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Microbiological Assessment of Surface Waters and Health Awareness of Four Vulnerable Communities in Can Tho City, Vietnam

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Abstract: Addressing the 17 Sustainable Development Goals (SDG) in a developing country like Vietnam is not easy. The study aimed to address at least three of the 17 SDG, namely, good health, clean water and sanitation and life below water. This study conducted microbiological analysis on surface waters of flood vulnerable communities and concurrently done household community perception survey on four communities. A majority of 245 respondents were dissatisfied with the water quality of the surface water. The discontentment of the respondents were verified by microbiological results. In the highly urbanized communities of An Cu and An Hoa, the *E. coli* and *T. coliform* values were compared with the Vietnam set standards. *E. coli* mean values were 125-445 times higher than the max tolerable limit of 200 MPN/100 mL and the *T. coliform* mean values obtained were 23-74 times higher than the set max tolerable limit of 10,000 MPN/100 mL.

Key words: Can Tho City, sustainable development goals, *T. coliform*, *E. coli*, perception survey

INTRODUCTION

Addressing the 2030 agenda for sustainable development, the world is shifting into a more sustainable and resilient development. The universal move of creating a local and nationalistic development that works for all is not easy for developing countries in South East Asia region. Most of the countries in this region are face with numerous problems and intensified with climate change. Especially in Vietnam where there are rapid urban growths, conversion of agricultural lands to industrial and land use development to boast social and economic transformation of the country (Phuc *et al*., 2014). It is more challenging to the city located at the downstream delta of the Mekong River, Can Tho where more intense and frequent flooding were experienced (Kuenzer and Renaud, 2012). Aside from climate change, flooding is expected to worsen with the constructions of dams (Khoi *et al*., 2008; Kuenzer and Renaud, 2012; MRC, 2010) in neighboring countries upstream and other anthropogenic activities that create water shortages and pollutions of receiving waters (Campbell, 2012; Khoi *et al*., 2008; Sebesvari *et al*., 2012; Toan *et al*., 2013).

Microbiological assessment of surface waters in the city is the major concern of this research. Microbiological analysis in chicken carcasses examined in Can Tho, collected from wet markets and supermarkets contain Salmonella with a mean average of 45.9 and 45.5%, respectively.

Bivalves and shrimp contaminations should also be considered as it often exceeded environmental standards (Anh *et al*., 2010; Onda *et al*., 2012). Faecal contamination induced during flooding is also worth considering (Figueras and Borrego, 2010; Veldhuis *et al*., 2010). Study shows contamination in green leafy vegetable with coliform and *E. coli* by values of 5 and 3 log cfu/g, respectively during flooding (Castro-Ibanez *et al*., 2015).

Food contamination is not only happening to developing countries but also to developed countries. In United Kingdom, *Escherichia coli* and *Salmonella* sp. were found present in bagged prepared salad vegetable, vegetable, spices and fresh herbs (Elviss *et al*., 2009; Olaimat and Holley, 2012; Sagoo *et al*., 2003). The food borne outbreaks cause by Noro Viruses (NoV) in Belgium, Canada and France were associated on fresh produce (Baert *et al*., 2011). In Germany, other parts of Europe and North America, outbreak in May, 2011 caused by *Escherichia coli*, cost 39 deaths and 810 cases (Bielaszewska *et al*., 2011). It was estimated that in 2010, 28% (1.8 bln.) of the world population used unsafe water

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and 11% (783 mln.) use unimproved sources (Onda *et al*., 2012). It was also estimated that 1800 children under the age of 5 die daily from preventable water-related diseases. Environmenta education and awareness aimed in reducing contamination should be in place and the role of every individual is very essential (Carrasco *et al*., 2012).

The study dealt with the microbial contamination of surface waters in Can Tho City and community perception survey on the quality of surface waters. This study was able to prove that for better understanding of highly technical problems social research should be done concurrently.

