CHAPTER FIVE
CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

This chapter presents (1) a summary of the study, (2) a summary of the findings, (3) discussion of the results, (4) conclusions, and (5) recommendations for further research.

5.1   SUMMARY OF THE STUDY

This study is experimental research which aimed to improve the quality of drinking water served to school students and to raise the awareness about protecting students from waterborne illness by providing knowledge of sanitary conditions of the water supply and good sanitation practices for improving water quality to school authorities.

5.1.1   Objective of the Study

The main objective of the study was to assess the quality of drinking water for school students after providing knowledge of sanitary conditions to the school administrators. The sub-objectives were to examine the contamination of sanitary indicators and waterborne pathogens in the drinking water and to evaluate the sanitary conditions of water supplies in schools along with the quality of drinking water.

5.1.2   Subjects, Materials, and Procedures

The subject in the study was the drinking water provided at governmental and private schools located in Bangkok, Nonthaburi and Patumthani provinces. The research instruments were the materials for collecting drinking water samples, i.e. a checklist for inspection of the sanitary conditions of water supplies, the laboratory equipment and materials, the culture media and chemicals for sample analysis, the publications and a compact disc for providing knowledge of sanitary conditions and a simple test kit for self-examination of Coliforms in drinking water.

The procedure of the study consisted of three stages, based on a one-group pretest-posttest design, which includes a pretest, an intervention and a posttest. In the pretest, drinking water samples were collected from ten targeted schools and analysed to determine the contamination of indicator microbes and waterborne pathogens. The intervention was done with school administrators or/and staff of the targeted schools by providing them the knowledge of sanitary conditions of the water supply and good sanitation practices for improving the drinking water quality. The published materials, and a compact disc (CD) of such knowledge were given to the schools along with discussions between the researcher and the school administrators or responsible staff. The posttest was conducted by using the same procedures as the pretest. The analytical results were presented as percentage of the frequency of bacteria in drinking water and as a mean value ($\overline{X}$) for the extent of Coliform contamination. Chi square (χ^2) test was used for determining the association between the two the sample groups with qualitative data.

5.2   SUMMARY OF THE FINDINGS

The results of the study can be summarized as follows:

5.2.1   Drinking Water Quality Before and After Intervention

As a whole, the drinking water samples contaminated with bacteria decreased from 16.4% to 10.8% after providing knowledge of sanitation to the school officials. The posttest samples collected from governmental schools showed higher contamination than the pretest samples (15.8% and 7.1%, respectively) whereas the samples from private schools showed the opposite result: i.e. the reduction of contamination from 19.2%. to 8.7%. The bacterial contamination in water samples before and after the intervention was significantly different ($p < 0.05$) and the bacterial contamination in water samples taken from governmental and private schools was significantly different ($p < 0.05$) as well.

Among the governmental schools, only the water samples from Wat Saima Community school contained waterborne pathogens. Two out of three private schools displayed positive Coliforms samples both before and after the intervention.

5.2.2 Concentration of Coliforms Contaminated in Drinking Water

The mean values ($\overline{X}$) of Coliform contamination in drinking water taken from all school, except Kanaratbamrung Pathumthani school, were lower than the standard limit of the Ministry of Public Health that is defined as less than 2.2 (Table 2).

5.2.3 Sanitary Conditions of Water Supply in Schools

According to the results of inspection of sanitary conditions of the water supply using a checklist, out of 10 targeted schools, five schools displays low quality water samples after the intervention; three of these were governmental schools, i.e. Wat saima Community, Sainoi, and Kanaratbamrung Pathumthani, and two were private schools, i.e. Rajinibon and Srisangwal. Tap water was the water source in all of these schools. The water cooler tanks were utilized as drinking water dispensers for six of a total of seven poor quality samples whereas the remainder were multiple-faucet basin. The areas surrounding the dispensers looked dirty as indicated by the presence of trash, rubbish and an unclean floor. All dispensers were connected with water filters that had been used for different periods. In all schools, the cleaning of water dispensers was carried out by school staff .

5.3 DISCUSSION

This section concerns the discussion of this study regarding bacterial contamination in drinking water for school students after providing knowledge of sanitary conditions of the water supply and good sanitation practices for improving water quality to the school authorities.

