博士論文（要約）

Assessment of Fluoride Intake from Groundwater and Intake Reduction from Delivering Bottled Water in Chiang Mai Province, Thailand

（タイ王国チェンマイ県における地下水からのフッ素摂取量及びボトル水供給による摂取削減量の評価）

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Fluoride intake from tap water supplied by fluoride-containing groundwater has been the primary cause of fluorosis among the residents of Buak Khang Subdistrict, Chiang Mai Province, Thailand. Furthermore, the people in Thailand generally soak sticky rice in tap water for 12–24 hours before steaming and rinse jasmine rice before cooking. To reduce fluoride intake, bottled water treated using reverse-osmosis membranes has been made available by community-owned water treatment plants. The overall objective of this study was to assess whether delivering RO-treated bottled water at an affordable price effectively reduces fluoride intake. The intention was to evaluate the fluoride intake form the different sources of water activities, namely, drinking cooking and rice soaking water. Specific objectives were targeted to:

I. Assess the fluoride intake from drinking and cooking water consumption. We also aimed to identify the drinking, cooking currently used by residents in the Buak Khang Subdistrict of San Kamphaeng District, Chiang Mai Province, in order to estimate the daily consumption of drinking water (L/capita/day) and cooking water (L/household/day), and to identify the factors such as age, sex and body weight affecting water consumption. To obtain accurate volumes of water consumption, bottles filled with RO-treated water were delivered to participating households; the volume of drinking water consumed by each member of the household and the volume of cooking water consumed by the household were recorded on weekdays and weekends. We also recorded each household's selection of drinking and cooking water sources, the fluoride concentrations of those water sources, and each household member's physical attributes in order to estimate how much each subject's fluoride intake was reduced by the delivery of RO-treated bottled water and to identify the vulnerable population groups who drink more water than others. A water consumption survey was also conducted at the local junior high school to estimate water consumption during school hours.

II. Determine the fluoride intake from jasmine rice and sticky rice consumption; thus, the amount of rice consumption (kg/meal) was directly measured. The processes for cooking jasmine and sticky rice were observed in the field survey in order to identify which process that fluoride can adsorbed on the rice. The cooked and uncooked of jasmine and sticky rice were collected for fluoride content analysis. The factors affecting fluoride adsorption on jasmine and sticky rice, namely: fluoride concentration in water, a time duration for soaking, temperature for soaking, and the ratio of water volume and rice for cooking and soaking were varied in laboratory experiment to identify the amount of fluoride adsorbed on rice and to estimate the possible fluoride intake from rice consumption based on the assumed cooking and soaking condition.

III. In order to verify by comparing those results in this study with those in the official reports that published by the local health agencies, namely, Chiang Mai Provincial Public Health and Intercountry Centre for Oral Health (ICOH)-Chiang Mai, Thailand. The previous data, namely, the level of fluoride in water and the reports of fluoride risk as dental fluorosis was necessary to

review in order to understanding the exists problems and the possible health risk based on previous recorded data. To assess the possible risk based on fluoride intake

Water consumption surveys were conducted by providing bottled water to 183 individuals from 35 randomly selected households and recording the amount of water consumed for drinking and cooking. The mean drinking water consumption was 1.62–1.88 L/capita/day and the cooking water consumption on weekends (5.06 ± 3.04 L/household/day) was higher than that on weekdays (3.80 ± 1.90 L/household/day). The per capita drinking water consumption exhibited a positive correlation with body weight; however, the low-weight subjects consumed more drinking water per kilogram of body weight than the heavy subjects. Although sex and day of the week did not significantly affect drinking water consumption per capita, drinking water consumption per kilogram of body weight was significantly higher among women, children, and the elderly because these groups generally have low body weights. The fluoride intake from using tap water for drinking and cooking was estimated to be 0.18 ± 0.10 mg/kg-body weight/day and 5.55 ± 3.52 mg/capita/day, respectively, and using bottled water for drinking and cooking reduced the fluoride intake to 0.002 ± 0.002 mg/kg-body weight/day and 0.07 ± 0.05 mg/capita/day, respectively (Chapter4, specific objective 1).

65.7% of 35 households still use tap water containing fluoride at 5.94 ± 0.29 mg/L of fluoride for rice soaking and rinsing. The amount of jasmine rice and sticky rice consumption was 0.166 ± 0.09 kg/meal and 0.212 ± 0.10 kg/meal, respectively. The fluoride adsorbed on rice exhibited a positive correlation with the initial fluoride in water, the duration and water volume for rice soaking. The fluoride intake from jasmine rice and sticky rice based on the field survey was 0.005 ± 0.011 mg/kg-body weight/day and 0.047 ± 0.046 mg/kg-body weight/day, respectively. The results of this study indicated that eating rice can significantly contribute to the total amount of fluoride intake; thus, it is recommended to use fluoride-free water or reducing time duration for rice soaking in areas using fluoride-containing groundwaters. Thus, bottled water delivery services could be used to mitigate fluoride intake in developing countries (Chapter5, specific objective 2).

Following the previous report by Chiang Mai Provincial Public Health in 2000, 84.2% of the areas in Chiang Mai Province had fluoride concentration in water less than 0.7 mg/L. However, 117 areas (8.67% of the total areas) including 49 areas from San Kamphaeng District still had high fluoride concentration in water (> 1.5 mg/L). The study area in this research was Buak Khang Subdistrict, San Kamphaeng district. The fluoride level in tap water from the village water treatment plant under the responsibility of G1 was 5.94 ± 0.29 mg/L (n=32). However, the fluoride concentration in tap water was slightly lower at 3.67 ± 0.04 mg/L (n=2) in 2008, possibly due to the small number of samples. Besides, 1,432 subjects in age 12 and 15 years were investigated the dental fluorosis level. The fluorosis levels were divided into 6 levels. The results show that 80.9% of subjects have normal teeth.

However, 2.02% out of 20.1% of subjects suffer from severe dental fluorosis. In this study, the hazard index (HI) is presented as the indicator in order to estimate fluoride health risk. if the tap water was selected as the water source for all water activities, the HI was greater than 1 (HI = 5.12 ± 0.26). However, the HI value of drinking water and cooking water consumption is greater than that from jasmine rice and sticky rice consumption. The possible way to mitigate the fluoride risk as fluorosis occurring is to use bottled water as low fluoride-containing water for the main water source, namely, drinking water and cooking water and/or for all water activities. Besides, the water-to-rice ratio and the time duration should be reduced during rice soaking especially for the area or country where people consume sticky rice as the staple food (Chapter6, specific objective 3).