MATERIALS AND METHODS

Study site: Figure 1 shows the exact locations in black dots, the household perception survey conducted. The selection was based on the vulnerability to flood and characteristics distinct by itself. These were the communities of An Cu, An Hoa, An Binh and Nhon Nghia. The microbiological surface water sampling sites, in red dots were in N1 Nhon Nghia in Tinh Lo 932 and N2 Nhon Nghia in Thanh Pho Can Tho in Phong Dien District, H1 An Hoa in Durong Huynh Thuc Khang 214, H2 An Hoa in Durong Huynh Thuc Khang 128B, C1 An Cu in Thanh Pho Can Tho and C2 An Cu in Durong De Tham 100A in Nien Kieu District.

Analytical method

Community perception survey: Respondents were randomly selected in 4 communities in 3 urban districts of Can Tho. The communities considered were: in the district of Nien Kieu, An Cu (AC) where manmade lake is located and An Hoa (AH) the boundary of the districts of Nien Kieu and Binh Thuy; in the district of Cai Rang, An Binh (AB) located along the famous floating market and in the suburban district of Phong Dien, Nhon Nghia (NN) where it has an agricultural setting. The distance of the surface water from their houses and from one respondent to another was strictly considered in the selection of respondents. There were 60 respondents per community except An Cu with 65. The survey instrument was in standard Likert Scale and translated in Vietnamese.

Water quality assessment: Water samples were obtained from six established sampling sites in the communities of Nhon Nghia (N1 and 2), An Hoa (H1 and 2) and An Cu (C1 and 2). Water samples were assessed in terms of Heterotrophic Bacteria (HPC) total coliform, *Eschericchia coli* and *Salmonella* sp. Water samplings were distributed in the months of December 2013 and January 2014 at approximately eight to ten (8:00-10:00) in the morning. Through grab sampling method, water samples from each sampling sites were placed in 500 mL of sterilised bottles and preserved in ice boxes before being measured in an accredited laboratory of Can Tho University.

Statistical analysis: The data obtained in the survey were analyzed using box plot and mean average for general information. Microbiological results were then compared statistically using F-value, t-test, two-way analysis of Variance (ANOVA) and Tukey's Honest Significant Difference (HSD) at 0.05 level of significance.

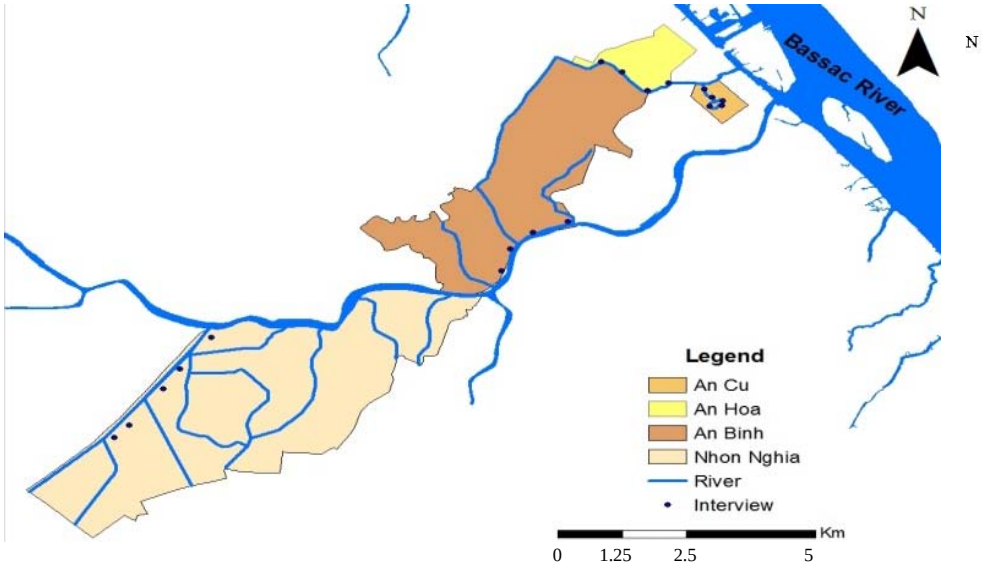

Fig. 1: The sites for the community perception survey and surface water quality assessment

RESULTS AND DISCUSSION

Community perception survey

General information: The four communities have the following general information. The average years of residency of An Cu, An Hoa, An Binh and Nhon Nghia were 33, 35, 30 and 37, respectively. The average number of people in the household was 5. Children below 5 years old, accounts for 11-13% of the total population per district.

