Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 22 | No. 4 | pp. 2273-2278 | 2023

Original Research Paper

https://doi.org/10.46488/NEPT.2023.v22i04.056

Open Access Journal

Microbiological Quality of Drinking Water and Food in a Rural Community

Y. Rapeepan*†, P. Piyabhorn, P. Phatcharaporn* and S. Theethawat****

*Faculty of Public Health, Kasetsart University Chalermphrakiat Sakon Nakhon Campus, 59/7 Chiangkrua, Mueang Sakon Nakhon District, Sakon Nakhon, 47000, Thailand

**Faculty of Science, Udon Thani Rajabhat University, Udon Thani, 41000, Thailand

†Corresponding author: Y. Rapeepan; rapeepan.y@ku.th

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 27-04-2023
Revised: 14-06-2023
Accepted: 16-06-2023

Key Words:
Drinking water
Food
Microbiological quality
Rural community

ABSTRACT

Safe water and food are essential for good human health. The contamination of water with infected fecal bacteria is common in areas with poor standards of hygiene and sanitation. This study investigated total coliform bacteria, fecal coliform bacteria, and *E.coli* in drinking water and food stalls using water from a rural community, where the rural living conditions increase the risk of water-related diseases. In total, 40 samples of bottled drinking water, 50 water samples from vending machines, 30 samples of household drinking water, 30 food samples were collected from household food, and 60 food samples were collected from food stalls, and coliform bacteria contamination was determined using the most probable number (MPN) technique. The results revealed that all the water and food samples contained coliform bacteria contamination, while all the water samples and 50% of the food samples contained fecal coliform bacteria. The numbers of household food samples contaminated with coliform bacteria and *E.coli* were 29 (97%) and 12 (40%), respectively. Entrepreneurs should be regularly maintaining clean drinking water vending machines. The government sector should be urgently solving the problem of drinking water standards to ensure suitable consumer safety.

INTRODUCTION

Drinking water quality and food quality are two important factors affecting human health. The human body needs sufficient nutrients to grow and help develop and repair worn parts to keep them in perfect condition and remain strong. Consequently, the human consumption of water and food that are clean and safe must be a priority as well. If water and food become contaminated by dirt, this may cause foodborne diseases. Common symptoms of foodborne diseases include diarrhea, nausea, abdominal cramps, headache, dizziness, and fever (DDC 2020). Centers for Disease Control and Prevention (CDC 2020) indicate that each year, foodborne diseases cause about 48 million cases of illness, with 128,000 requiring hospitalization and 3,000 deaths. The annual incidence levels of foodborne or waterborne diseases in Thailand, such as diarrhea, food poisoning, dysentery, cholera, and typhoid fever or typhus, were 271, 933, 25, 640, 679, 1 and 153 cases, respectively (DDC 2020). In addition, in the 2020 Annual Report, Health Area 8 reported the sickness rate in Sakon Nakhon province, where diarrhea was identified as the disease most requiring monitoring with a morbidity rate of 569.33 per 100,000 population, followed by pneumonia, pneumonitis, dengue fever, influenza, and food poisoning with morbidity rates of 131.63, 96.07, 78.83 and 49.96, respectively, per 100,000 population (Office of Health District 2020). Foodborne illness occurs when people eat or drink beverages contaminated with bacteria and their toxins, parasites, viruses, chemicals, or other agents. The symptoms include severe stomach cramps, diarrhea, fever, nausea, and vomiting (Administration FDA 2020). Foodborne disease reported all over the world has confirmed the fact that many foodborne disease outbreaks result from improper food handling, such as the use of leftover ingredients, improper food storage, and poor personal hygiene (Campos et al. 2009, FAO 2013, Hejar et al. 2011, Ryu et al. 2011).

Thailand's hot weather alternating with rain compounds the problems of contamination, as these climatic conditions are suitable for the growth of many pathogens, especially for diseases caused by food and water. This has been compounded by the coronavirus 2019 epidemic (COVID-19), as most people are restricted to their homes to reduce the spread and infection. Therefore, many people are preparing their food, which can cause sickness from food and water-borne diseases if not made properly, use unhygienic conditions, or involve undercooked or unheated food or easily spoiled food. Therefore, morbidity due to diarrhea

caused by unsafe food and water consumption requires much attention and surveillance. Consequently, this study investigated the biological quality of food and drinking water samples to develop guidelines to prevent poor food and drinking water consumption as basic data for government sectors to control and monitor the food and drinking water quality.

