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Sources of Water Supply and Water Quality for Local Consumption: The Case Study of Eco-Tourism Village, Suan Luang Sub- District Municipality, Ampawa District, Samut Songkram Province, Thailand

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***Abstract*—**The aim of this research paper was based on an examination of sources of water supply and water quality for local consumption, conducted at eco- tourism villages of Suan Luang Sub-District Municipality of Amphawa District, Samut Songkram Province. The study incorporated both questionnaire and field work of water testing as the research tool and method. The sample size of 288 households was based on the population of the district, whereas the selected sample water sources were from 60 households: 30 samples were ground water and another 30 were surface water. Degree of heavy metal contamination in the water including copper, iron, manganese, zinc, cadmium and lead was investigated utilizing the Atomic Absorption- Direct Aspiration method. The findings unveiled that 96.0 percent of household water consumption was based on water supply, while the rest on canal, river and rain water. The household behavior of consumption revealed that 47.2 percent of people routinely consumed water without boiling or filtering prior to consumption. The investigation of water supply quality found that the degree of heavy metal contamination including metal, lead, iron, copper, manganese and cadmium met the standards of the Department of Health.

***Keywords*—**Sources of water supply, water quality, water supply.

I. Introduction

SMUT Songkram Province is located at the mouth of Mae Klong River to the Gulf of Thailand, marked on the tourism map of Thailand as the province of fertile land and seacoast attraction. As short distance traveled by car from Bangkok, Samut Songkram Province has a greater potential to be developed as a center of coastal leisure and eco-tourism destination. The province has therefore attempted to promote sustainable tourism development in each municipality. The province has presently enjoyed an increasing number of visitors of both domestic and international markets.

Suan Luang Sub- District Municipality, Ampawa District, Samut Songkram Province is characterized by its low plain of the central Thailand. Situated within an area of approximate 6.5 kilometer squares, each area of the province is connected by canals. The residents are mainly living by agriculture such as coconut plantation. Use of chemical substances in the agricultural activities can be commonly seen throughout the province. This relatively causes contamination of chemical substances in soil and water sources. Despite the fact that the province has plenty of canals and rivers, people are still encountered with scarcity of water for consumption as the water property is based on an estuarine environment [1].

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A. Definition of Water Supply

Office of Water Management [2] defined water supply as the water supplied for household consumption, produced from two main sources which are surface water such as lakes, rivers and canals, and ground water. Surface water is found to contain organic contaminants and small particulate suspended matters while ground water generally contains inorganic contaminants such as dissolved minerals and coming with the water in relatively slow passage through the rocks and sediments of the Earth's crust. Geological, geographical, climate and seasonal characters cause extensive variation in the degree of inorganic contaminants in water in each area. Safe and qualified water for consumption must be distributed to home through proper and standard water supply system along the water pipes. By its general characteristic, water for home consumption contains Chlorine (Cl_2) dissolved in the body, even in purified water, since Chlorine is used in purification process.

B. Water Supply Production of Surface and Ground Water

Designs of water supply production of both surface and ground water normally take account of community demands that include the factors of number of consumers, sources of water, quality and amount of water to be produced. Basically, two types of water supply production designs are found in communities [3].

1. Water Supply Production Designed for Raw Water from Surface Water

The system for water production from surface water requires purification process to improve the quality of water. Sedimentation technique is utilized as a pre- treatment of water prior to filtration and disinfection. Alum and lime calcium hydroxide solution are used in the sedimentation process to removes undesirable small particulate suspended matters. The water is further treated through filtration, stored

in clear water storage tank and disinfected by use of Chlorine solution. Purified water will be pumped up, using volute pump, from the clear water storage tank to high tower tank. Water ready for consumption will be distributed through pipe line network to households. Designs of community's water tanks vary by standard of different water management organizations (Figs. 1-5)

Fig. 1 The design of the Department of Public Works

Fig. 2 The design of the Office of Accelerated Rural Development

Fig. 3 The design of the Department of Mineral Resources

Fig. 4 The design of the Department of Water Resources

Fig. 5 The design of the Department of Local Administration cooperated with the Metropolitan Waterworks Authority

2. Water Supply Production Designed for Raw Water from Ground Water

Iron and manganese are common in ground water in Thailand and amount of these inorganic substances are usually found at an excessive degree not appropriate for household consumption. System for water production is therefore usually designed for higher effective iron and manganese removal. However, other heavy metals still cannot be removed such as mercury or Chlorine. Dissolved iron and manganese can be removed and oxidized to a solid form by mixing with air by use of a pressure aerator, called water aeration technique. The next process is sand filtration followed by chlorination. Designs of water distribution system for ground water can be divided into 2 types.

