INVESTIGATING POTENTIAL ACIDIFICATION OF MANGROVE SOILS IN THE ECOLOGICAL SHRIMP FARMING: A CASE STUDY IN TAM GIANG COMMUNE OF NAM CAN DISTRICT, CA MAU PROVINCE

NGUYEN DUC HUNG[*], NGUYEN THO[**],
TRAN THI KIM TU[***], DOAN THI KIEU OANH[****]

ABSTRACT

Our study aimed to investigate the acidity status of mangrove soils in the ecological shrimp system to forecast their potential acidification risks. Results indicated that there were slight increases of soil acidity. High content (>5%) of soil organic carbon (SOC) in the depth of 0 – 80 cm is one of the main contributors to soil pH buffering capacity, and may help reduce sharply soil acidity changes.

Keywords: soil acidification, soil organic carbon, ecological shrimp farming, sustainable aquaculture.

TÓM TẮT

Khảo sát sự chua hóa của đất rừng ngập mặn trong mô hình nuôi tôm sinh thái: Trường hợp nghiên cứu tại xã Tam Giang, huyện Năm Căn, tỉnh Cà Mau

Nghiên cứu của chúng tôi nhằm khảo sát tình trạng chua hóa của đất ngập mặn trong các hệ thống nuôi tôm sinh thái và dự báo nguy cơ chua hóa tiềm tàng do môi trường đất gây ra. Kết quả nghiên cứu cho thấy đã có sự gia tăng nhẹ về độ chua của môi trường đất. Hàm lượng carbon hữu cơ trong đất (SOC) cao (> 5%) ở độ sâu 0-80 cm là một trong những đóng góp chính vào khả năng đệm pH và có thể làm giảm mạnh sự thay đổi về độ chua của đất.

Từ khóa: sự chua hóa của đất, carbon hữu cơ trong đất, nuôi tôm sinh thái, nuôi trồng thủy sản bền vững.

1. Introduction

Shrimp farming is now widely spread almost all over the coastal regions of Vietnam, especially in the Mekong delta [3]. The expansion of semi-intensive and intensive shrimp culture has led to the loss of mangrove forests and the acidification of pond water and soil through formation of acid sulfate soils [7]. It is directly affecting the sustainability of these areas by causing multiple problems in different ways. Some adverse effects on the environment such as the acidification of pond water and soil

[*] Ph.D., Saigon University; *Email: duchung@sgu.edu.vn*

[**] Ph.D., Ho Chi Minh City Institute of Resources Geography

[***] B.Sc., University of Science Ho Chi Minh City

[****] B.Sc., Saigon University

through formation of acid sulfate soils were determinate in many models of shrimp farming [6]. Ca Mau is known as one of the Mekong delta's provinces that have an extensive and vital shrimp farming industry but will be greatly impacted by climate change. Recently, ecological shrimp farming may be considered as an alternative and more sustainable way of economic development for this region. However, potential impacts of the shrimp farming in this region remain debated issues towards local people as well as scientific community. We know that the productivity of shrimp that may be controlled or influenced through many factors including climate, geomorphology, tidal range, water input, and other factors. Among these factors, interactions between soil and water environment have received much attention from environmental researchers.

In Nam Can district of the Ca Mau province, farmers of Tam Giang commune covered by large area of mangrove trees *Rhizophora apiculata*, especially in Biosphere Reserve Park 184, were encouraged to apply the ecological shrimp farming. This model aims to ensure high quality, sustainably produced shrimps, and reduce the risks of destroying local environment and sustainability by using natural fertilizers and mangrove-based farming (40 – 60% of area in each farm). The system of certified ecological shrimp in the Tam Giang commune has been continuously certified since 2002 [5]. Over the last decade, with the efforts of the local authority, Naturland Organization, and CAMIMEX Company, many farmers have received the ecological shrimp farming certification in Nam Can district [9]. According to the Ca Mau authorities, prospects for ecological shrimp farming are positive. They want to scale up organic certification to 20,000 hectares of integrated mangrove-shrimp farms by 2020 [1]. However, the future of this model depends not only on the farmers, but also on government stimuli, publicity, technological improvements that ensure a sustainable development.

