Domestic Water Qualities of Khmer Minority Communities in the Mekong Delta, Vietnam

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ABSTRACT

A study on the domestic water quality of Khmer minority communities was carried out in An Giang and Soc Trang provinces in the Mekong Delta, Vietnam. The research revealed that the exploitation and management of domestic water source differed between two provinces. Groundwater and rainwater are major domestic water sources of Khmer communities in Tri Ton and Tinh Bien District of An Giang Province, while rainwater is the most widely used domestic water form of Khmer community in Soc Trang Province. After domestic water quality parameters, including pH, BOD5, COD, total-Fe, arsenic, hardness, E. coli, and total coliforms, were tested, the experimental data showed that the domestic water samples of Khmer communities in the two provinces contaminated by organic matter and microbial infection, which was due to living habits and low cognition about domestic water quality of the Khmer people. Thus, suggestion for the enhancement of domestic water quality is needed to improve living standard for rural Khmer minority communities.

1. INTRODUCTION

The Mekong Delta constitutes a great amount of land in the South of Vietnam and being home for variety of ethnic minorities, such as Khmer, Hoa, and Cham people, who are the most vulnerable groups in the region. The majority of these people mainly inhabit in An Giang and Soc Trang provinces [1, 2]. Although Khmer people are one of the target beneficiaries of impoverished alleviation policies, the number of well-off households remains high. Therefore, less literacy and traditional custom of a small minority of these people create burden in approaching to clean water and hygienic environment [3]. In addition, climate change turns serious and natural resources are suffering from a shortage of reserves. Besides, water resources are primarily threatened, particularly by drought, floodtide, salinity intrusion, etc. on a large scale in Vietnam [3].

The Khmer group of Vietnam is the largest ethnic minority group with over 1.3 million people (about 7%) of about eighteen million totally, followed by Chinese and Cham with about 823,000 (about 1.0%) and 10,000 people respectively [4]. In which, large numbers of Khmer are found in the Mekong Delta making up 7.34% population (with around 1.3 million of 17.7 million) and representing 1.4% of the total population of Vietnam (roughly 1.3 million out of 92.7 million) [4]. The Khmer in the Delta are concentrated in 23 districts of the eight provinces of An Giang, Kien Giang, Can Tho, Hau Giang, Vinh Long, Tra Vinh, Soc Trang and Bac Lieu. Of these 1.3 million, 53% live under the poverty line based on the MOLISA criteria (Pacode program, 2004). The MPDA also points out that the proportion of poor Khmer is higher than the average for the Delta (32% as compared to 23% for the entire region). Over time, they have effort to actively control of their knowledge in the struggle for natural resource under growing scarcity.

Khmer people's culture is known as one of the most long-lasting cultures in the Mekong Delta [5]. They usually settle in the same village located farther away from the city centre, Kinh people, and other ethnic minorities. Also, they are currently having difficulty in accessing public services, due to the topography, distance away from the centre and economic troubles. Therefore, rainwater and groundwater, which are natural water resources, are a primary provision for their domestic consumption.

Furthermore, climate change (drought, storms, and

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salinity intrusion) has threatened and negatively impacted on domestic water quality and traditionally storing methods. This proposes an issue for many studies and conducting a survey on domestic water quality of the Khmer people essentially responses to the above issue.

This study aimed to analyse existing water quality (following the national regulations on domestic water quality) and water-storing methods in serving public activities of the Khmer people, hence the raising of the Khmer people's awareness in terms of "clean water" as well as recommendation on water use under climate change.

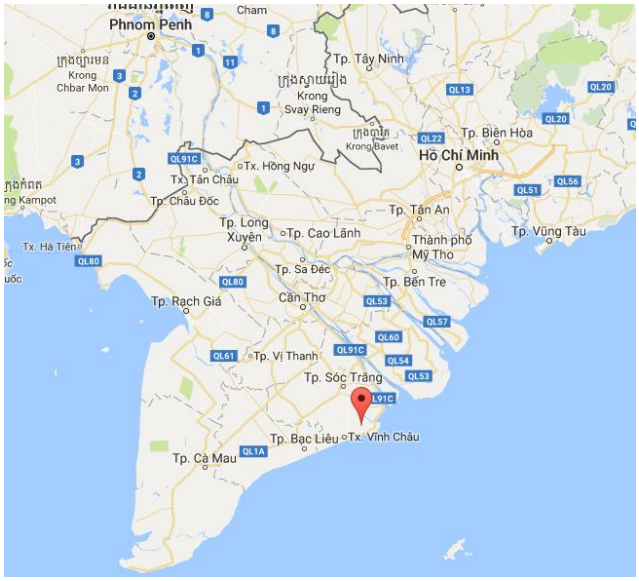

Fig. 1. The Geographic Location of Tinh Bien and Tri Ton Districts, An Giang Prov., and Vinh Chau Town, Soc Trang Prov., Vietnam.