2.1) Type 1: Direct Feed

Direct feed system (Fig. 6) will be used with water with quality met with the standard and quality treatment is not necessary. Mostly it is suitable for high amount of water supply and used to ensure that availability during peak rush hours is met.

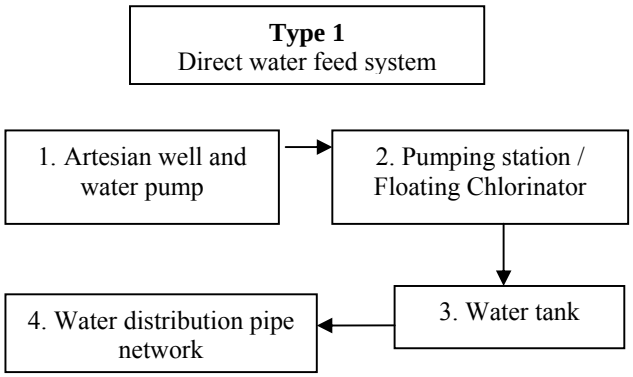

Fig. 6 Direct Feed System

Filter tank (Fig. 7) will be used with ground water with an excessive degree of dissolved iron not appropriate for household consumption. Water quality treatment is therefore required. Water quality treatments can be made in 2 methods, to be used depending on amount of dissolved iron stained in water. The first method is for ground water with dissolved iron less than 5 ppm (part per million). In this case, sand filtration is employed with aerator. The second method is for ground water with dissolved iron more than 5 ppm. Highly effective De-Iron Filter will be used in this case.

2.2) Type 2: Filter Tank

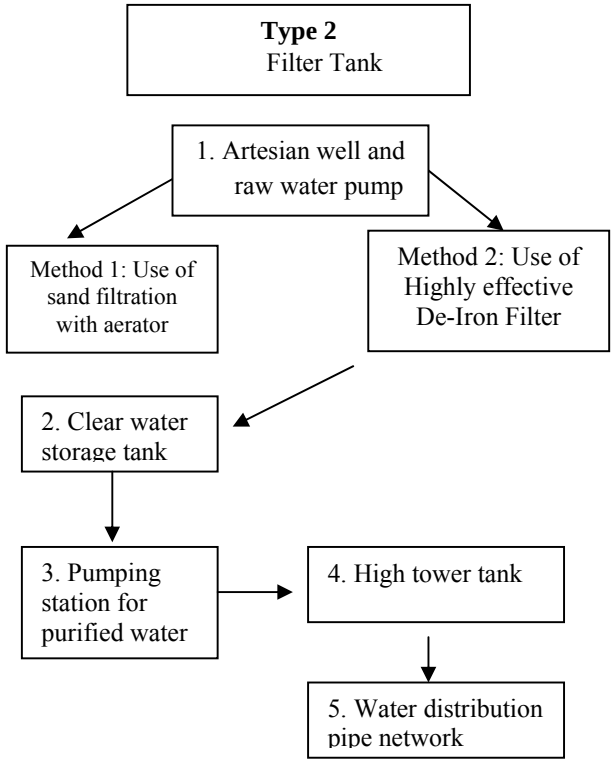

Fig. 7 Filter Tank system

C. Water Quality Standards

One of the key to quality living of people is safe water supply [4]. Water quality criteria (Table I) were therefore established by the Department of Health to ensure safe water consumption.

Sivapan Choo-in [5] studied about the quality of water in Ampawa Canal around Amphawa Floating Market, Samut Songkram Province. The sample water was tested using the parameters of temperature, Turbidity, smell, salinity, Electrical Conductivity (EC), pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Nitrogen as Nitrite and Nitrogen as Ammonia, fat, oil and grease (FOG), suspended solid, Phosphorus as Phosphate, heavy metal including copper, nickel, manganese, cadmium and lead. The finding revealed that water quality of Amphawa Canal meets the criteria for consumption under the condition of disinfection by use of appropriate methods. The water is suitable for preserving aquatic animals, fishery and swimming. Other market activities lead to higher amount of fat, oil and grease.