As well as in any other farming models, soil properties can indicate the present status and determine the characteristics of the ecological shrimp farming. Soil data obtained may help to plan a proper action for enhancement of this ideal model. According to the author's knowledge, information about the potential soil acidification in the ecological shrimp farming is very scarce. It must be firstly considered to exert one of the most direction controls related to the sustainability for the ecological shrimp farming. Thus, the aim of our study was to investigate the vertical distribution of acidity status including soil pH, SOC content and exchangeable acidity (H^+ and Al^{3+}) of mangrove soils that located in ecological shrimp-farms of the Tam Giang commune as a case study to forecast their potential acidification risks.

2. Materials and methods

2.1. Study area

The Tam Giang commune locates in the coordinates 8°47'60'' to 8°50'49''N and 105°04'30'' to 105°14'42''E. State fisheries-forestry enterprises 184 (SFFE 184) and Tam Giang III are two enterprises covered on this commune. Ecological shrimp-farming model has been practiced in SFFE 184. Meanwhile, Tam Giang III was reserved to produce the mangrove seedlings and protect the regional biodiversity. So all of sampling farms were located in SSFE 184 (Fig. 1).

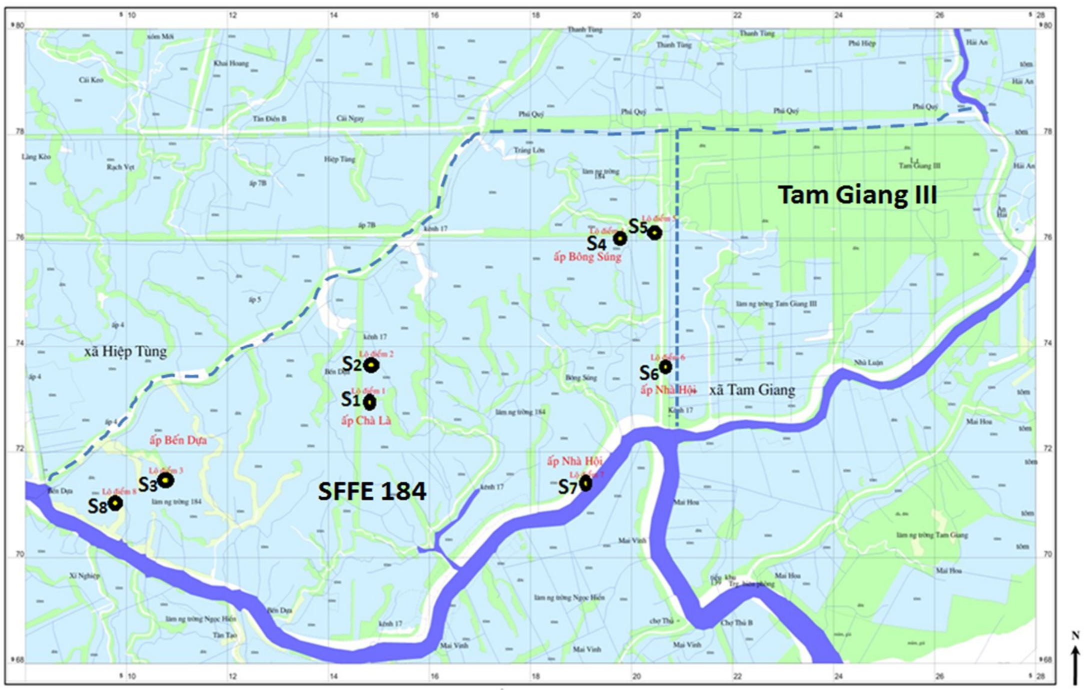

Figure 1. *Map with location of soil sampling sites in the Tam Giang commune, Nam Can district*

2.2. Soil sampling

Sampling was carried out at eight ecological shrimp-farming ponds (3 – 5 ha) in March 2015. In each of the sampling farms, three subsites spaced in a triangular pattern with 60 – 100m between each subsite were selected to assure representative samples (Fig. 2). In each sampling subsite, a 3.4cm diameter hand corer was carefully inserted into the soil and pushed down to 120cm depth. Soil intervals of 20cm were cut from the corer and packed in plastic bags, stored on ice [8]. Three cores in sampling farm were pooled together into one composite sample. In total, 48 soil samples were collected, i.e., one sample from each six intervals of 20cm at each of the 8 sampling farms.