2. 2. MATERIAL AND METHODOLOGY

Research sites

The research was conducted in An Hao Commune of Tinh Bien district and O Lam Commune of Tri Ton District, An Giang Province and Lac Hoa Commune, Vinh Chau Town, Soc Trang Province (see Figure 1). Tinh Bien District occupies a total area of about 20,260 hectares, located in the Mekong River headwaters at an altitude of up to 5-30 m, where is home to 121,399 people (35,696 Khmer people). The main livelihoods of people are mainly agriculture (crop cultivation and livestock raising), seasonal employing, and small trading shop. The access to clean water supply is still a big challenge in these rural areas. Besides, Tinh Bien and Tri Ton District are a region of hills and mountains, which is difficult to access the markets, administration centers, and water supply networks. In recent years, drought has caused serious water shortage because of its low average annual rainfall of 1,478 mm [6]. Therefore, people in Tinh Bien and Tri Ton need to take a long way from their home in the dry season to take water, which is sometime not safe for human use. Vinh Chau, meanwhile, is a coastal town situated downstream of the Mekong River, along the East Sea, Vietnam. It is about 473.4 km^2 in area, where there are 52.84% of the Khmer people out of a total of 183,918 people reside in. The average annual rainfall is reported to be 1,864 mm in this area, where is annually contaminated by saline water [6]. Domestic water is mainly from rainwater, groundwater, and pipeline water, which are identical to the ones in Tinh Bien. Therefore, An Giang and Soc Trang were chosen for this study, since they have typical conditions of mountain in Tri Ton and Tinh Bien (An Giang) in the upstream of Mekong River in Vietnam and coastal region in Vinh Chau (Soc Trang) in the downstream of Mekong River, where Khmer community lives with high population density.

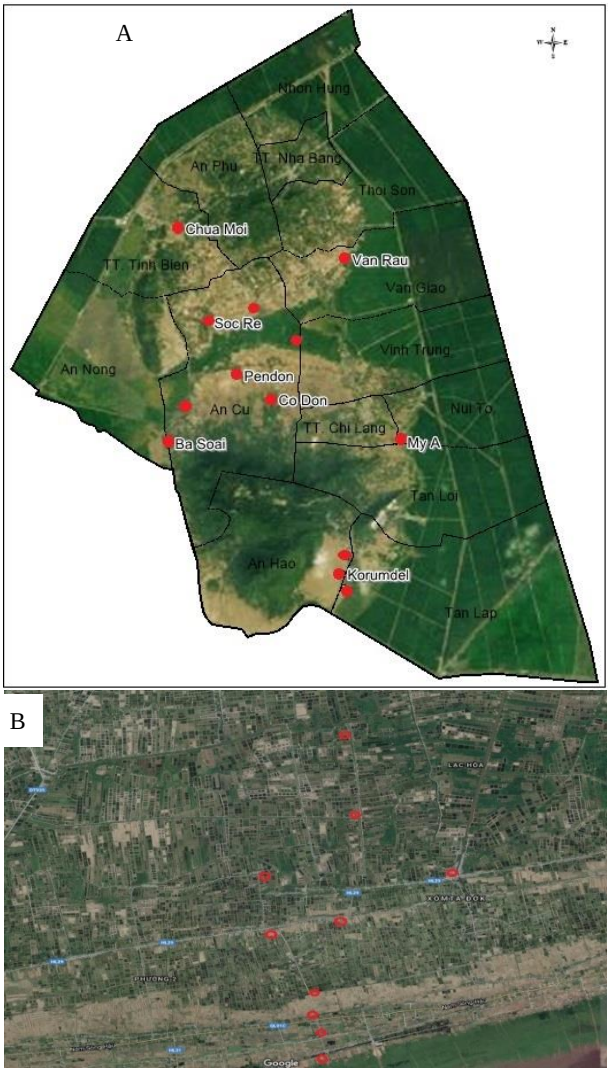

Fig. 2. Water Sampling Sites in (A) Tinh Bien and Tri Ton Districts, An Giang Province and (B) Hoa Lac Commune, Vinh Chau Town, Soc Trang Province.

