bays	[1]

3.5. Application of AMBI in Vietnam: Opportunities & Challenges

In Vietnam, BMWP is presently being used broadly for determining the EcoQ [13, 14, 15], whereas many biotic indices are efficient in the EcoQ that may be little - known. Howerver, many indices are not easy to use because they require enormous calibration databases. By contrast, AMBI proved to be simple to employ, inexpensive, highly sensitive, perhaps too straightforward, and in particular its requirement of minimal local calibration databases [1].

Clearly, AMBI has been used successfully for detecting EcoQ in the TGOSFP. The obtained results were also recorded with an undisturbed and slightly disturbed EcoQ in the TGOSFP. Surveys of eight organic shrimp farming ponds located in Tam Giang commune done in dry, transitional and rain seasons indicate a small seasonal changes. Despite these unpromising ratings, the general EcoQ status would likely be improved between three seasons. More specifically, in dry season, the AMBI classification for eight ponds were predominantly slightly disturbed. By contrast, undisturbed condition was observed mostly in transitional, particularly in rain seasons (only one pond classified as slightly disturbed - TG6).

Unfortunately, we also point out some limitations for the first use of AMBI in Vietnam as well as tropical regions. First, there are no estimates available to date on the EcoQ in the organic shrimp farming ponds which was carried out in Vietnam. Therefore, we can not compare ourselves results with others. Next, as only 7 of 28 species (39%) were on the original AMBI database. This is not surprising that AMBI was first developed and as the most commonly used in Europe, many species living in tropical regions, ecological assignments provided by European datasets are unknown or are not in concordance with their ecology. Thus, this method necessary to have special concern on this point for the future.

Several modifications should be to enhance AMBI's performance in subtropical and tropical regions such as (i) incorporate local ecologist expertise in new EG assignments and re - assignments based on previous data from monitoring programs or the local expertise experience with the ecological characteristics of the macrobenthic communities in the studied habitats, (ii) use the AMBI in combination with other indices, e.g the BMWP, ITI, BQI, M - AMBI.

4. Conclusion

The MC in TGOSFP has characterized by high density and quite diverse that is a rich natural food resource for shrimp in the TGOSFP. Further more, according to AMBI, the EcoQ in the TGOSFP was attributed with an undisturbed and slightly disturbed EcoQ and the general EcoQ would likely be improved between three season. The present study represents the first attempt at determining the EcoQ by AMBI method in Vietnam, however, it is also suggested that prior its application care must be taken regarding the pre - established assignment of each of the species sampled to an EG.

References

[1] H. Teixeira, S. B. Weisberg, A. Borja, J . A. Ranasinghe,, D. B. Cadien, R. G. Velarde, ... & J. K. Ritter, Calibration and validation of the AZTI's Marine Biotic Index (AMBI) for Southern California marine bays, Ecological Indicators 12 (2005) 84.

[2] S. Bustos - Baez, C. Frid, Using indicator species to assess the state of macrobenthic communities, Advances in Polychaete Research, Springer, 2003.

[3] C. J. Dauvin, T. Ruellet, N. Desroy, L. A. Janson, The ecological quality status of the Bay of Seine and the Seine estuary: use of biotic indices, Marine Pollution Bulletin 55 (2007) 241.

[4] D. P. Z Amitage, D. Moss, F. J. Wright, T. M. Furse, The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running - water sites, Water research 17 (1983) 333.

[5] J. Word, The infaunal trophic index, a functional approach to benthic community analyses, PhD thesis, University of Washington, 1990.

[6] B.S. Weisberg, A. J. Ranasinghe, M. D. Dauer, C. L. Schaffner, J. R. Diaz, B. J. Frithsen, An estuarine benthic index of biotic integrity (B-IBI) for Chesapeake Bay, Estuaries and Coasts 20 (1997) 149.

[7] J. Grall, M. Glémarec, Using biotic indices to estimate macrobenthic community perturbations in the Bay of Brest. Estuarine, Coastal and Shelf Science 44 (1997) 43..

[8] A. Borja, J. Franco, V. Pérez, A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments, Marine Pollution Bulletin 40 (2000) 1100.

[9] N. Simboura, A. Zenetos, Benthic indicators to use in ecological quality classification of Mediterranean soft bottom marine ecosystems, including a new biotic index, Mediterranean Marine Science 3 (2002) 77.

[10] R. Rosenberg, M. Blomqvist, C. H. Nilsson, H. Cederwall, A. Dimming, Marine quality assessment by use of benthic species-abundance distributions: a proposed new protocol within the European Union Water Framework Directive, Marine Pollution Bulletin 49 (2004) 728.

[11] F. Salas, C. Marcos, A. Pérez - Ruzafa, C. J. Marques, Application of the exergy index as ecological indicator of organically enrichment areas in the Mar Menor lagoon (south-eastern Spain), Energy 30 (2005) 2505.