The last flood before this study was conducted happened on 17th of November 2013. The frequency of flooding in the urbanized areas was once a year as against 3-4 in sub-urban districts. On the average, the respondents have tolerable limits for flood of 92-100% per district.

Livability and water use: On the question of satisfaction on the contribution of surface water to their living standards, the answers varied based on their dependency in water for their day to day income. In An Cu, the answers were so divided, 26 (40%) disagreed, 25 (38.5%) agreed while 14 (21.5%) were neutral. If the respondents were not directly benefitting from the manmade lake, they would disagree. But if the respondents were owners or employers of businesses along the manmade lake, they would agree. Definitely the ones who answered neutral were just simply playing fair.

In An Hoa, 21 (35%) disagreed while 22 (37%) strongly disagreed. The area during the study was more residential than commercial. They commented that the surface water smells, especially in low tide as domestic wastes were directly thrown into the surface water. In An Binh, the answers were influenced by the benefit of surface water to their basic needs. Those who disagreed 23 (38%) have sources of income that do not use the surface water. They used the water supplied by the local distributor. Those who answered neutral and agreed were indirectly and directly benefited from the water in the river. In Nhon Nghia, majority of the respondents, 30 (50%) agreed that the surface water in the neighborhood contributed so much to their living standard. The respondents used the surface water for cooking, drinking, bathing, irrigation and domestic use.

Majority of respondent's, An Cu 39 (60%), An Hoa 49 (82%), An Binh 36 (60%) and Nhon Nghia 27 (45%) were dissatisfied with the quality of surface waters. It means that they were aware of the poor quality of surface water in the neighborhood.

Willingness and capacity to improve the quality of water: The respondents were asked on their willingness and capacity to improve the quality of surface water. The responses per community were summarised in the Likert Scale of (Strongly Agree, SA; Agree, A; Neutral, N; Disagree, D; Strongly Disagree, SD) and further plotted using box plot as shown in Fig. 2.

In the question, I can help improve the quality of water, respondents of An Cu (55%), An Hoa (42%), An Binh (50%) and Nhon Nghia (42%) agreed. In volunteering to help improve water quality, respondents

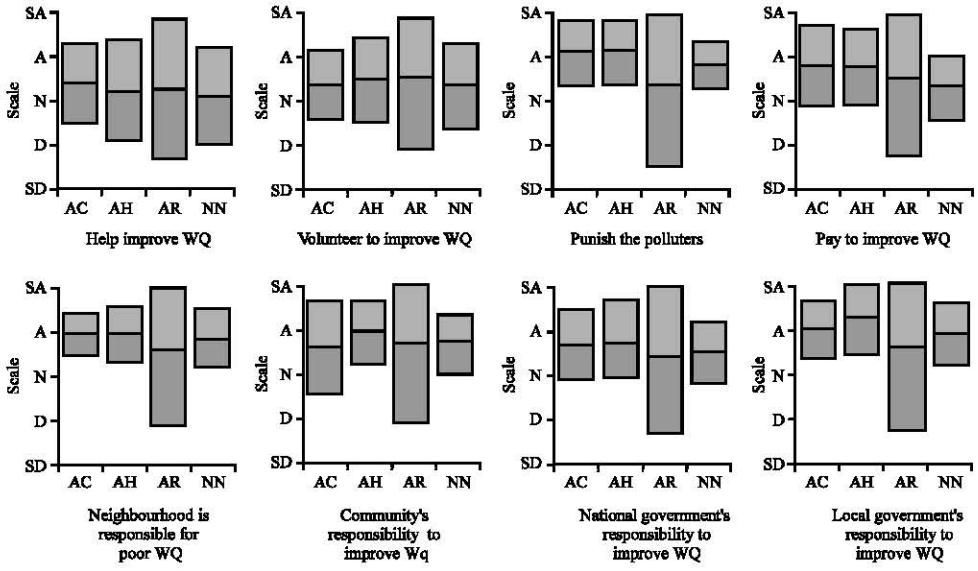

Fig. 2: Responses on the willingness and capacity to improve the quality of water