Sampling sites

In this study, domestic water samples, including ground water, surface water of ponds/lakes, and rainwater, were collected in Tinh Bien and Tri Ton districts, An Giang province; and Hoa Lac commune, Vinh Chau town, Soc Trang province in the dry and rainy seasons of 2016. The quality parameters, including pH, DO, heavy ions, organic compounds, and microorganisms, of these water samples were determined and assessed by comparing to the requirement of National water quality standards of Vietnam, such as Vietnam National Technical Regulation on surface water quality 08:2008/BTNMT (QCVN 08:2008), type A_1; National technical regulation on underground water quality 09:2008/BTNMT (QCVN 09:2008); and National technical regulation on the domestic water quality 02:2009/BYT (QCVN 02:2009) (see Table 1 for more detail). The sampling sites are shown in the Fig.2. The sampling method and storage of water samples were carried out according to the guidelines of the National Technical Regulation on sampling, storing, and analysis of water quality. The sample names are shown in Table 2.

Table 1. Water Quality Parameters, Analytical Methods and Limit value of water quality parameters for Water Source Evaluation

No.	Parameters	Unit	Analytical method	QCVN 08:2008	QCVN 02: 2009/BYT	QCVN 09 : 2008/BTNMT
1	pH		EPA 150.1	6-8.5	6.0 – 8.5	5.5-8.5
2	BOD_5 (20^oC)	mgO_2/l	SM 5210-B	4	-	
3	COD	mgO_2/l	SMEWW 5220C-1995	10	-	4
4	Total Iron (Fe)	mg/l	SMEWW 3500-2005	0.5	0.5	5
5	Total Arsenic (As)	mg/l	SMEWW 3500-2005	0.01	0.05	0.05
6	Hardness	mg $CaCO_3/l$	Standard Method 2320B:2005	-	350	500
7	E. coli	CFU/ 100ml	SM 1603	20	-	-
8	Coliform	CFU/ 100ml	SM 1604	150	-	3

Table 2. List of Sample Names

No.	Water location-sample property	Sample name
An Giang province		
1	Korumdel-surface water of lake	AG01
2	Soc Re-surface water of lake	AG02
3	Phum Korumdel-shallow well	AG03
4	Phum xa Du-shallow well	AG04
5	Chau Von-shallow well	AG05
6	Chua Moi-close groundwater	AG06
7	Cay Duoc-close groundwater	AG07
8	Cha Rat-close groundwater	AG08
9	Co Don-close groundwater	AG09
10	Pendon-close groundwater	AG10
11	Cay Khoa-close groundwater	AG11
12	Cay Khoa-rainwater	AG12
13	Ba Soai-rainwater	AG13
Soc Trang province		
1	Mai Vu Quang household-rainwater	ST01
2	Duong Thi Son Chuong household-rainwater	ST02
3	Ly Sen household-rainwater	ST03
4	Lam Xo Ny household-rainwater	ST04
5	Lam Thuong household-close groundwater	ST05
6	Thach Tha household-close groundwater	ST06
7	Lam Xo Ny household-close groundwater	ST07
8	Thach Hem household-close groundwater	ST08
9	Filled water of Mi Pha	ST09
10	Filled water of Chi Vy	ST10

3. 3. RESULTS AND DISCUSSION

Traditional water deployment and management of the Khmer people in the Mekong Delta

Traditionally, Khmer people in Tri Ton and Tinh Bien district, An Giang province used groundwater in shallow wells and open lakes and rain water for drinking and domestic use. The people collect water by taking plastic buckets of water back home and store in the pottery jars for later use. Pipe water was introduced by the government water program recently however, Khmer people rarely use it. They mainly use rainwater and groundwater. Water, to a

large extent, is still be contained traditionally in jars, ponds, etc., while groundwater is stored in dug wells with 20-30 m in depth, which have being used for 10-20 years. These dug wells turn exhausted in the dry season from December to coming April.

During this period, the Khmer people primarily seek more groundwater from underground stream for domestic use. The simple method, which they usually use, is that they take full advantage of indigenous knowledge learnt from generation to generation to find the groundwater stream.

Fig. 3. Domestic Water Containers of Khmer Community in Tinh Bien District, An Giang.

Fig. 4. Domestic Water Containers of Khmer Community in Vinh Chau Town, Soc Trang.