2.3. Soil analysis

Samples of soil intervals were sorted easily in depth 0 – 120cm. After sampling, all soil samples were taken to the laboratory of the Saigon University. The soils were air-dried, ground using a pestle and mortar and then passed through a 2mm mesh before analysis.

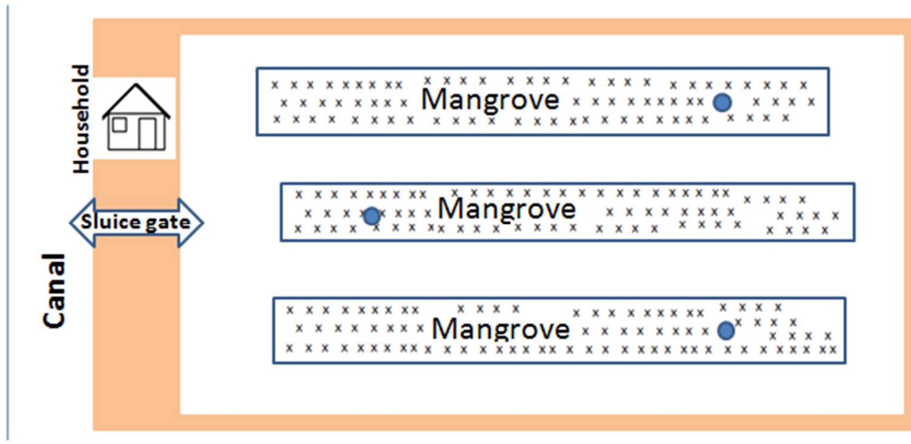

***Figure 2.** Schematic diagram of ecological shrimp-farms in Tam Giang commune. Symbol ● is equal to one subsite where one soil core was taken and symbols x corresponding to mangroves*

Soil pH was determined in suspension (20g dry soil + 50 ml water) using a pH-62K (APEL Co Ltd, Saitama, Japan). The total exchangeable acidity (meq100 g^{-1}) was determined by titrations of 50mL extract with 1N KCl (ratio 1:5) after a shake for 1 h. Then, the concentration of exchangeable H^+ was obtained by titration of the same 50mL KCl extract after a boil for 1 min to eliminate CO_2 and addition of 5mL NaF 3.5% to precipitate all exchangeable Al^{3+}. In these titrations, 0.02N NaOH standard solution was used with phenolphthalein as an indicator (titration from colorless to pink). The difference between total exchangeable acidity and H^+ content gave the exchangeable Al^{3+} content. The determination of SOC is based on the *Walkley-Black* method by using $K_2Cr_2O_7$ for complete oxidation of the *organic carbon* in the soil sample [2]. Statistical analyses were performed using Statistica 7.0 software.

3. Results and discussion

3.1. Distribution of soil acidity and SOC content

Knowledge of soil acidity is useful in evaluating soils because pH exerts a very strong effect on the solubility and availability of many nutrient elements. Soil pH ranges from 5.4 to 5.8, with an average of 5.5 (Fig. 3). The pH value was lowest in interval of 60 – 80 cm that has gradually been transformed into loam and consequently the pH value has decreased, indicating a slight reduction in this interval.

Soil organic matter is one of the main contributors to soil pH-buffering capacity, its high content may help reduce sharply soil acidity changes. The relatively large SOC contents (>5%) in the depth of 0 – 80cm are indicative the high potential of SOC in mangrove soils related to the ecological farming systems. The highest SOC content was in the interval of 60 – 80 cm and it tends to be lower on the depth over 80 cm (Fig. 3).