MATERIALS AND METHODS

In total, 40 water samples were collected from bottled drinking water, 50 water samples were collected from vending machines, 30 water samples from households, 30 food samples from households, and 60 food samples were collected from food stalls, using a standard method (APHA 2017) and examined for total coliform bacteria and fecal coliform bacteria using the most probable number (MPN) method and *Escherichia coli* using the streak plate method.

Drinking Water Analysis

The drinking water samples were analyzed in the laboratory for total coliform bacteria, and fecal coliform bacteria were determined with the MPN method. All parameters were determined according to the standard methods for examining water and wastewater, 23rd edition (APHA 2017).

Food Analysis

All food samples were detected for the presence of total coliform bacteria was carried out using a rapid test kit (SI-2) and *Escherichia coli* (*E. coli*) using the MPN method according to the standard methods and streak plate method according to the Clinical Microbiology Procedures Handbook, 4th Edition (Leber 2020).

RESULTS

Drinking Water Quality

Household drinking water quality: The 30 household drinking water samples used to analyze the biological drinking water quality had levels of total coliform bacteria (TCB) and fecal coliform bacteria (FCB), as presented in Table 1.

Analysis of the biological quality of the drinking water from households showed that all household drinking water samples contained TCB, and half were contaminated with FCB. The drinking water quality analysis indicated the samples did not meet the standards with the World Health Organization value, which requires that no TCB and FCB be detected in drinking water.

Bottled drinking water quality: Forty samples were taken from bottled drinking water sold in shops and analyzed for TCB and FCB in the laboratory. The results are shown in Table 2.

The results of the microbiological analysis show that the bottled drinking water quality was very poor, as all samples

Table 1: Biological characteristics based on total coliform bacteria (TCB) and fecal coliform bacteria (FCB) of drinking water quality from household drinking water (N = 30).

Drinking water sample	TCB [MPN.100 mL^{-1}]	FCB [MPN.100 mL^{-1}]	Drinking water sample	TCB [MPN.100 mL^{-1}]	FCB [MPN.100 mL^{-1}]
1	≥ 2,400	2.87	16	< **2.2**	0
2	7.17	0	17	< **2.2**	0
3	< **2.2**	< **2.2**	18	< **2.2**	0
4	< **2.2**	0	19	< **2.2**	< **2.2**
5	< **2.2**	< **2.2**	20	5.20	< **2.2**
6	≥ 2,400	3.43	21	< **2.2**	< **2.2**
7	< **2.2**	< **2.2**	22	4.26	< **2.2**
8	< **2.2**	0	23	< **2.2**	0
9	2.77	< **2.2**	24	< **2.2**	< **2.2**
10	< **2.2**	< **2.2**	25	< **2.2**	0
11	< **2.2**	0	26	< **2.2**	0
12	2.72	< **2.2**	27	≥ 2,400	4.26
13	4.35	< **2.2**	28	< **2.2**	0
14	< **2.2**	0	29	< **2.2**	0
15	< **2.2**	0	30	< **2.2**	0

MPN = most probable number; Drinking water quality with the World Health Organization was established for TCB and FCB to be undetected (WHO 2017).

This publication is licensed under a Creative Commons Attribution 4.0 International License

had total coliform bacteria and fecal coliform bacteria that exceeded the standard (In drinking water, TCB and FCB must not be found).

The results of the microbiological analysis show that the bottled drinking water was very poor, as all samples had total coliform and fecal coliform bacteria that exceeded the WHO standard value.

Drinking water vending machines: In the laboratory, 50 water samples were taken from Drinking water vending and analyzed for TCB and FCB. The results are shown in Table 3.

Out of 50 samples tested from drinking water vending machines. The results were reported of all drinking water vending machine samples containing TCB and FCB. Indicated that it exceeded the standard for drinking water with the World Health Organization value, which requires that no TCB and FCB be detected in drinking water.

Biological Characteristics of Food Quality

Household food: Coliform bacteria were detected using a rapid test kit (SI-2), and *E. coli* using streak plates of 30 household food samples. The results are shown in Table 4. Coliform bacteria were detected in 29 (97%) of the samples of household food, and 12 (40%) of the samples were contaminated with *Escherichia coli*. Of all the food samples analyzed, only one passed the standard (3%), and 29 (97%) did not meet the standard.

Food stall: Sixty food samples were taken from the food stall, and the detection of *E. coli* in the laboratory by using streak plates. The results are shown in Table 5.

The results of the *Escherichia coli* analysis show that the quality of the food stall was very poor, 40 (66.67 %) samples had levels of *E. coli* that exceeded the standard, and 20 (33.33 %) did not meet the standard with the Ministry of Public Health guideline value indicated of food uncleanness caused by unsanitary sanitation of food stalls.