The Khmer people in Vinh Chau town, Soc Trang province differ from the Khmer people in Tinh Bien district, An Giang province is that they mainly use more rainwater collected directly from the roof of their houses for domestic consumption. Besides, groundwater is also a widely used form of domestic water, where water is pumped from borehole and stored in tanks for later use. However, but it is often contaminated by alum-iron and saline water.

In summary, rainwater and groundwater are a priority of the Khmer people's domestic consumption, collected from the roof (water coconut's leaves, steel sheet, or tile). Rainwater and groundwater are contained in jars or uncovered ponds, which cause, undeniably, contamination. As seen in Fig. 3 and 4, Khmer people usually store water in ponds, lakes, jars… without good storage condition, leading to the contamination by dust from ambient air, litters or leaves, and organism such as insects, bacteria, and fungi.

Physicochemical properties of water samples

pH value of water is one of important parameters. For water with the pH value of less than 5.5, for example, it could damage the water container. For domestic purpose, the pH value in water should be in the range of 6.5 to 8.5, which is regulated in QCVN 02:2009. The pH values of domestic water in An Giang and Soc Trang provinces are shown in Fig. 5.

The result showed that the pH values of samples were almost in the regulated pH range for both rain and dry seasons. However, there were some water samples with pH values out of the regulated pH range. Thus, the human health would be affected if the domestic water with pH value out of the regulated pH range was used for long time. The reasons for changes in pH value of water samples could be (1) leaf decomposition increasing the pH value of surface water of the lake (for AG02 sample in dry season); (2) influence of stratigraphic structure on the groundwater

quality decreasing the pH value (for AG06 sample in dry season and for AG09 sample in rainy season); (3) the properties of natural rainwater resource with pH value of below 7 (for AG12 in rainwater); or (4) the effect of rainwater collection equipment (for example, leaf decomposition on the roof) increasing the pH value of rainwater (for ST02 sample in dry season).

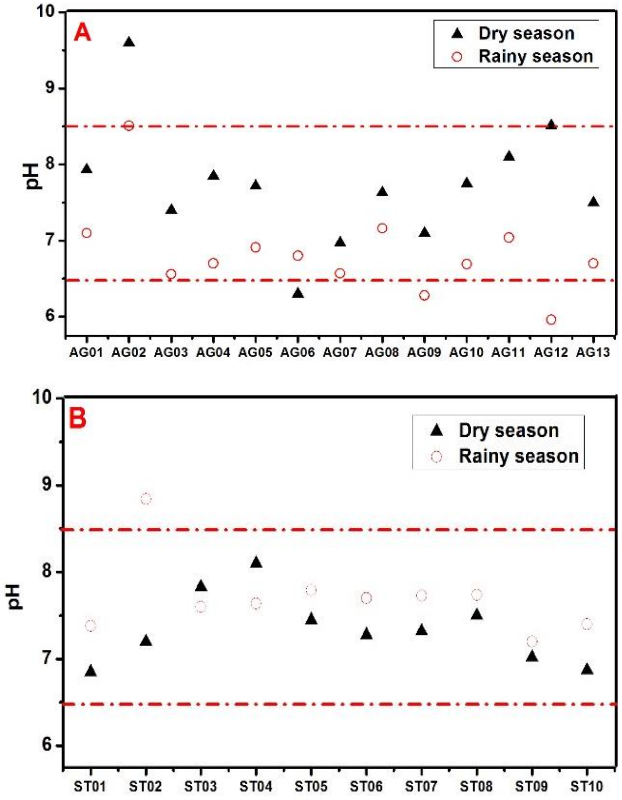

Fig. 5. Water pH Values in (A) An Giang Prov. and (B) Soc Trang Prov.

Biological oxygen demand (BOD_5) is an important environmental parameter for organic contamination, which can be decomposed by biological method, in water. For domestic water, the BOD_5 value is limited less than 4 mgO_2/L regulated in QCVN 08:2008. The experimental data at two conducted sites are showed in the Fig.6. The BOD_5 of domestic water at conducted sites in An Giang province was observed be in the range of 0.09 to 2.13 mgO_2/L, while that in Soc Trang province was in the range of 0.5 to 7.95 mgO_2/L. In general, the BOD_5 value was quite different between rainny and dry seasons. The BOD_5 values of water samples in Soc Trang province were above the regulated BOD_5 limit. Thus, the organic contamination of domestic water in Khmer communities in Soc Trang province was above the limit of regulated BOD_5 value (for example, ST01, ST02, ST04, ST06, and ST08 samples in dry season; and ST06, ST07, and ST08 samples in rainy season). The water samples in An Giang province had the BOD_5 value of below the biodegradable organic contamination level, especially the domestic water samples from groundwater in Soc Trang province (for ST03 and ST05 samples) or filled water (for ST09 and ST10 samples) which showed the water quality with a high degree of stability of BOD_5 values in both dry and rainy seasons. As regards the biodegradable organic contamination of domestic water samples, it could be resulted from the contamination of biodegradable organic compounds from leaves of the roof for rainwater sample; or disoluble organic contamination of soil flowing into groundwater or of tanks during the water storage.

