Songklanakarin J. Sci. Technol.
31 (4), 367-372, Jul. - Aug. 2009

Songklanakarin Journal
of Science and Technology

http://www.sjst.psu.ac.th

Original Article

Impact of marine tourism on the recreational water quality of Muk Island, Trang Province, Southern Thailand

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Received 29 January 2008; Accepted 2 December 2009

Abstract

The characteristics of the water consisting of several parameters in the surrounding area of Muk Island were examined. Reference surface water was also concurrently sampled at stations located outside the recreational area stations. Relative modifications (RM) in the recreational area stations water quality were assessed as the difference between the magnitude of a specific parameter recorded at the recreational area stations and the concurrently recorded value of the parameter at the reference station, relative to the mean value at the reference station. In this study, the specific parameters of dissolved oxygen (DO) concentration, total suspended solids (TSS), total inorganic nitrogen (TIN = NO^{-}_{2} + NO^{-2}_{3} + NH^{+}_{3}) and ortho-phosphate (PO^{-3}_{4}) were shown to be significantly modified in December and April, but non-significantly modified in September. The total coliform bacteria (TC) and fecal coliform (FC) in seawater at the recreational area stations were found to be higher than the coastal water quality standard. With a water quality criteria based coastal water quality standard for tourism, a significant but not dangerous level of pollution was observed in this area. TC and FC were the most significant pollutants in the recreational area stations.

Keywords: environmental impact, marine tourism, relative modification (RM)

1. Introduction

Marine tourism is a component of the wider tourism sector that is considered to be rapidly growing in terms of both its volume and value (Vogt, 1997). Although marine tourism lays claim to higher principles, it nevertheless impinges upon the environment at its target destinations by consuming and competing for resources such as water, land, and marine resources. Like any resource use activities, tourism risks becoming unsustainable if ecological capacities are not respected (Wall, 1997). Much of the tourism literature consists of impact studies that deal with the outcome of tourism after development has taken place, while a priori assessments of a site's environmental capacity for accommodating tourism are less common. Yet studies have shown after the fact that the resource demands and activities of tourism can easily surpass an area's biophysical limits, resulting in deteriorated environmental qualities (Musa, 2002), as well as a decline in sea water quality. Several investigations have been made, with the aim of finding out the causes and consequences of water quality deterioration associated with tourism development. The results show that the present mode of water utilization is not sustainable, and some of the local residents have already complained about water quality degradation. Increasing numbers of tourists, relative service infrastructures, such as restaurants and hotels and in addition, insufficient management measures, result in the decline of water quality (Tananone, 1990; Bywater, 1991; Baoying and Yuanqing, 2007). Muk Island is located on the southern coast of the Andaman Sea, Trang province. The island is a

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potentially important area in terms of marine tourism. The Tourism Office of Trang province reported that mass tourism was a short-range phenomenon largely within nation states. Mass tourism is now global with tourists from developed countries visiting, most by Scandinavian countries. The number of international arrivals has shown a steady increase approximately 1.2 thousand in 1998 to over 10 thousand in 2006, corresponding to an average annual growth rate of about 10%. This substantially underestimates the total extent of tourism as it does not include long and short-distance tourism within countries. The waste production from tourism activity on the island is on the increase and without proper measures for management. The aim of the present study is to examine the impact of marine tourism on sea water qualities. The information from the present study can be used for the future management of marine tourism on Muk Island and the criteria for assessment are discussed regarding how existing environmental conditions influence options for future marine tourism development.

2. Materials and Methods

2.1 Study area

Muk Island is located on southern Andaman sea coast of Thailand. The island is now strongly promoted for marine tourism in Trang province. The study area is sheltered and characterized by the presence of sandy beach and limestone mountains. The accommodation facilities for tourism are often located close to the beach zone and may influence the littoral zone of Muk Island. The waste from those accommodations is being generated at present and untreated wastewater is being directly discharged into the beach. Sea water samples were collected from fourteen stations in three recreational areas and four reference stations were also concurrently sampled at stations located in outside the Island. (Figure 1).