DISCUSSION

Contamination of drinking water by TCB and FCB is an important hazard indicator. Bacteria may contaminate the soil, water influenced by surface water, and human or animal waste (Yongyod 2018). The World Health Organization has stipulated that such bacteria must never be detected in drinking water. Contaminated drinking water and poor

Table 2: Biological characteristics based on total coliform bacteria (TCB) and fecal coliform bacteria (FCB) of drinking water quality from bottled drinking water (N = 40)

Drinking water sample	TCB [MPN.100 mL^{-1}]	FCB [MPN.100 mL^{-1}]	Drinking water sample	TCB [MPN.100 mL^{-1}]	FCB [MPN.100 mL^{-1}]
1	**< 2.2**	**< 2.2**	21	**41**	**4**
2	**6**	**< 2.2**	22	**17**	**3**
3	**8**	**4**	23	**12**	**4**
4	**3**	**< 2.2**	24	**9**	**< 2.2**
5	**3**	**< 2.2**	25	25	6
6	**4**	**< 2.2**	26	**28**	**27**
7	**68**	**< 2.2**	27	**36**	**16**
8	9	3	28	**≥ 2,400**	**≥ 2,400**
9	**< 2.2**	**< 2.2**	29	**6**	**4**
10	**8**	**6**	30	**6**	**4**
11	**< 2.2**	**< 2.2**	31	**19**	**12**
12	**< 2.2**	**< 2.2**	32	**4**	**< 2.2**
13	**3**	**3**	33	**≥ 2,400**	**≥ 2,400**
14	**16**	**10**	34	**107**	**107**
15	**3**	**3**	35	**≥ 2,400**	**8**
16	**≥ 2,400**	**< 2.2**	36	**23**	**8**
17	**≥ 2,400**	**71**	37	**≥ 2,400**	**18**
18	**18**	**3**	38	**≥ 2,400**	**≥ 2,400**
19	**3**	**< 2.2**	39	**4**	**< 2.2**
20	**< 2.2**	**< 2.2**	40	**≥ 2,400**	**≥ 2,400**

This publication is licensed under a Creative Commons Attribution 4.0 International License

Table 3: Biological characteristics based on total coliform bacteria (TCB) and fecal coliform bacteria (FCB) of drinking water vending machines (N = 50).

Drinking water sample	TCB [MPN.100 mL^{-1}]	FCB MPN.100 mL^{-1}]	Drinking water sample	TCB [MPN.100 mL^{-1}]	FCB [MPN.100 mL^{-1}]
1	**≥ 2,400**	22	26	21	7.8
2	**≥ 2,400**	4	27	**≥ 2,400**	**≥ 2,400**
3	540	**< 2.2**	28	540	217
4	4.5	**< 2.2**	29	32	15
5	21	8.2	30	**< 2.2**	**< 2.2**
6	7.8	**< 2.2**	31	**≥ 2,400**	**≥ 2,400**
7	140	**< 2.2**	32	**≥ 2,400**	**≥ 2,400**
8	3.6	**< 2.2**	33	**≥ 2,400**	350
9	**≥ 2,400**	**< 2.2**	34	4	**< 2.2**
10	17	**< 2.2**	35	**< 2.2**	**< 2.2**
11	**≥ 2,400**	3.6	36	**< 2.2**	**< 2.2**
12	540	11	37	31	**< 2.2**
13	4	**< 2.2**	38	43	**< 2.2**
14	26	23	39	7.8	**< 2.2**
15	**≥ 2,400**	13	40	70	**< 2.2**
16	920	33	41	6.1	5.6
17	5	**< 2.2**	42	**< 2.2**	**< 2.2**
18	**< 2.2**	**< 2.2**	43	**≥ 2,400**	**< 2.2**
19	5.5	3.7	44	6.1	**< 2.2**
20	**< 2.2**	**< 2.2**	45	**< 2.2**	**< 2.2**
21	**< 2.2**	**< 2.2**	46	**< 2.2**	**< 2.2**
22	**≥ 2,400**	3.7	47	**< 2.2**	**< 2.2**
23	**≥ 2,400**	14	48	**< 2.2**	**< 2.2**
24	**< 2.2**	**< 2.2**	49	**< 2.2**	**< 2.2**
25	23	7.8	50	**< 2.2**	**< 2.2**

MPN = most probable number; Drinking water quality with the WHO value for TCB and FCB to be not detected (WHO 2017).

Table 4: Detection of coliform bacteria and *E. coli* in household food samples (N=30).