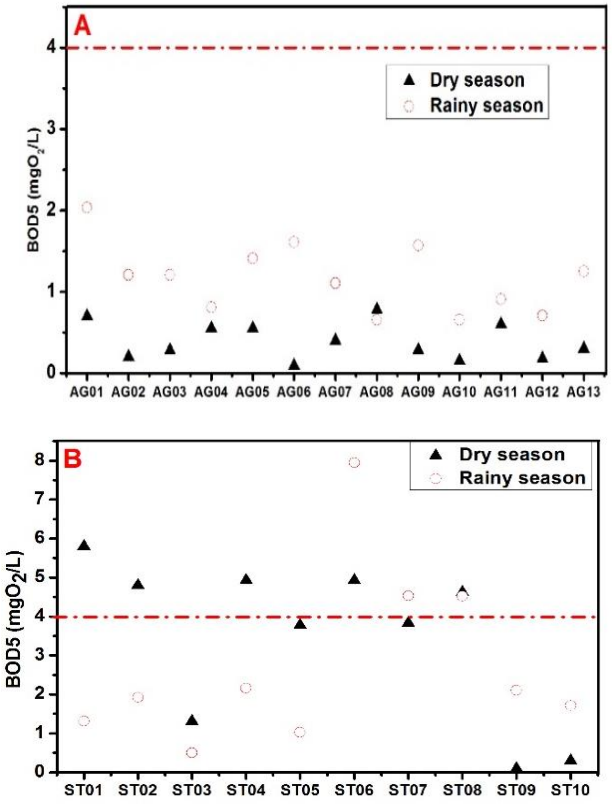

Fig. 6. BOD_5 Values of Domestic Water in (A) An Giang Prov. and (B) Soc Trang Prov.

Similar to BOD_5 parameter, chemical oxidation demand (COD) is also an important environmental parameter of the disoluble organic contamination in water [7]. The COD experimental data are showed in the Fig.7. As can be seen from these data, most of the COD values in domestic water samples in both mentioned provinces were over the COD limit regulated in the QCVN 08:2008 and QCVN 09:2008. Moreover, the COD values of water samples in both provinces showed quite a difference between two seasons. It was obvious that the COD data were distributed in the range of 0.8 to 294 mgO_2/L and 0.64 to 242 mgO_2/L for water samples in An Giang province and in Soc Trang province, respectively. Additionally, the COD values of water samples in the begining of rainy season and the end

of dry season were many times higher than the regulated COD limit, due to the contamination from leaves of the roof for rainwater samples or from disoluble organic compouds in soil or water tank.

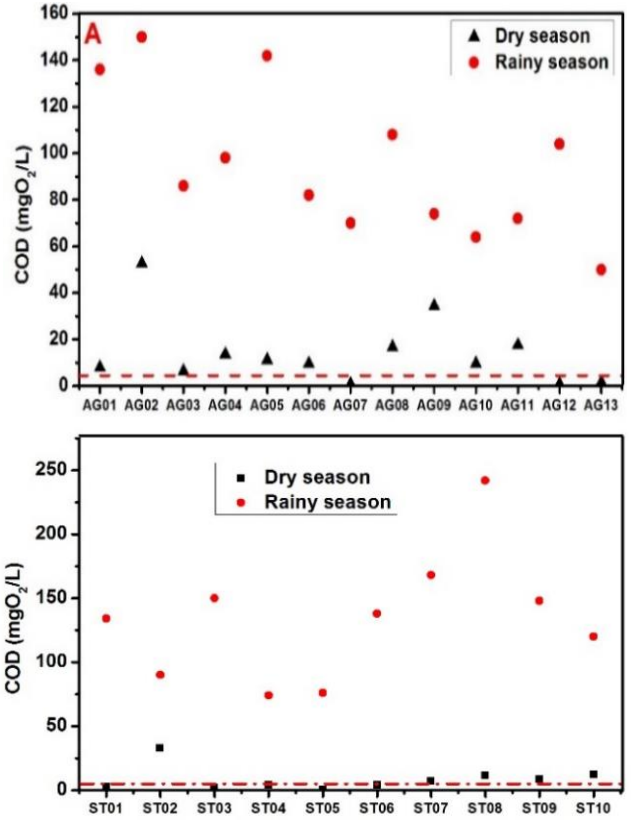

Fig. 7. COD Values in (A) An Giang Prov. and (B) Soc Trang Prov.