Table 1: Mean values of microbiological analysis in MPN/100 mL in six sampling sites in Can Tho

	N. Nghia		An Hoa		An Cu	
Parameters	N1	N2	H1	H2	C1	C2
H. Bacteria	194	244	4582	6313	1164	1236
Salmonella	1536	1637	5679	5671	2253	3100
T. coliform	45150	34617	742583	493000	229000	742500
E. coli	7483	3079	53608	83083	24975	58333

Table 2: Vietnamese Standards in MPN/100 mL

	A1	A2	B1	B2
Variables	Water supply	Aquatic plants	Irrigation	Traffic
H. Bacteria	-	No set standard	-	-
Salmonella	-	No set standard	-	-
T. Coliform	2500	5000	7500	10000
E. coli	20	50	100	200

in An Cu (58%), An Hoa (53%), An Binh (65%) and Nhon Nghia (48%) agreed. In the question of willingness to pay to improve the quality of water, respondents in An Cu (81%), An Hoa (75%), An Binh (70%) and Nhon Nghia (41%) also agreed. In the questions, the polluters should be punished for polluting the water and the community should be responsible for the deterioration of the water quality, respondents in An Cu (83, 89%); An Hoa (81, 78%); An Binh (81, 73%) and Nhon Nghia (78, 70%) agreed in both questions, respectively.

In the question that the communities have the responsibilities to improve the quality of water majority of the respondents in An Cu (74%), An Hoa (75%), An Binh (78%) and Nhon Nghia (65%) agreed. For the questions that the national and local government were responsible for improving the water quality, An Cu (74, 80%), An Hoa (57, 80%), An Binh (63, 83%) and Nhon Nghia (57, 77%) agreed, respectively.

Microbiological water quality assessment: During wet seasons water-borne diseases were common especially in developing countries (Shimi *et al*., 2010). The monitoring group of Can Tho were regularly doing microbiological analysis in coliform but not with the three other microbial parameters measured in this study because of cost (Monitoring, 2013). The mean values of HPC, total coliform, *Escherichia coli* and *Salmonella* sp. in six sampling sites are shown in Table 1 and compared with the set Vietnam's standard per classification in Table 2.

During the duration of this study, there were no set standard for HPC and Salmonella. The mean values of Heterotrophic Bacteria (HPC) ranges from 194-6,313 MPN/100 mL and Salmonell a ranges from 1,536-5,679 MPN/100 mL in the six sampling sites. For Environmental Protection Agency (EPA) standard, HPC values above 500 CFU/mL would mean the need for further treatment for total coliform and *E. coli*.

The *T. coliform* mean values for all sampling sites were beyond the max level of 10,000 MPN/100 mL for B2 classification. The values obtained in the urban areas of An Cu and An Hoa were 23-74 times higher than the max tolerable limit. The mean values of *E. coli* obtained ranges from 3,079-83,083 MPN/100 mL. The values in An Cu and An Hoa were 125-445 times higher than the max tolerable limit of 200 MPN/100 mL.

The means of HPC, Salmonella, *T. coliform* and *E. coli* in six established sampling sites were statistically analyzed. The f value and t-tests showed no significantly differences in sampling sites within the same community except the means of *T. coliform* and *E. coli* of An Cu. Taking into considerations the sampling sites and periods, two-way ANOVA was used. ANOVA showed significant difference in the means HPC, Salmonella, *T. coliform.* and *E. coli* in six sampling sites between communities. Analysing further with Tukey's HSD, the HPC means in the sampling sites of An Hoa (H1 and 2) differed significantly with the other means; the *T. coliform* and *E. coli* means of Nhon Nghia (N1 and 2) differed significantly with the other means and Salmonella means of Nhon Nghia (N1 and 2) differed significantly with the means of An Hoa (H1 and 2).