Food sample number	Coliform bacteria	*E. coli*	Food sample number	Coliform bacteria	*E. coli*
1	+	+	16	+	+
2	+	-	17	+	-
3	+	+	18	+	+
4	+	-	19	+	+
5	-	-	20	+	-
6	+	-	21	+	+
7	+	-	22	+	-
8	+	-	23	+	+
9	+	-	24	+	+
10	+	-	25	+	+
11	+	-	26	+	+
12	+	-	27	+	-
13	+	-	28	+	-
14	+	-	29	+	+
15	+	-	30	+	+

The standard for food from the Ministry of Public Health (2020). + = Positive - = Negative

This publication is licensed under a Creative Commons Attribution 4.0 International License

Table 5: Detection of *E. coli* in food stall samples (N=60).

Food sample number	*E. coli*	Food sample number	*E. coli*	Food sample number	*E. coli*
1	+	21	+	41	-
2	+	22	+	42	-
3	-	23	+	43	+
4	-	24	+	44	+
5	-	25	-	45	-
6	+	26	+	46	+
7	+	27	+	47	+
8	+	28	-	48	+
9	+	29	-	49	+
10	+	30	+	50	+
11	+	31	+	51	+
12	+	32	+	52	+
13	+	33	-	53	+
14	-	34	-	54	+
15	+	35	+	55	+
16	-	36	+	56	+
17	-	37	-	57	+
18	-	38	-	58	+
19	-	39	+	59	+
20	-	40	-	60	+

The standard for food from the Ministry of Public Health (2020). + = Positive - = Negative

sanitation are linked to the transmission of contaminating bacteria. Poor quality drinking water is a significant factor affecting the health of consumers (WHO 2018). Causes of bacterial contamination in bottled drinking water may result from a drinking water factory that does not meet the standards, especially from poor production processes and poor worker hygiene, such as not wearing gloves, masks, and hats. There was no hand washing after going to the toilet before filling the water (Bereda et al. 2016, Li & Wu 2019, Phusomya & Yongyod 2022).

Additionally, bacterial contamination can occur in the home due to the incorrect storage location of drinking water bottles, such as near the toilet, garbage disposal point, on the ground, or in a corner that may be the habitat of animals, insects, diseases, germs, and bacteria. Bacterial contamination from drinking water vending machines may be due to insufficient cleaning and sanitation of the water vending machines. Low quality of membrane filtration and lack of disinfection may contribute to bacteria re-growth after water treatment (Phusomya & Yongyod 2022). High coliform bacteria present in drinking water also indicate that the water treatment system in vending machines is not being sanitized and maintained regularly (Tan et al. 2016).

Coliform bacteria and *E. coli* in household foods and food stalls can be linked to contamination resulting from inappropriate processing, incomplete heating, using contaminated water during preparation and washing, or secondary contamination due to contact with contaminated materials such as chopping boards, knives, and serving utensils. These bacteria in foods could induce potential health problems for consumers. Poor personal hygiene, improper handling and storage practices of foods, and poor knowledge of safe cooking methods are associated risk factors that must be properly managed to reduce the potential for food contamination by foodborne diseases (Bereda et al. 2016). Food safety public awareness and control measures must be continually addressed to reduce and limit *E. coli*. Proper hand washing, preventing cross-contamination while preparing food, storage of meat below 4.4°C, and using a thermometer to confirm an internal temperature of 71°C during cooking are considered necessary steps to take for preventing foodborne illnesses (Baker et al. 2016, FSIS 2011, Vogt & Dippold 2005). The potential negative effects of contamination include food poisoning, diarrhea, or, in severe cases, even death (Daud et al. 2017, Pratum & Khananthai 2017).

This publication is licensed under a Creative Commons Attribution 4.0 International License

CONCLUSION

The biological quality of drinking water in the household and in purchased bottled water indicated that the major problem in the drinking water was total coliform bacteria and fecal coliform bacteria. Household food samples and food stall samples indicated that the major contamination was coliform bacteria and *Escherichia coli*. Consequently, suitable factory and household raw materials should be utilized along with strict compliance with sanitary principles to obtain quality drinking water and food that are not harmful to human health.

The findings of this study advised that the government sectors should monitor the drinking water factories in addition to monitoring drinking water and food quality to ensure the water and food produced are of acceptable quality. The government should improve consumer knowledge about food safety, foodborne diseases, and good personal hygiene and sanitation to improve the health quality of household food.

ACKNOWLEDGEMENTS

The authors are pleased to acknowledge the Faculty of Public Health, Kasetsart University Chalermphrakiat Sakon Nakhon campus, for their support during the laboratory analysis.

REFERENCES

Administration FDA. 2020. Foodborne pathogens. Food and beverages. Food and Drug Administration, Silver Springs, MD, USA.