Iron is one of the heavy metals and the water with iron contamination usually have low quality and affect life activities of local human [8]. According to regulations in the QCVN 08:2008 and QCVN 02:2009, the iron concentration limit is less than 0.5 mg/L for domestic water purpose. The analysis results of iron contaminations in collected water samples are showed in Fig.8. In general, it was seen that the iron contaminations in water samples in both An Giang and Soc Trang provinces were lower than the regulated iron concentration limit. However, the iron contamination in AG1 water sample in dry season and rainy season were approximately 5.48 times and 10.96 times, respectively higher than the regulated iron contamination. Moreover, the experimental results indicated that the AG1 water sample was collected from the surface water of the lake. Water in the lake was milky in the whole year. Additionally, water in this lake stemmed from flowing rainwater. Thus, the iron contamination of AG1 sample could be the dilution of iron in soil into the flowing rainwater before to the lake. Twice as many iron concentrations in water of this lake were found in the dry season as in the rainy season, which was because of no adding of water source and iron amounts deposited at the lake bottom in the dry season.

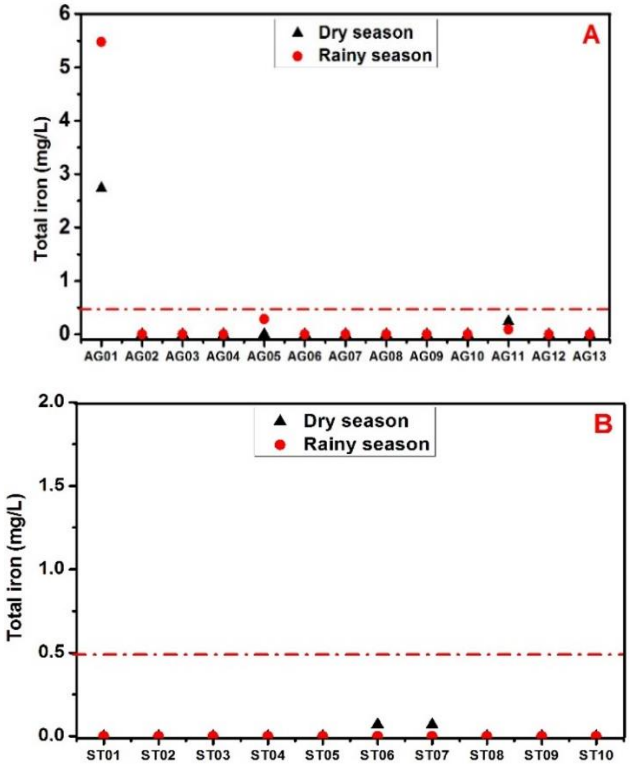

Fig. 8. Total Iron Concentration of Water in (A) An Giang Prov. and (B) Soc Trang Prov.

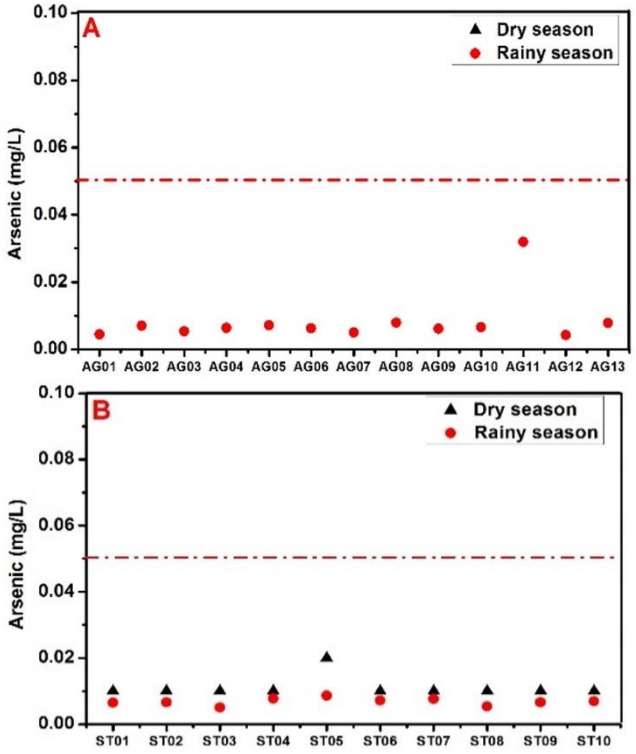

Fig. 9. Total Arsenic Concentrations of Water in (A) An Giang Prov. and (B) Soc Trang Prov.