[12] I. Muxika, A. Borja, J. Bald, Using historical data, expert judgement and multivariate analysis in assessing reference conditions and benthic ecological status, according to the European Water Framework Directive, Marine Pollution Bulletin 55 (2007) 16.

[13] N. C. Thuan, N. H. Chiem, D. T. Duong, Water quality assessment base on BMWPViet Nam at Cai May canal, Phu Tan district, An Giang province, Can Tho University Journal of Science 15 (2010) 125.

[14] C. T. Truong, A. T. T. Ngo, Application of macroinvertebrates for assessment of water quality in 4 main canal systems in Ho Chi Minh city, Science & Technology Development 10 (2007) 25.

[15] N. V. Khanh, P. T. H. Ha, L. T. Son,. Using bioindicator macro invertebrates assessment of the

water quality in five pools in Da Nang city, Hue University Journal of Science 63 (2010) 91.

[16] A. Borja, G. J. Rodríguez, K. Black, A. Bodoy, C. Emblow, F. T. Fernandes, ... N. Papageorgiou, Assessing the suitability of a range of benthic indices in the evaluation of environmental impact of fin and shellfish aquaculture located in sites across Europe, Aquaculture 293 (2009) 231.

[17] A. Afli, R. Ayari, S. Zaabi, Ecological quality of some Tunisian coast and lagoon locations, by using benthic community parameters and biotic indices, Estuarine, Coastal and Shelf Science 80 (2008) 269.

[18] L. Bigot, A. Grémare, M. J. Amouroux, P. Frouin, O. Maire, C. J. Gaertner, Assessment of the ecological quality status of soft-bottoms in Reunion Island (tropical Southwest Indian Ocean) using AZTI marine biotic indices, Marine Pollution Bulletin 56 (2008) 704.

[19] A. Bakalem, T. Ruellet, C. J. Dauvin, Benthic indices and ecological quality of shallow Algeria fine sand community, Ecological Indicators 9 (2009) 395.

[20] A. Borja, G. B. Tunberg, Assessing benthic health in stressed subtropical estuaries, eastern Florida, USA using AMBI and M - AMBI, Ecological Indicators 11 (2011) 295.

[21] Ministry of Agriculture and Rural Development (MARD), https://tongcucthuysan.gov.vn/en-us/aquaculture/doc-tin/006222/2016-10-28/ca-mau-set-outs-to-become-viet-nams-largest-shrimp-hub, Access 1 May. 2016.

[22] L. Lebel, H. N. Tri, A. Saengnoree, S. Pasong, U. Buatama, K. L. Thoa, Industrial transformation and shrimp aquaculture in Thailand and Vietnam: pathways to ecological, social, and economic sustainability?. AMBIO, A Journal of the Human Environment 31 (2002) 311.

[23] P. N. Hong, T. H. San, Mangroves of Vietnam (Vol. 7), IUCN 1993.

[24] Thai agricutural standard (TAS), Organic marine shrimp farming, Royal Gazette Vol. 124 Section 78E 2007.

[25] N. Tho, N. V. Ut, R. Merckx, Physico ‐ chemical characteristics of the improved extensive shrimp farming system in the Mekong Delta of Vietnam, Aquaculture Research 42 (2011) 1600.

[26] D. Johnston, M. Lourey, D. V. Tien, T. T. Luu, T. T. Xuan, Water quality and plankton densities in mixed shrimp ‐ mangrove forestry farming systems in Vietnam, Aquaculture Research 33 (2002) 785.

[27] T. T. Thai, N. T. M. Yen, N. Tho, N. X. Quang, Meiofauna in the mangrove – shrimp farms ponds, Ca Mau province, Journal of Science and Technology 55 (2017) 271.

[28] N. V. Thanh, N. N. Chau, The zoobenthos of Can Gio mangrove ecosystem. Publishing House for Science and Technology Hanoi Vietnam 2005.

[29] T. R. Abbott, S. Dance, T. Abbott, Compendium of seashells, Odyssey 1983.

[30] J. P. Hayward, S. J. Ryland, Handbook of the marine fauna of North - West Europe, Oxford University Press 1995.

[31] K. Fauchald, The polychaete worms; definitions and keys to the orders, families and genera, Natural History Museum of Los Angeles County 1977.

[32] J. F. Springsteen, M. F. Leobrera, B. C. Leobrera, Shells of the Philippines (Vol. 100), Carfel Seashell Museum, Manila 1986.

[33] G. A. Gao, Z. Q. Chen, N. J. Zeng, B. Y. Liao, Y. J. Yang, Macrofauna community in the mangrove area of Ximen Island, Zhejiang, Journal of Marine Sciences 23 (2005) 33.

[34] A. Saravanakumar, S. J. Serebiah, A. G. Thivakaran, M. Rajkumar, Benthic macrofaunal assemblage in the arid zone mangroves of gulf of Kachchh-Gujarat, Journal of Ocean University of China 6 (2007) 303.