The 245 respondents were aware of the deteriorating water quality of surface waters in their respective communities. They were willing to help or even volunteer to improve the quality of water in the canals/rivers. The respondents were unanimous in agreeing that the polluters should be punished for polluting the water. If they were willing to pay, it is understandable that polluter should pay more and penalized for doing harm to the community. And they also agreed that the community where they belong should also be held responsible.

The respondents think that the national and local government should improve the water quality as their water utility bill includes the cost of wastewater treatment. They also agreed that it is the responsibility of the national and local governments to strictly implement laws governing surface water.

Microbiological water quality assessment: HPC can persist after treatment of drinking water of 10 CFU/mL or less. This study finds it necessary to know phosphorus concentration as this can enhance microbiological growth even in treated drinking water (Allen *et al*., 2004; Miettinen *et al*., 1997). Phosphate affects the growth of phytoplankton and increase HPC (Psarra *et al*., 2005; Thingstad *et al*., 2005).

The HPC mean values of H1 and 2 in An Hoa were significantly different with the means of all other sampling sites. These sites were always full of domestic wastes.

One of the major problem in developing countries and world's leading causes of intestinal illness is Salmonella (Levantesi *et al*., 2012). Typhoid fever is a serious disease caused by Salmonella, extreme cases can lead to death (DeRoeck *et al*., 2007). In developing countries in the south and southeast Asia, Salmonella enterica was the most common cause of bacterial infections (Deen *et al*., 2012).

There is no standard for Salmonella in Vietnam. This study finds it necessary to know the *Salmonella* values in the surface waters in the communities of Nhon Nghia and An Binh. The respondents in these communities used untreated water for domestic and irrigation needs. Salmonella can be acquired in fruits and vegetable washed with contaminated waters (Levantesi *et al*., 2012). This can be a major threat for human health and economic growth (Akhtar *et al*., 2014).

The *T. coliform* value does not necessarily mean feacal pollution in environmental waters. The *T. coliform* values obtained were 4.5-74 times higher than the max level of B2 classification of 10,000 MPN/100 mL. High values of *T. coliform* in Nhon Nghia (N1 and 2) were crucial as the respondents use surface waters for drinking, cooking, bathing, washing clothes and houses. In the PRoAcc report in terms of *T. coliform* of surface water, only 8 out of 34 sampling stations in Can Tho, met the criteria set by Vietnam standard (Trinh *et al*., 2010).

Study showed high values of *T. coliform, E. coli* and enterobacteriaceae in drinking water stored in containers in the river basin of Hue City, Vietnam (Seino *et al*., 2008). The Vietnamese are aware of the poor quality of their drinking water. They buy bottled water for those who can afford and boil water before drinking to those who cannot. The mean *E. coli* values obtained in Nhon Nghia were 15-37 times higher than the max level set by the government. Majority of the respondents in this community use surface water as their daily water source. The values obtained in the urban areas of An Cu and An Hoa were 125-445 times higher than the max tolerable. It was occasionally observed in the urban areas of An Cu, people were catching fishes to be sold to passer bys at low cost.

The *E. coli* is the best indicator of fecal pollution. For developing countries, the most isolated bacterial strain found in children <5 years old was ETEC (enterotoxigenic). This accounts diarrhea cases and 10,000 death worldwide (Cabral, 2010). In Ho Chin Minh City, study showed *E. coli* counts were higher in markets and restaurants than from the cultivation fields (Ha *et al*., 2008). High *E. coli* values and other pathogens were expected in Vietnam due to mixed drainage system (Yen-Phi *et al*., 2010). The mean values of microbiological parameters obtained were higher in densely populated communities, An Hoa and An Cu.

CONCLUSION

Majority of the 245 respondents in the four communities in Can Tho agreed that they were dissatisfied with the water quality of surface water within their neighbourhood. Their social perceptions were verified by the microbiological analysis results. The values obtained exceeded tens to hundreds times higher than the standard set by Vietnam. Surprisingly, although not satisfied with the water quality, survey showed that the respondents were not making efforts in protecting themselves from possible water-borne diseases.