It is known that arsenic is highly toxic and has a strong effect on human health. The arsenic concentration limit is less than 0.05 mg/L, regulated in QCVN 02:2009. The presence of arsenic in groundwater in Mekong delta, including An Giang and Soc Trang provinces, was observed [9, 10]. The data of arsenic contaminations of domestic water in the two provinces are showed in Fig.9. However, no arsenic contamination was observed in the domestic water used for Khmer communities.

Hardness of water could be the amount of calcium and magnesium ions in the water. The hardness is one of the critical environment parameters because the presence of calcium and magnesium ions in the domestic water is the cause of nephrolith for human. The water hardness is limited to below 350 mg$CaCO_3$/L in QCVN 02:2009/BYT. Fig.10 compares the hardness of water samples between two provinces. However, the closed-groundwater samples with high hardness, which was over the regulated hardness limit, were observed visually.

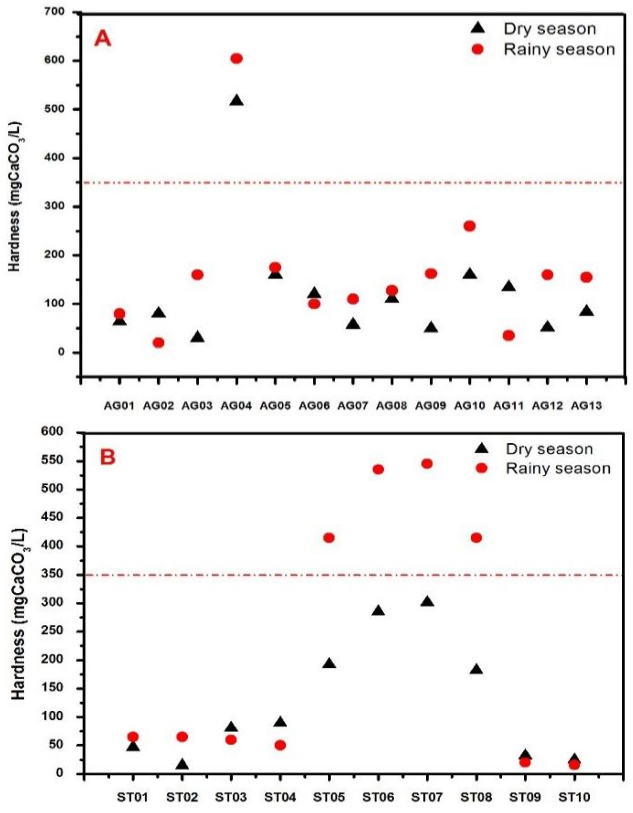

Fig. 10. Hardness of Domestic Water in (A) An Giang Prov. and (B) Soc Trang Prov.

The microbial parameter of water quality is also critical due to its directly effect of intestinal diseases on human health. The *E. Coli* parameter is a measure of the amount of *E. Coli* bacteria in water, while total *Coliforms* parameter relates to pathogenic and nonpathogenic bacteria. The results of *E. Coli* and total *Coliforms* parameters in water samples are shown in Fig.11 and 12, respectively. Too many examined water samples were contaminated with microorganisms. In terms of water storage of households in An Giang and Soc Trang provinces, the domestic water was stored in the tanks with the temporary covers. Thus, this could be a main cause for the growth of microorganisms during the domestic water storage of Khmer communities.