TABLE I
WATER QUALITY CRITERIA B.E. 2553

No.	Parameter	Unit	Criteria
1	Physical characteristics		
	pH	(pH at 25°C)	Between 6.5 - 8.5
	Turbidity	(NTU)	Less than 5
	Color	(Platinum-Cobalt)	Less than 15
2	Chemical characteristics		
	Total Dissolved Solids	(mg/l)	Less than 1,000
	Hardness	(mg/l)	Less than 500
	Sulfate (SO_4^{2-})	(mg/l)	Less than 250
	Chlorine (Cl)	(mg/l)	Less than 250
	Nitrate (NO_3^{2-})	(mg/l)	Less than 50
	Fluoride (F)		Less than 0.7
3	Heavy metal contents characteristics		
	Iron (Fe)	(mg/l)	Less than 0.5
	Manganese (Mn)	(mg/l)	Less than 0.3
	Copper (Cu)	(mg/l)	Less than 1.0
	Zinc (Zn)	(mg/l)	Less than 3.0
4	Toxic heavy metal contents characteristics		
	Lead (Pb)	(mg/l)	Less than 0.01
	Chromium (Cr)	(mg/l)	Less than 0.05
	Cadmium (Cd)	(mg/l)	Less than 0.003
	Arsenic (As)	(mg/l)	Less than 0.01
	Mercury	(mg/l)	Less than 0.001
5	Bacterial quality		
	Coliform Bacteria	(MPN/ 100ml)	Not found
	Fecal Coliform Bacteria	(MPN/100 ml)	Not found

II. OBJECTIVES

The objective of this research was to examine sources of water supply and water quality for local consumption. The case is eco- tourism villages of Suan Luang Sub - District Municipality of Amphawa District, Samut Songkram Province.

III. METHODOLOGY

The study utilized both questionnaire and field work of water testing as the research tool and method. The questionnaire was employed in order to examine the sources of water and consumption behavior of 228 households in 15 villages. Whereas water quality was tested with the selected sample water sources from 60 households: 30 ground water

samples and another 30 surface water samples. The samples were tested, applying the Atomic Absorption – Direct Aspiration Method, to find the degree of copper, iron, manganese, zinc, cadmium and lead at the lab of the Faculty of Sciences, Suan Sunandha Rajabhat University.

IV. Findings

The findings unveiled that 96.0 percent of household water consumption was based on water supply, while the rest on canal, river and rain water. The household behavior of consumption revealed that an average expense on water supply of the household samples was 82.94 Baht per month per household. Moreover, it was found that 47.2 percent of people routinely consumed water without boiling or filtering prior to consumption. People consume water on routine activities such as drinking and cooking, cloth and dish washing, bathing, cleaning bathroom and toilet, and gardening. The majority of the households (84.2 percent) use big earthen jar to contain water followed by plastic container and water tank respectively. Average household wastewater is 144.01 liters per day per household. Testing result for water quality was exhibited in Tables II, III.

TABLE II
30 Surface Water Samples (Water from Canals) Were Tested to Assess the Degree of Heavy Metal Contaminants

Contaminants	Intensity of Metal Contamination (mg/l)		
	Lowest	Highest	Average
Fe	$1x10^{-6}$	$5.2 x10^{-5}$	$8 x10^{-6}$
Pb	$1 x10^{-6}$	$2.14 x10^{-4}$	$5.3 x10^{-5}$
Zn	$5 x10^{-5}$	$1.16 x10^{-4}$	$7.3 x10^{-5}$
Cu	$1 x10^{-6}$	$8 x10^{-6}$	$2 x10^{-6}$
Mn	$7.4 x10^{-6}$	$1.27 x10^{-4}$	$9.8 x10^{-5}$
Cd	$1 x10^{-6}$	$1.34 x10^{-4}$	$4.2 x10^{-5}$

TABLE III
30 Ground Water Samples Were Tested to Assess the Degree of Heavy Metal Contaminants

Contaminants	Intensity of Metal Contamination (mg/l)		
	Lowest	Highest	Average
Fe	$3.5 x10^{-5}$	$1.24 x10^{-4}$	$7.7 x10^{-5}$
Pb	$1 x10^{-6}$	$6.84 x10^{-4}$	$1.91 x10^{-4}$
Zn	$1 x10^{-6}$	$2.8 x10^{-5}$	$2 x10^{-6}$
Cu	$1 x10^{-6}$	$1.6 x10^{-4}$	$6 x10^{-6}$
Mn	$1.5 x10^{-5}$	$7.9 x10^{-5}$	$4.1 x10^{-5}$
Cd	$4.4 x10^{-5}$	$9.8 x10^{-4}$	$1.27 x10^{-4}$

TABLE IV
Presents a Comparison View of Degree of Heavy Metal Contamination in Surface and Ground Water and Water Quality Criteria

Contaminants	Surface water (mg/l)	Ground water (mg/l)	Criteria (mg/l)
Fe	$8 x10^{-6}$	$7.7 x10^{-5}$	0.5
Pb	$5.3 x10^{-5}$	$1.91 x10^{-4}$	0.05
Zn	$7.3 x10^{-5}$	$2 x10^{-6}$	5.0
Cu	$2 x10^{-6}$	$6 x10^{-6}$	1.0
Mn	$9.8 x10^{-5}$	$4.1 x10^{-5}$	0.3
Cd			0.01

The finding suggested that the quality of water met the criteria of water quality set by the Department of Health.