The results of this study should not be taken for granted. The study should encourage concerned agencies and local government of the city to take the opportunity to top human resources that were willing to help and volunteer to improve the quality of water in Can Tho. It is high time to motivate every individual to be responsible and become water/waste/environmental managers in their own houses/community. There is a need for environmental education and health awareness to these vulnerable communities. With this move, at least 3 out of 17 SDG, namely, good health, clean water and sanitation and life below water will be directly or indirectly be addressed.

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REFERENCES

Akhtar, S., M.R. Sarker and A. Hossain, 2014. Microbiological food safety: A dilemma of developing societies. Crit. Rev. Microbiol., 40: 348-359.

Allen, M.J., S.C. Edberg and D.J. Reasoner, 2004. Heterotrophic plate count bacteria-what is their significance in drinking water?. Int. J. Food Microbiol., 92: 265-274.

Anh, P.T., C. Kroeze, S.R. Bush and A.P.J. Mol, 2010. Water pollution by intensive brackish shrimp farming in South-East Vietnam: Causes and options for control. Agric. Water Manage., 97: 872-882.

Baert, L., K. Mattison, F. Loisy-Hamon, J. Harlow and A. Martyres *et al*., 2011. Review: Norovirus prevalence in Belgian, Canadian and French fresh produce: A threat to human health? Int. J. Food Microbiol., 151: 261-269.

Bielaszewska, M., A. Mellmann, W. Zhang, R. Kock and A. Fruth *et al*., 2011. Characterisation of the Escherichia coli strain associated with an outbreak of haemolytic uraemic syndrome in Germany, 2011: A microbiological study. Lancet Infect. Dis., 11: 671-676.

Cabral, J.P.S., 2010. Water microbiology. Bacterial pathogens and water. Int. J. Environ. Res. Public Health, 7: 3657-3703.

Campbell, I.C., 2012. Biodiversity of the Mekong Delta The Mekong Delta System. Springer, Berlin, Germany, pp: 293-313.

Carrasco, E., A. Morales-Rueda and R.M. Garcia-Gimeno, 2012. Cross-contamination and recontamination by Salmonella in foods: A review. Food Res. Intl., 45: 545-556.

Castro-Ibanez, I., M.I. Gil, J.A. Tudela and A. Allende, 2015. Microbial safety considerations of flooding in primary production of leafy greens: A case study. Food Res. Intl., 68: 62-69.

DeRoeck, D., L. Jodar and J. Clemens, 2007. Putting typhoid vaccination on the g lobal health agenda. N. Engl. J. Med., 357: 1069-1071.

Deen, J., V.L. Seidlein, F. Andersen, N. Elle and N.J. White *et al*., 2012. Community-acquired bacterial bloodstream infections in developing countries in South and Southeast Asia: A systematic review. Lancet Infect. Dis., 12: 48-487.

Elviss, N.C., C.L. Little, L. Hucklesby, S. Sagoo and S. Surman-Lee *et al*., 2009. Microbiological study of fresh herbs from retail premises uncovers an international outbreak of salmonellosis. Intl. J. Food Microbiol., 134: 83-88.

Figueras, M.J. and J.J. Borrego, 2010. New perspectives in monitoring drinking water microbial quality. Int. J. Environ. Res. Public Health, 7: 4179-4202.

Ha, N.T.V., M. Kitajima, N.V.M. Hang, K. Matsubara and S. Takizawa *et al*., 2008. Bacterial contamination of raw vegetables, vegetable-related water and river water in Ho Chi Minh City, Vietnam. Water Sci. Technol., 58: 2403-2411.

Khoi, C.M., V.T. Guong, M. Drouillon, P. Pypers and R. Merckx, 2008. Chemical estimation of phosphorus released from hypersaline pond sediments used for brine shrimp Artemia franciscana production in the Mekong Delta. Aquacult., 274: 275-280.