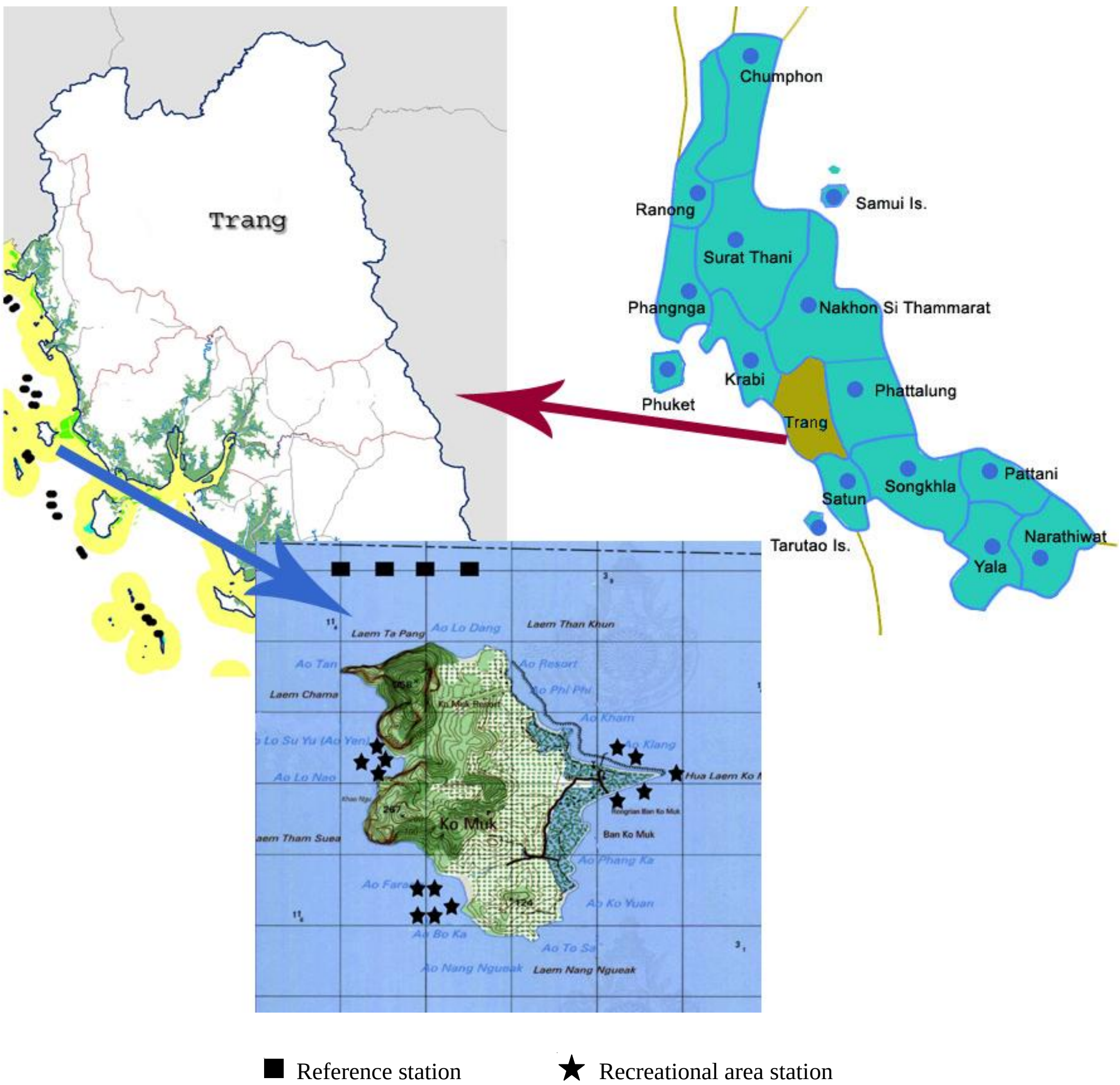

Figure 1. Map showing the location of study site and sampling site, Mook Island, Kantang district, Trang province

2.2 Analytical method

Water temperature and dissolved oxygen (DO) concentrations were measured in situ using a YSI oxygenmeter. Samples were kept on ice and analyzed soon upon return to the laboratory. Before determination of ammonia-N, nitrite, nitrate and phosphate concentrations, samples were filtered through pre-washed GF/C filters. Ammonia-N of water samples was analyzed by the phenolhypochlorite method (Solorzano, 1969). Nitrite of water samples was analyzed by the diazotization method (Strickland and Persons, 1972). Nitrate was analyzed by the cadmium reduction method (Strickland and Persons, 1972). The nitrate in water samples was reduced to nitrite and the original nitrite and nitrite from reduction were analyzed using the same diazotization methods (Strickland and Persons, 1972). The filtrable reactive phosphate was analyzed by the ascorbic acid method (Strickland and Persons, 1972). TC and FC in sea water were analyzed by the standard method for the examination of water and wastewater (APHA, 1980).