5.3.1 Drinking Water Quality After Intervention

As expected, the overall bacterial contamination in drinking water samples taken from the ten targeted schools significantly decreased (from 16.4% to 10.8%) after providing knowledge of sanitary conditions to the school administrators (Table 4). According to information obtained from direct inquiry, the lower prevalence of bacteria in drinking water might have resulted from improvement of the

sanitary conditions of the water supply equipment in schools, including cleaning the water cooler tanks (used as water storage containers dispensing drinking water) and checking the effectiveness of water filters which was carried out after the schools had received the analytical report of the pretest examination. The school administrators were concerned about drinking water samples that did not meet the standards of the Ministry of Public Health; thus prevention of the incidence of waterborne pathogens in drinking water was required. A study carried out by the Department of Health (กรม อนามัย, กองสุขาภิบาลอาหารและน้ำ, 2548) offered similar results to this study. That is after raising awareness about the importance of clean and safe water for children in day care centers and schools in Pitsanulok province, the drinking water quality was 25.0% better than before setting up the drinking water monitoring system. In general, water cooler tanks must be cleaned regularly to ensure that water stored in the tank does not become contaminated by bacteria that the tank previously held (WHO, 2005). The frequency of cleaning depends on type of water source, amount of water consumed, and other factors. Furthermore, the water filter used to remove impurities and/or microorganisms in the water must be also examined and cleaned regularly according to the manufacturer's instructions to prevent it from being clogged with excessive impurities that minimize the filtration capability. A study carried out to apply proper procedures for treatment of drinking water in Tanzania revealed that a sand filter with good maintenance was effective for removal of harmful bacteria from turbid, contaminated drinking water (Pumphrey, Divelbiss, & Oerther, 2006). Also, Levesque, et. al, 1994, compared the microbiological quality of water coolers and municipal tap water and found that even if they could not specify the main factors influencing microbial contamination in water coolers, they were able to infer by their findings that regular cleaning of water coolers as recommended potentially limits contamination.

After the intervention, three out of the seven governmental schools still exhibited the presence of Coliforms (Table 4). As for the private schools, two schools showed the presence of Coliforms but no waterborne pathogens. The presence of Coliforms, which is a sanitary indicator group, indicated poor sanitary conditions of the water supply system and inadequate sanitation practices in

controlling water quality in schools. Contamination by Coliforms in the water samples might be related to the following problems.

- Inefficient water filters
- Poor hygienic conditions of water storage containers or water dispensers (water cooler tanks and multiple-faucet basins) and/or the attached faucets
- Ignorance and negligence about maintenance of drinking water quality and water facilities by the authorities
- Lack of budget and available time for improving the water quality
- Hygienic conditions of the area surrounding the water dispenser
- Leakage of water cooler tank or damaged water filters

To prevent contamination of Coliforms, the above problems must be identified and resolved. Accordingly, upon delivery of the posttest analytical results to the schools, the results and recommendations for improving water quality were submitted. After this study, further activity was planned by the researcher in order to support those schools showing positive contamination in the drinking water. They can submit drinking water samples to the laboratory of the Department of Medical Sciences for microbiological examination if they have set up corrective action plans for improving drinking water quality in their schools.

Of the ten targeted schools, only drinking water samples taken from Wat Saima Community school after the intervention displayed contamination by *C. perfringens* (Table 4). Much concern was focused on the incidence of *C. perfringens* since it is a waterborne pathogen persisting in an aquatic environment which can be transmitted through drinking water to consumers leading to diarrheal disease. Normally, diarrhea-causing strains of *C. perfringens* exist in soil, water, and dust; therefore, it can be easily distributed into an exposed environment and transmitted to water storage containers (WHO, 2006). Water cooler tanks and water filters, that are not regularly cleaned can also be contaminated with this bacterium.

The existence of Salmonellae in a pretest water sample taken from Wat Saima Community school was of much concern as well because Salmonellae can cause severe diseases. Advice for preventing contamination in drinking water was

provided to school authorities during the intervention. It was found that Salmonellae was not detected again in the posttest samples.

5.3.2 Concentration of Coliforms in Drinking Water

The existence of Coliforms in drinking water samples indicates poor sanitary conditions of the water supply system in schools, but the average concentration displayed as the mean value ($\overline{X}$) both before and after intervention (Table 5) did not exceed the standard regulations as prescribed by the Ministry of Public Health (Table 2). It could be concluded that on account of the high frequency of Coliforms negative samples, low mean values of average Coliform counts were obtained. Of all drinking water taken from the targeted schools, only one sample from Kanaratbumrung Pathumthani school offered a higher mean value than the standard limit. These results reveal that drinking water in almost all the targeted schools was relatively clean or in good hygienic condition.