Kuenzer, C. and F.G. Renaud, 2012. Climate and Environmental Change in River Deltas Globally: Expected Impacts, Resilience and Adaptation. In: The Mekong Delta System, Renaud, F.G. and C. Kuenzer (Eds.). Springer, Netherlands, ISBN:978-94-007 -3961-1, pp: 7-46.

Levantesi, C., L. Bonadonna, R. Briancesco, E. Grohmann and S. Toze *et al*., 2012. Salmonella in surface and drinking water: Occurrence and water-mediated transmission. Food Res. Intl., 45: 587-602.

MRC., 2010. Mekong river commission, state of the basin report 2010: Mekong river commission. Phnom Penh, Cambodia.

Miettinen, I.T., T. Vartianen and Martikainen, 1997. Phosphorous and bacterial growth in drinking water. Appl. Environ. Microbiol., 63: 3242-3245.

Monitoring, C.T.E., 2013. Environmental monitoring monthly report. Can Tho Center for Natural Resource and Environment Monitoring, Can Tho City,Vietnam.

Olaimat, A.N. and R.A. Holley, 2012. Factors influencing the microbial safety of fresh produce: A review. Food Microbial., 32: 1-19.

Onda, K., J. LoBuglio and J. Bartram, 2012. Global access to safe water: Accounting for water quality and the resulting impact on MDG progress. Intl. J. Environ. Res. Public Health, 9: 880-894.

Phuc, N.Q., V.A.C.M. Westen and A. Zoomers, 2014. Agricultural land for urban development: The process of land conversion in Central Vietnam. Habitat Intl., 41: 1-7.

Psarra, S., T. Zohary, M.D. Krom, R.F.C. Mantoura and T. Polychronaki *et al*., 2005. Phytoplankton response to a Lagrangian phosphate addition in the Levantine Sea: Eastern mediterranean. Deep Sea Res. Topical Stud. Oceanogr., 52: 2944-2960.

Sagoo, S.K., C.L. Little, L. Ward, I.A. Gillespie and R.T. Mitchell, 2003. Microbiological study of ready-to-eat salad vegetables from retail establishments uncovers a national outbreak of salmonellosis. J. Food Prot., 66: 403-409.

Sebesvari, Z., H.T.T. Le, V.P. Toan, U. Arnold and F.G. Renaud, 2012. Agriculture and Water Quality in the Vietnamese Mekong Delta. In: The Mekong Delta System, Renaud, F.G. and C. Kuenzer (Eds.). Springer, Netherlands, ISBN:978-94-007-3961-1, pp: 331-361.

Seino, K., T. Takano, N.K. Quang, M. Watanabe and T. Inose *et al*., 2008. Bacterial quality of drinking water stored in containers by boat households in Hue City, Vietnam. Environ. Health Preventive Med., 13: 198-206.

Shimi, A.C., A.G. Parvin, C. Biswas and R. Shaw, 2010. Impact and adaptation to flood: A focus on water supply, sanitation and health problems of rural community in Bangladesh. Disaster Prev. Manage. Intl. J., 19: 298-313.

and S. Groom *et al*., 2005. Nature of phosphorus limitation in the ultraoligotrophic Eastern Mediterranean. Sci., 309: 1068-1071.

Toan, P.V., Z. Sebesvari, M. Blasing, I. Rosendahl and F.G. Renaud, 2013. Pesticide management and their residues in sediments and surface and drinking water in the Mekong Delta, Vietnam. Sci. Total Environ., 452: 28-39.

Trinh, T.L., P.V.D. Steen and P. Lens, 2010. Wastewater reuse towards adaptation to climate change in the Mekong Delta Vietnam water quality in Can Tho City. ProACC UNESCO IHE, Vietnam, Asia.

Veldhuis, J.A.E.T., F.H.L.R. Clemens, G. Sterk and B.R. Berends, 2010. Microbial risks associated with exposure to pathogens in contaminated urban flood water. Water Res., 44: 2910-2918.

Yen-Phi, V.T., A. Rechenburg, B. Vinneras, J. Clemens and T. Kistemann, 2010. Pathogens in septage in Vietnam. Sci. Total Environ., 408: 2050-2053.