2.3 Data Analysis

Modifications at the recreational area stations water quality were assessed as the difference between the magnitude of a specific parameter recorded at the recreational area stations and the concurrently recorded value of the parameter at the reference station. Relative Modification (RM) is defined as:

$$RM = (Cc - Cr) / Mr$$

Where Cc is the parameter value recorded at the recreational area stations, Cr is the parameter value recorded concurrently at the reference stations, and Mr is the parameter annual mean value at the reference stations. A parameter was considered significantly modified if the annual mean value of its quantified RM was significantly different from zero, i.e., if the 95% confidence interval did not include zero (Demirak *et al.*, 2006).

3. Results

3.1 Water qualities

Concentrations of water quality parameters at the recreational area stations and the reference station from December 2006, April and September 2007 are shown in Table 1.

3.1.1 Dissolved oxygen

The DO concentration (December, April, and September) in the recreational area stations varied generally from 5.10 to 6.70 mg/L, 6.07 to 7.59 mg/L and 7.02 to 7.19 mg/L, respectively. But the concentrations of DO in reference stations during study periods varied from 5.34 to 6.08 mg/L, 6.17 to 7.18 mg/L and 7.12 to 7.21 mg/L, respectively. Mean RM values for DO concentrations were significantly modified in December and April, but not in September (Figure 2). The concentration of DO at the recreational area stations were negatively modified for all study periods.

3.1.2 Total suspended solids

The displayed pattern of variability in the recreational area stations during the study period in similar to the pattern displayed in the reference waters. In some recreational area stations, concentrations of TSS increased in December and minimum concentrations persisted in April. From observation, high water turbulence occurred during the northeast monsoon season, making high water turbidity in the recreational area stations on the east coast of Muk Island, except the station far from the coast, which showed lower TSS than in other areas. Therefore, mean RM for TSS at the recreational area stations was significantly positive in December and April, but negative in September. Mean RM values for TSS concentration was not significantly modified in September (Figure 3).

3.1.3 Total inorganic nitrogen

The ranges of TIN concentrations (December, April, and September) in surface water of the recreational area

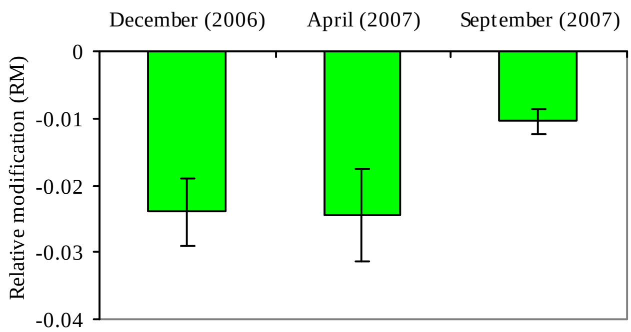

Figure 2. Mean relative modification of dissolved oxygen (DO).

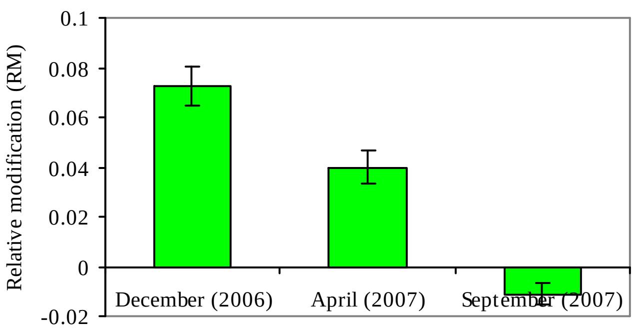

Figure 3. Mean relative modification of total suspended solids (TSS).

Table 1. Temporal variations of DO, TSS, TIN and PO^{-3}_4 in surface water at sampled stations over the study periods.