American Public Health Association (APHA) 2017. Standard Methods for the Examination of Water and Wastewater. 23rd ed. American Public Health Association Inc, Washington DC, The USA.

Baker, C.A., Rubinelli, P.M., Park, S.H., Carbonero, F. and Ricke, S.C. 2016. Shiga toxin-producing *Escherichia coli* in food: Incidence, ecology, and detection strategies. Food Cont., 59: 407-419.

Bereda, T.W., Emerie, Y.M., Reta, M.A. and Asfaw, H.S. 2016. Microbiological safety of street vended foods in Jigjiga City, Eastern Ethiopia. Ethiop. J. Health Sci., 26(2): 163-172.

Campos, A.K.C., Cardonha, Â.M.S., Pinheiro, L.B.G., Ferreira, N.R., de Azevedo, P.R.M. and Stamford, T.L.M. 2009. Assessment of personal hygiene and practices of food handlers in municipal public schools of Natal, Brazil. Food Contr., 20(9): 807-810.

Center for Disease Control (CDC). 2020. Foodborne Germs and Illnesses. Available at: https://www.cdc.gov/foodsafety/foodborne-germs.html (Accessed May 9, 2021).

Daud, M.K., Nafees, M., Ali, S., Rizwan, M., Bajwa, R.A., Shakoor, M.B., Arshad, M.U., Chatha, S.A.S., Deeba, F., Murad, W. and Malook, I. 2017. Drinking water quality status and contamination in Pakistan. BioMed Res. Int., 17: 651.

Department of Disease Control (DDC). 2020. Ripe, hot, clean: preventing food and water communicable diseases. Thailand. Available at: https://ddc.moph.go.th/brc/news.php?news=12792&deptcode=brc (Accessed May 14, 2021).

Food and Agriculture Organization (FAO) 2013. Foodborne disease monitoring and surveillance systems. Available at: http://www.fao.org/3/J2381E/J2381E.htm (Accessed May 30, 2021).

FSIS. 2011. Shiga toxin-producing *Escherichia coli* in certain raw beef products. Fed. Reg., 76(182): 2010-0023.

Hejar, A., NorAfiah, M., Hayati, K., Salmiah, S., Yusma, M. and Titi, R. 2011. Cleanliness of food premises in Bahau. Malay. J. Pub. Med., 11(3): 31.

Leber, A.L. 2020. Clinical microbiology procedures handbook. Fourth Edition. John Wiley & Sons, American Society of Microbiology, Washington, DC, USA.

Li, P. and Wu, J. 2019. Drinking water quality and public health. Exp. Health, 11(2): 73-79.

Ministry of Public Health. 2020. Notification of Ministry of Public Health (No 414) B.E. 2563, Issued by virtue of the Food Act B.E.2522, Re: Standards for Contaminants in Food. Ministry of Public Health, Thailand.

Office of Health District. 2020. Annual Report 2020, Office of Health District 8. Strategy and Information Group, Ministry of Public Health, Thailand.

Phusomya, P. and Yongyod, R. 2022. Application of hazard analysis and critical control points concept for rural bottled drinking water production process. Urban Water J., 19(10): 1060-1065.

Pratum, C. and Khananthai, N. 2017. Assessment of factors affecting drinking water quality from free water dispensers in the higher education institution. IJESE, 12: 787-797.

Ryu, J.H., Ko, J., Park, H., Yang, S. and Kim, H. 2011. Microbial examination of nonheated foods served in feeding programs of elementary schools, Iksan City, Jeonbuk Province, Korea. J.Food Protect., 74(9): 1564-1568.

Tan, E.Y., Arifullah, M. and Soon, J.M. 2016. Identification of *Escherichia coli* strains from water vending machines of Kelantan, Malaysia, using 16S rRNA gene sequence analysis. Exp. Health, 8: 211-216.

Vogt, R.L. and Dippold, L. 2005. *Escherichia coli* O157: H7 outbreak associated with consumption of ground beef, June-July 2002. Pub. Health Rep., 120(2): 174-178.

World Health Organization (WHO). 2017. Guidelines for Drinking Water Quality. Fourth Edition incorporating the first addendum, World Health Organization, Geneva, Switzerland.

World Health Organization (WHO) 2018. Drinking Water. World Health Organization fact sheets, Available at: https://www.who.int/en/news-room/factsheets/detail/drinking-water (Accessed June 15, 2021).

Yongyod, R. 2018. Drinking water quality and evaluation of environmental conditions of water vending machines. Asia-Pac. J. Sci. Technol., 23(1): 1-5.

This publication is licensed under a Creative Commons Attribution 4.0 International License