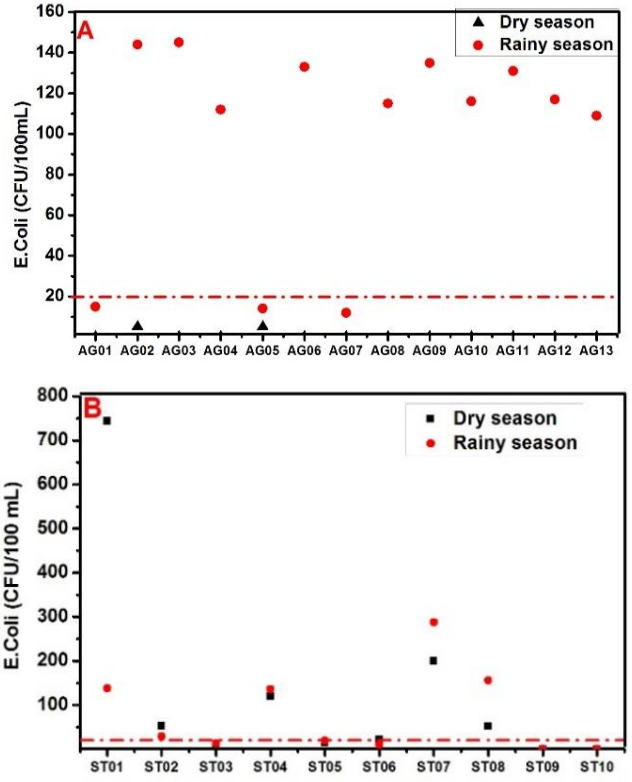

Fig. 11. E. Coli Contamination of Domestic Water in (A) An Giang Prov. and (B) Soc Trang Prov.

The existing water use and containers of the Khmer communities remained the potential impact on healthcare condition. However, the survey revealed that it was impossible to find the replacement of water source as the following reasons: (1) their water use habit (90% of respondents acknowledged that the high quality of the existing hygienic water sources met their demand); (2) water shortage at the research sites being severe. Therefore, the recommendation, which is environmentally friendly and applicable to low skilled people, is needed. More importantly, scientific technology, applied in water quality improvement, must have less impact on traditional custom of the Khmer people to preserve their typical culture. Some simple methods for improving the supply water quality of Khmer community are suggested, such as sand or activated carbon filtration, and water boiling and cooling for daily use [3, 11].

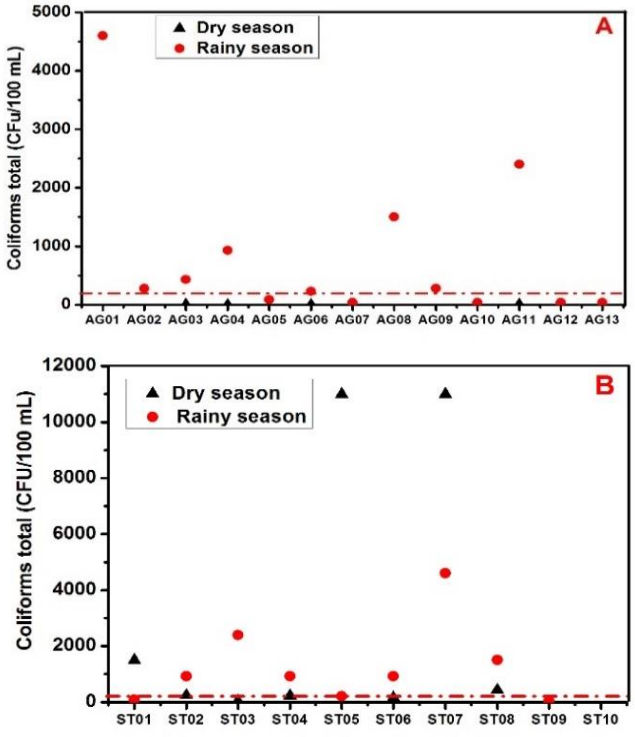

Fig. 12. Total Coliforms Contamination of Domestic Water in (A) An Giang Prov. and (B) Soc Trang Prov.

4. CONCLUSION

The study into the Khmer community's domestic water quality was conducted in An Giang and Soc Trang provinces, the Mekong Delta, Vietnam. From the results in this study, it was apparent that water exploitation and management differed between An Giang and Soc Trang provinces. Particularly, rainwater and groundwater were primarily used forms of Khmer people in An Giang, while rainwater was used more by Khmer community in Soc Trang. Groundwater was mostly used in An Giang. Water quality was remarkably different. Water quality troubles in two research sites were figured out based on (1) the shortage of domestic water and (2) low quality of domestic water. In particularly, contents of organic compounds and pathogens did not meet the water quality standard, which are considered as two major issues in domestic water supply. Besides, results showed a slight effect of hardness on the domestic water source in the rain season in Soc Trang. The research recommended public and technical responses, which did not severely impact on the Khmer community custom in Vietnam, to the current water quality in both provinces, hence the possible enhancement of life quality of the ethnic minority under climate change and socio-economic changes.

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