Water quality parameters	December 2006		April 2007		September 2007	
	Ref. stations	Rec. stations	Ref. stations	Rec. stations	Ref. stations	Rec. stations
Dissolved oxygen (DO) (mg/L)	5.34-6.08	5.10-6.70	6.17-7.18	6.07-7.59	7.12-7.21	7.02-7.19
Total suspended solids (TSS) (mg/L)	17.80-20.10	16.60-35.70	16.42-23.47	15.47-23.26	22.00-22.40	20.00-23.20
Total inorganic nitrogen (TIN) (mg/L)	0.121-0.131	0.122-0.155	0.163-0.197	0.163-0.220	0.161-0.168	0.160-0.194
Orthophosphate (PO^{-3}_4) (mg/L)	0.012-0.018	0.012-0.014	0.014-0.075	0.013-0.016	0.011	0.010-0.012

Remark : Ref. Stations = Reference stations; Rec. stations = Recreational area stations.

stations varied from 0.122 to 0.155 mg/L, 0.163 to 0.220 mg/L and 0.160 to 0.194 mg/L, respectively. But the concentrations of TIN in surface water of reference stations during study periods varied from 0.121 to 0.197 mg/L. Maximum values were recorded in surface water of the recreational area stations in April, similar to the TIN values in the reference station. Minimum values were recorded in surface water of the recreational area stations and reference stations in December. Mean RM values for TIN concentration was significantly modified in December and April, except in September. The concentration of TIN at the recreational area stations were positively modified for all study periods (Figure 4).

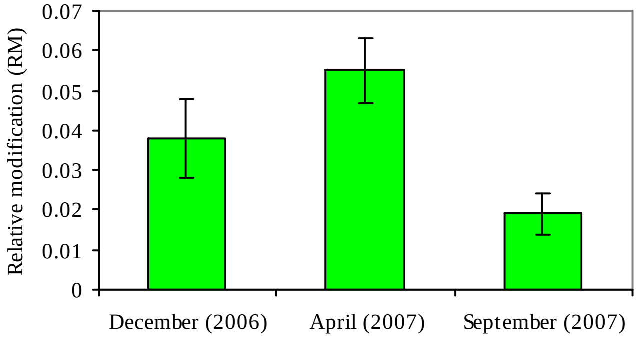

Figure 4. Mean relative modification of total inorganic nitrogen (TIN).

3.1.4 Orthophosphate

The ranges of PO^{-3}_4 concentrations were 0.011-0.075 mg/L in surface water of reference stations over the study period. The PO^{-3}_4 concentrations (December, April, and September) at the recreational area stations varied from 0.012 to 0.014 mg/L, 0.013 to 0.016 mg/L and from 0.010 to 0.012 mg/L, respectively. Mean RM values for PO^{-3}_4 concentration was significantly negative for the sampling period in December and April, but mean RM of PO^{-3}_4 concentration was non significantly negative for the sampling period in September (Figure 5).

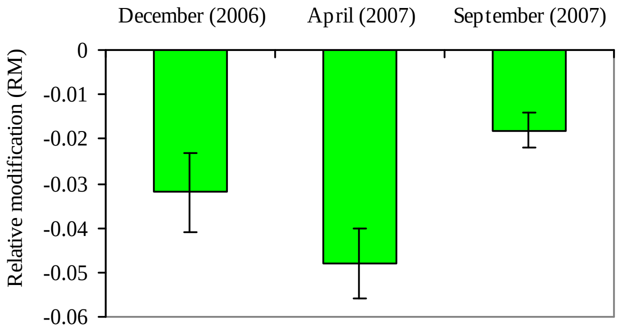

Figure 5. Mean relative modification of orthophosphate (PO^{-3}_4).

3.2 Bacteriological study

In the bacteriological study, the highest values of TC and FC were found in the recreational area stations in December and April, the content in MPN/100 mL was higher than 1,600, but low values were found at this station in September, while the value of TC and FC in the reference area were below the detection limit in all study periods (Table 2).

Table 2. TC and FC in surface water at different sampled stations of Muk Island.

Stations	TC (MPN/100 ml)			FC (MPN/100 ml)		
	Dec-06	Apr-07	Sep-07	Dec-06	Apr-07	Sep-07
Reference stations	ND	ND	ND	ND	ND	ND
Recreational area stations	>1,600	>1,600	4.75	>1,600	>1,600	5.5

ND = Non detected

4. Discussion

The DO concentration (December, April, and September) in the recreational area stations of this study are higher than environmental criteria as recommended by the Pollution Control Department (1994). DO concentration at the recreational area stations displayed a pattern of seasonal variability similar to the pattern displayed in the reference waters DO concentrations and were significantly modified in December and April, but not in September. DO concentrations at all study sites were shown to be negatively modified for every sampling period. Mean RM values were approximately two times higher in December and April than September. This result is very difficult to correlate with community and tourism accommodation, because DO in sea water is affected by various factors, such as temperature (Pilson, 1998).