V. Conclusion

The research findings can be concluded in 5 main areas.

(1) The majority of household water consumption was based on water supply, while the rest on canal, river and rain water.

(2) 47.2 percent of people routinely consumed water without boiling or filtering prior to consumption. Moreover, people consume water on routine activities such as drinking and cooking, cloth and dish washing, bathing, cleaning bathroom and toilet, and gardening.

(3) The water quality test of 30 surface water samples (water from canals) found that the water was contaminated with the heavy metal contaminants as the following details:

(3.1) iron for the amount of $1 x 10^{-6}$ mg/l as the lowest, $5.2 x 10^{-5}$ mg/l as the highest, and $8 x 10^{-6}$ mg/l as an average degree;

(3.2) lead for the amount of $1 x 10^{-6}$ mg/l as the lowest, $2.14 x 10^{-4}$ mg/l as the highest, and 5.3 x 10-5 mg/l as an average degree;

(3.3) zinc for the amount of $5 x 10^{-5}$ mg/l as the lowest, $1.16 x 10^{-4}$ mg/l as the highest, and $7.3 x 10^{-5}$ mg/l as an average degree;

(3.4) copper for the amount of $1 x 10^{-6}$ mg/l as the lowest, $8 x 10^{-6}$ mg/l as the highest, and $2 x 10^{-6}$ mg/l as an average degree;

(3.5) manganese for the amount of $7.4 x 10^{-6}$ mg/l as the lowest, $1.27 x 10^{-4}$ mg/l as the highest, and $9.8 x 10^{-5}$ mg/l as an average degree; and

(3.6) cadmium for the amount of $1 x 10^{-6}$ mg/l as the lowest, $1.34 x 10^{-4}$ mg/l as the highest, and $4.2 x 10^{-5}$ mg/l as an average degree.

(4) The water quality test of 30 ground water samples found that the water was contaminated with the heavy metal contaminants as the following details:

(4.1) iron for the amount of $3.5 x 10^{-5}$ mg/l as the lowest, $2.4 x 10^{-4}$ mg/l as the highest, and $7.7 x 10^{-5}$ mg/l as an average degree;

(4.2) lead for the amount of $1 x 10^{-6}$ mg/l as the lowest, $6.84 x 10^{-4}$ mg/l as the highest, and $1.91 x 10^{-4}$ mg/l as an average degree;

(4.3) zinc for the amount of $1 x 10^{-6}$ mg/l as the lowest, $2.8 x 10^{-5}$ mg/l as the highest, and $2 x 10^{-6}$ mg/l as an average degree;

(4.4) copper for the amount of $1 x 10^{-6}$ mg/l as the lowest, $1.6 x 10^{-4}$ mg/l as the highest, and $6 x 10^{-6}$ mg/l as an average degree;

(4.5) manganese for the amount of $1.5 x 10^{-5}$ mg/l as the lowest, $7.9 x 10^{-5}$ mg/l as the highest, and 4.1 x 10-5 mg/l as an average degree; and

(4.6) cadmium for the amount of $4.4 x 10^{-5}$ mg/l as the lowest, $9.8 x 10^{-4}$ mg/l as the highest, and $1.27 x 10^{-4}$ mg/l as an average degree.

(5) It can be concluded that the amount of iron, lead, zinc, copper, manganese and cadmium found in both surface

and ground water meet with the standard of water quality established by the Department of Health, Thailand.

VI. Discussion

The findings of this research paper suggested the reason for the majority consumption based on water supply of household families in eco- tourism villages of Suan Luan Sub- District Municipality, Amphawa District, Samut Songkram Province. The location of the province connects with the sea, resulting in high amount of estuarine water which cannot be consumed. The sources of consumption water therefore come from surface and ground water brought into the purification process prior to household consumption. The assessment of degree of heavy metal contamination was found not exceeding water quality criteria indicated by Department of Health, which can ensure safety consumption for both local communities and tourism activities.

Acknowledgment

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References

[1] Paiboon Jeamponk, "The household behaviour on solid waste and wastewater Management in municipal area with cleanliness policy determined by community," Bangkok, Suan Sunandha Rajabhat University, 2011.
[2] Office of Water Management, "Manual on surface quality control," Bangkok, Department of Water Resources, Ministry of Natural Resources and Environment, 2004.
[3] Department of Water Resources, "Manual on water management, operation and maintenance of rural water supply," Bangkok, 2007.
[4] Department of Health, "Announcement of MOPH on quality criteria of drinking water," Ministry of Public Health, 2010 (copy).
[5] Sivapan Choo-in, "Quality of water in Ampawa Canal, Ampawa Floating Market, Samut Songkram Province," Bangkok, Suan Sunandha Rajabhat University, 2010.