[35] H. A. Parulekar, A. B. Waugh, Quantitative studies on the benthic macrofauna of northeastern Arabian sea shelf, Indian Journal Marine Science 4 (1975) 174.

[36] A. S. Netto, F. Gallucci, Meiofauna and macrofauna communities in a mangrove from the Island of Santa Catarina, South Brazil, Hydrobiologia 505 (2003) 159.

[37] J. Schrijvers, D. V. Gansbeke, M. Vincx, Macrobenthic infauna of mangroves and surrounding beaches at Gazi Bay, Kenya, Hydrobiologia 306 (1995) 53.

[38] T. Ysebaert, P. Meire, D. Maes, J. Buijs, The benthic macrofauna along the estuarine gradient of the Schelde estuary, Aquatic Ecology 27 (1993) 327.

[39] B. Thilagavathi, D. Varadharajan, A. Babu, J. Manoharan, S. Vijayalakshmi, T. Balasubramanian, Distribution and diversity of macrobenthos in different mangrove ecosystems of Tamil Nadu coast, India, Journal of Aquaculture Research & Development 4 (2013) 1.

[40] S. P. Kumar, B. A. Khan, The distribution and diversity of benthic macroinvertebrate fauna in

Pondicherry mangroves, India, Aquatic biosystems 9 (2013) 15.

[41] J. Y. Tang,X. S. Yu, Y. Y. Wu, A comparison of macrofauna communities in different mangrove assemblages, Zoological Research 28 (2007) 255.

[42] S. Dittmann, Abundance and distribution of small infauna in mangroves of Missionary Bay, North Queensland, Australia, Revista de biología tropical 49 (2007) 535.

[43] L. C. Marte, The Food and Feeding Habit of Penaeus Monodon Fabricius Collected From Makato River, Aklan, Philippines (Decapoda Natantia) , Crustaceana 38 (1980). 225

[44] I. Muxika, A. Borja, J. Franco, The use of a biotic index (AMBI) to identify spatial and temporal impact gradients on benthic communities in an estuarine area, ICES CM 2003.

[45] A. Borja, I. Muxika, J. Franco, The application of a Marine Biotic Index to different impact sources affecting soft-bottom benthic communities along European coasts, Marine Pollution Bulletin 46 (2003) 835.

[46] C. H. I. A. R. A. Casselli, M. A. S. S. I. M. O. Ponti, M. A. R. C. O. Abbiati, Valutazione della qualità ambientale della laguna costiera Pialassa Baiona attraverso lo studio dei suoi popolamenti bentonici. In XIII Congresso Societá Italiana de Ecología Como Villa Olmo 2003.

[47] V. Solis - Weiss, F. Aleffi, N. Bettoso, P. Rossin, G. Orel, S. Fonda - Umani, Effects of industrial and urban pollution on the benthic macrofauna in the Bay of Muggia (industrial port of Trieste, Italy), Science of the total environment 328 (2004) 247.

[48] M. P. A. Valença, J. P. Santos, Macrobenthic community for assessment of estuarine health in tropical areas (Northeast, Brazil): review of macrofauna classification in ecological groups and application of AZTI Marine Biotic Index, Marine pollution bulletin 64 (2012) 1809.

[49] P. Muniz, N. Venturini, M. A. Pires - Vanin,R. L. Tommasi, A. Borja, Testing the applicability of a Marine Biotic Index (AMBI) to assessing the ecological quality of soft-bottom benthic communities, in the South America Atlantic region, Marine Pollution Bulletin 50 (2005) 624.

Đánh giá chất lượng môi trường nền đáy ao nuôi tôm sinh thái bằng chỉ số sinh học biển azti’s dựa trên quần xã động vật đáy không xương sông cỡ lớn

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Tóm tắt: Quần xã động vật đáy không xương sống cỡ lớn trong các ao tôm sinh thái xã Tam Giang, huyện Năm Căm, tỉnh Cà Mau được khảo sát trong ba mùa (mùa khô, chuyển mùa và mùa mưa). Kết quả cho thấy quần xã động vật đáy không xương sống cỡ lớn có mật độ cao và khá đa dạng, đây là nguồn thức ăn dồi dào cho tôm trong ao nuôi. Đồng thời chúng tôi cũng áp dụng một chỉ số sinh học mới (chỉ số AMBI) để đánh giá chất lượng môi trường nền đáy. Kết quả ghi nhận hầu hết các ao có chất lượng sinh thái nền đáy ở mức tốt và được cải thiện qua từng mùa. Chỉ số AMBI đã áp dụng thành công ở Việt Nam, tuy nhiên cần phải cải thiện chỉ số này để phù hợp hơn vào điều kiện nước ta.

Từ khóa: AMBI, ao tôm sinh thái, chất lượng sinh thai nền đáy, quần xã động vật đáy không xương sống cỡ lớn, tỉnh Cà Mau.