Increasing TSS concentration in December was due to the effect of the southwest monsoon hitting the west coast of the island and resuspension of sediment from the sea bottom as a result of current and wave action. The east coast was less affected by the monsoon. Thus, the relative modification of total suspended solids was not significant in September. However, TSS concentrations from this study was lower than the environmental criteria recommended by the Pollution Control Department (1994).

TIN concentration was shown to be have a positive RM, suggesting perhaps that the sources of some TIN input to the coastal water may come from untreated wastewater discharge from resort areas, especially in December and April. NH^{+3}, NO^{-2} and NO^{-3} are the most common ionic reactive forms of dissolved inorganic nitrogen in aquatic ecosystems (Wetzel, 2001; Rabalais, 2002). However, the concentrations of NO^{-2}, NO^{-3}, and NH^{+3} in the present study are in the acceptable range recommended by tphe Pollution Control Department (1994).

PO^{-3}_{4} concentration was shown to have significantly negative RM in April, but not in December and September. This suggests that some orthophosphate may be taken up by marine phytoplankton. Phosphate uptake by natural phytoplankton in coastal region has been reported (Aubriot *et al.*, 2004).

TC and FC have for decades been commonly used as a bacterial indicator of sanitary quality of water. An indicator organism is a microorganism whose presence is evidence that water has been polluted with the feces of humans or other warm-blooded animals. Indicator bacteria in a waterway come from many sources (Addy *et al.*, 2003). At reference stations, TC and FC in surface water were not detected, but the values of TC and FC at the recreational area stations in December and April were higher than the value recommended by the Pollution Control Department (1994), suggesting perhaps that the sources of some TC and FC input to the coastal water may come from untreated wastewater discharge from resort areas. Data have also shown that coliform bacteria are found in the environment in the absence of a known sewage source of contamination and have been shown to multiply within warm tropical environments (Hardina and Fujioka, 1991; Roll and Fujioka, 1997; Solo-Gabriele *et al.*, 2000; Desmarais *et al.*, 2002). Stimulated growth of bacteria in marine water is generally attributed to the rich organic content of sewage from the community (Markosova and Jezek 1994; Wang, 1999). The PCD standard stated that no water sample should contain more than 1,000 TC/100 mL. (Pollution Control Department, 1995), while the WHO standard (WHO, 1967) states that no water sample should contain more than 1,000 TC/100 mL. Fecal indicator organisms are measured to approximate the concentrations of pathogens associated with fecal contamination, and provide an estimation of the risk presented to swimmers using beaches (Anderson *et al.*, 2005; Harwood *et al.*, 2005). Fecal indicator organisms are used as the standard for water quality assessments in many countries (Englebert *et al.*, 2008).

This study demonstrates that an assessment of marine water conditions is useful for identifying factors which might impede the growth and development of future tourism initiatives. This can be used to infer appropriate approaches towards planning and managing tourism so that constraints, such as water pollution, are respected as in the case of resort basic waste disposal systems. Desired outcomes have to be set through collaborative processes involving all stakeholders, and monitoring programmes put in place that can detect changes and respond to those changes in a timely manner. Finally, the importance of institutional support cannot be ignored. Government must play its role in providing adequate infrastructure, leadership, legislative and financial support that will build the foundation for sustainable development over the longer term. The information from our study on Muk Island can be applied to other destinations that seek guidelines for planning sustainable marine tourism. The private resort must have an adequate infrastructure for proper sanitation to serve the needs of tourists and obtain the cooperation and support of resource users in managing local resources.

5. Conclusions

The overall condition of marine water quality in the surrounding area of Muk Island is assessed as good. The relative modification of marine water was shown to be significant during the high season (December and April), but most parameters showed non-significant modification during the low season (September). The coliform bacteria in seawater at the recreational area stations were found to be higher than the coastal water quality standard. The results from this study indicate that the marine water quality in this area was affected by tourism activity on Muk Island.

Acknowledgments

I am very grateful to the Faculty of Science and Fisheries Technology, Rajamanagala University of Technology Srivijaya, for laboratory support. The author wishes to express thanks for funding from the Southern Division of the Research Network, The Commission of Higher Education. I wish to thank Bill Templer for assistance in editing the manuscript.