5.3.3 Sanitary Conditions of Water Supplies in Schools with Low Quality Samples

Coliforms (which are a commonly-used bacterial indicator of sanitary condition) were detected in drinking water samples taken from five of the ten targeted schools (Table 4). Any portion of the water supply system in a school, starting from the water source to the dispensing of drinking water through faucets for consumption can be contaminated with Coliforms (WHO, 2006). Moreover, the risk of having contamination problems depends on how good the sanitary conditions of the water supply is, how well the drinking water facilities (water storage container or water dispenser) are maintained and where they are located. The checklist used for inspecting sanitary conditions in this study includes the variables affecting drinking water quality, e.g. status of the water filters, the cleaning of the water cooler tank (Appendix A). According to the results of inspecting the sanitary conditions (Table 6-10), poor quality drinking water samples from all schools were dispensed from faucets of water cooler tanks and multiple-faucet basins, all of which were located in dirty surrounding areas (indicated by trash, rubbish and an unclean floor). Thus, contamination could occur by dust-attaching bacteria proliferating in the

surrounding areas. Even if all the positive schools had responsible staff for regular cleaning of the water tanks, negligence could allow accumulated impurities to become unintended habitats for various variable microorganisms. In addition, leaking pipes, joints or valves of the water tanks and other facilities could be a source of contamination as well. During submission of the posttest results, the school administrators were requested to improve sanitary conditions of the positive water dispensing points based on good sanitation practices to minimize contamination and were given the Water Safety Plan set by WHO (2006) as follows.

- Development of an understanding of the specific system and its capability to supply water that meets health-based targets;

- Identification of potential sources of contamination and how they can be Controlled;

- Validation of control measures employed to control hazards;

- Implementation of a system for monitoring the control measures within the water system;

- Timely corrective actions to ensure that safe water is consistently supplied; and

- Undertaking verification of drinking water quality to ensure correct implementation which is required to meet relevant water quality standards.

Additional research in other parts of the country done by fourteen Medical Sciences Centers obtained similar results with higher bacterial contamination found because of variable water sources in rural areas, e.g. underground water, well water and rainwater, all of which are exposed to bacterial contamination. Corrective actions were also recommended to those schools having low quality drinking water by cooperation with local authorities such as health officers or local interior authorities ("ปัญหา "น้ำดื่ม"," 2550).

5.4   CONCLUSION

The following conclusions can be drawn from the discussion above.

5.4.1   The overall bacterial contamination in the drinking water samples taken from ten targeted schools significantly decreased after providing knowledge of sanitary conditions to the school administrators.

5.4.2   For preventing contamination of bacteria, the possible causative problems must be identified and resolved. Upon delivery of the posttest analytical results to school administrators, the results and recommendations for improving water quality were provided.

5.4.3   Much concern was focused on the incidence of *C. perfringens* and Salmonellae in drinking water samples since they can cause diarrheal disease.

5.4.4   Most of the average concentrations of Coliforms displayed as the mean value $(\overline{X})$ both before and after the intervention did not exceed the standard regulations as prescribed by the Ministry of Public Health.

5.4.5   Because of the low extent of Coliforms in the drinking water samples, it can be concluded that drinking water in most of the targeted schools is relatively clean or in good hygienic condition.

5.4.6   Any portion of the water supply system in a school, from the water source to the dispensing of drinking water through faucets for consumption can be a source of contamination; thus prevention of contamination is required.

5.4.7   The school administrators were requested to improve the sanitary conditions of the positive water dispensing points based on good sanitation practices.

5.5   RECOMMENDATIONS FOR FURTHER RESEARCH

Based on the findings and conclusions of this study, the following recommendations are made for future research.

5.5.1   Other researchers should repeat this method of study in other schools to evaluate the procedure by comparing the results with this study.

5.5.2   Additional schools should be included in further studies to extend the number of schools supplying safe drinking water to students.

5.5.3 Corrective action plans and activities to improve drinking water quality in schools having bacterial contamination problems should be further studied and conducted by utilizing technical operations.