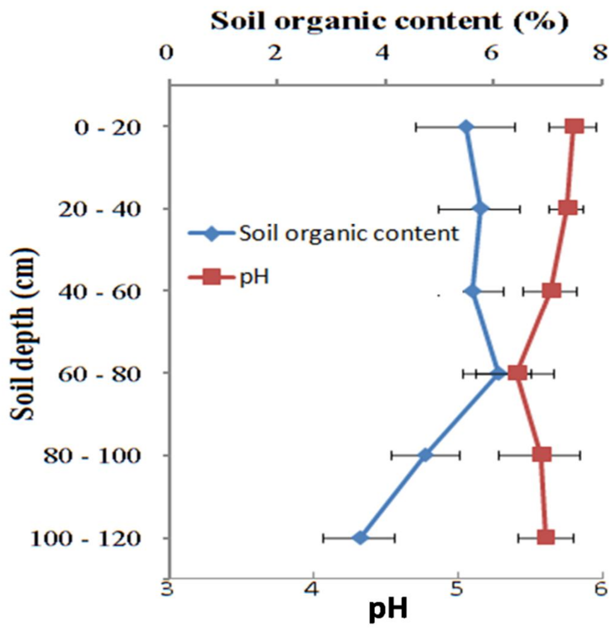

Figure 3. *The distribution showing soil pH and SOC content in ecological shrimp farms. Horizontal bars indicate the standard errors of the means (n = 8)*

Practically, the surface layer of mangrove soils has the highest level of SOC, which decreases with depth down the soil profile [4], [10]. However, our data have not showed the significant differences of SOC content in the depth of 0 – 80 cm, indicating that there was an increasing decomposition of organic matter and no more accumulation of carbon due to the ecological farming operations. These results showed the necessity for deeper investigations about SOC that may bring useful predictions for the sustainable development of ecological shrimp farming.

3.2. Variation of the exchangeable acidity

In this work, the exchangeable acidity of soil is expressed in unit of meq/100 g and could estimate from a regression equation (Fig. 4). Exchangeable acidity was in the range of 0.17 – 1.16 meq/100g (mean 0.50 meq/100g). Over all sampling depths, exchangeable acidity was strongly (R^2=0.62, p < 0.001) correlated with H^+ (Fig. 4a) and moderately (R^2 = 0.50, p < 0.001) correlated with exchangeable Al (Fig. 4b). Exchangeable Al^{3+} also contributes to soil acidity. We found that lower pH and increasing exchangeable Al^{3+} significantly presented in the most soil intervals.

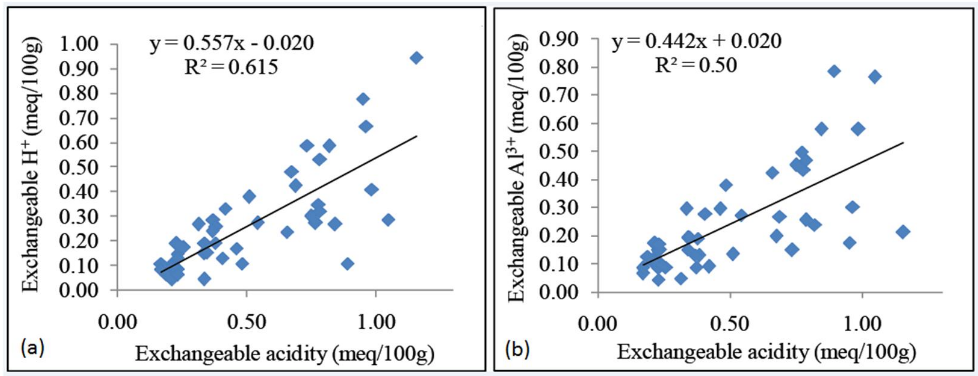

Figure 4. *Linear relationship between the exchangeable acidity with H^+ (a) and Al^{3+} content (b)*

4. Conclusions

In our research, soil pH, SOC content and exchangeable acidity were considered as the main factors on the potential acidification status of mangrove soils related to the ecological shrimp farming. We could conclude that there were slight increases of soil acidity among intervals of 0 – 80cm. The high of SOC content may play key roles in the pH-buffering capacity. It is necessary to conduct deeper investigations about SOC to establish their baseline data in the futures studies.

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