References

Anderson, K.L.,Whitlock J.E., and Harwood, V.J. 2005. Persistence and differential survival of fecal indicator bacteria in subtropical waters and sediments. Apply Environmental Microbiology, 71, 3041-8.

Addy, K., Herron, E. and Green, L. 2003. Bacterial Monitoring <http://www.uri.edu/ce/wq/ww/html/ww.html> (March, 2003).

APHA, AWWA and WPCF. 1980. Standard method for the examination of water and wastewater. 15th ed. American Public Health Publishers, New York.

Aubriot, D., Conde, S. B. and Sommaruga, R. 2004. Phosphate uptake behavior of natural phytoplankton during exposure to solar ultraviolet radiation in a shallow coastal lagoon. Marine Biology. 144, 623-631.

Baoying, N. and Yuanqing. H. 2007. Tourism Development and Water Pollution: Case Study in Lijiang Ancient Town. China Population, Resources and Environment. 17, 123-127.

Bywater, M. 1991. Prospects for Mediterranean beach resorts: An Italian case study. Travel and Tourism Analyst, 5, 75 89

Demirak A., Balci, A. and Tufekci, M. 2006. Environmental impact of the marine aquaculture in Gulluk bay, Turkey. Environmental Monitoring and Assessment, 123, 1-12.

Desmarais T.R., Solo-Gabriele H.M. and Palmer C.J. 2002. Influence of soil on fecal indicator organisms in a tidally influenced subtropical environment. Apply Environmental Microbiology. 56, 1165-1172.

Englebert, E.T., McDermott, C. and Kleinheinz. G.T. 2008. Effects of the nuisance algae, Cladophora, *Escherichia coli* in recreational beaches in Wisconsin. Science and the Total Environment, 404, 10-17.

Hardina, C.M. and Fujioka, R.S. 1991. Soil: the environmental source of *Escherichia coli* and enterococci in Hawaii's stream. Environmental Toxicology and Water Quality, 6, 185-195.

Harwood, V.J., Levine, A.D., Scott, T.M., Chivukula, V., Lukasik, J. and Farrah, S.R. 2005. Validity of the indicator organism paradigm for pathogen reduction in reclaimed water and public health protection. Apply Environmental Microbiology, 71, 3163-3170.

Markosova, R. and Jezek, J. 1994. Indicator bacteria and limnological parameters in fish ponds. Water Research, 28, 2477-2485.

Musa, G., 2002. Sipadan: a SCUBA-diving paradise: an analysis of tourism impact, diver satisfaction and tourism management. Tourism Geographies, 4, 195-209.

Pilson, M.G.G. 1998. An introduction to the chemistry of the sea. Prentice-Hall., Inc.

Pollution Control Department. 1994. Laws and standards on pollution control in Thailand. 3rd edition. Pollution Control Department, Ministry of Science Technology and Environment, Bangkok, Thailand.

Rabalais, N.N. 2002. Nitrogen in aquatic ecosystems. Ambiology, 31, 102-12.

Roll, B.M. and Fujioka, R.S. 1997. Source of fecal indicator bacteria in a brackish; tropical stream and their impact on recreational water quality. Water Science and Technology, 35, 179-186.

Solo-Gabriele, H.M., Wolfert, M.A., Desmarais, T.R. and Palmer, C.J. 2000. Sources of *Escherichia coli* in a coastal subtropical environment. Apply Environmental Microbiology, 66, 230-237.

Solorzano, L. 1969. Determination of ammonia in natural water by phenolhypochlorite method. Limnology and Oceanography, 14, 799-802.

Strickland, D.J. and Persons, T.R. 1972. A practical handbook of seawater analysis. Fishery Research Board of Canada Bulletin. (2nd edition) Ottawa, Canada.

Tananone, B., 1990. International tourism in Thailand: environment sad community development. Contours, 5, 7-9.

Vogt, H. 1997. The economic benefits of tourism in the marine reserve of Apo Island, Philippines. Proceedings of the Eighth International Coral Reef Symposium, vol. 2. Smithsonian Tropical Research Institute, Panama, 2102-2104.

Wall, G., 1997. Is ecotourism sustainable?. Environmental Management, 21, 483-491.

Wetzel, R.G. 2001. Limnology. 3rd edition. New York: Academic Press.

Wang, C.W. 1999. ASEAN marine water quality criteria for bacteria. http://www.marinepcd.org/document/marine/bacteria.pdf. (March, 1999).

WHO. 1967. Control of Water Pollution, W.H.O., Geneva.