ความเหมาะสมของน้ำประปาและน้ำบ่อตื้นสำหรับการบริโภคของชุมชนพื้นที่ตำบลสำนักขามในเขตเศรษฐกิจพิเศษสงขลาและพื้นที่ใกล้เคียง

Water Supply and Well Water Suitability for Drinking in Communities at Sumnakkham in Songkhla Special Economic Zone and Nearby Area

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บทคัดย่อ

เขตเศรษฐกิจพิเศษสงขลาตั้งอยู่ในอำเภอสะเดา จังหวัดสงขลา เป็นพื้นที่ที่มีความสำคัญเนื่องจากเป็นพื้นที่ดึงดูดการพัฒนาเศรษฐกิจที่ขับเคลื่อนการลงทุนจากต่างประเทศชายแดนไทย-มาเลเซีย ตำบลสำนักขาม อำเภอสะเดา จังหวัดสงขลา เป็นพื้นที่จัดตั้งนิคมอุตสาหกรรมสะเดา โดยทั่วไปการดำเนินกิจการของนิคมอุตสาหกรรมอาจก่อให้เกิดมลพิษที่ส่งผลกระทบต่อคุณภาพของแหล่งน้ำในอนาคตได้ ดังนั้นจึงนำไปสู่ข้อสงสัยเกี่ยวกับคุณภาพน้ำที่ใช้บริโภคในพื้นที่ของประชาชนก่อนที่จะมีการเริ่มดำเนินการของนิคมอุตสาหกรรม ซึ่งการวิจัยนี้มีวัตถุประสงค์เพื่อประเมินความเหมาะสมของน้ำประปาและน้ำบ่อสำหรับการบริโภคของพื้นที่ตำบลสำนักขามในเขตเศรษฐกิจพิเศษสงขลาและพื้นที่ใกล้เคียงคือตำบลปริก อำเภอสะเดา จังหวัดสงขลา โดยเก็บตัวอย่างน้ำ 9 ตัวอย่าง จากบ้านพักอาศัยของประชาชน 4 หลัง สถานที่ทางศาสนา 4 แห่ง และการประปาเทศบาล 1 แห่ง ซึ่งตัวอย่างน้ำบริโภคทั้งหมดได้รับการวิเคราะห์โดยเปรียบเทียบกับเกณฑ์น้ำประปาดื่มได้ตามประกาศกรมอนามัย พ.ศ. 2553 ผลการศึกษาพบว่า ตัวอย่างน้ำส่วนใหญ่ผ่านเกณฑ์มาตรฐานทั้งหมด ยกเว้นตัวอย่างน้ำบริโภคจำนวน 3 ตัวอย่าง ที่เก็บจากก๊อกน้ำของมัสยิด 2 แห่ง และที่บ้านพักอาศัย 1 หลัง ในตำบลสำนักขาม ซึ่งตรวจพบโคลิฟอร์มแบคทีเรีย ฟีคอลโคลิฟอร์มแบคทีเรียและยังพบความเข้มข้นของเหล็ก ฟลูออไรด์ และค่าความขุ่นเกินค่ามาตรฐาน นอกจากนี้ยังพบว่า ค่าพีเอชและความเข้มข้นของเหล็กในน้ำบ่อในพื้นที่พักอาศัยอยู่ในช่วงไม่เหมาะสม ดังนั้นเพื่อปรับปรุงคุณภาพชีวิตของผู้บริโภคจึงจำเป็นต้องดำเนินการปรับปรุงและติดตามคุณภาพน้ำอย่างต่อเนื่อง เพื่อให้เกิดความมั่นใจในคุณภาพของน้ำบริโภคในชุมชน

คำสำคัญ: เขตเศรษฐกิจพิเศษสงขลา ตำบลสำนักขาม น้ำประปา น้ำบ่อ การบริโภคน้ำ

Abstract

The Songkhla Special Economic Zone located in Sadao district is an important area because it attracts foreign investment-driven economic development at the Thailand-Malaysia border. Sumnakkham subdistrict, Sadao district, Songkhla province is an established area in the Sadao Industrial Estate. As a whole, industrial estate operations may cause pollution that affects the quality of water resources in the future. Therefore, it led to doubts about the water quality consumed by people in the area prior to the start of industrial estate operations. The purpose of this study was to assess the water supply and well water suitability for drinking in Sumnakkham in Songkhla Special Economic and Prik subdistricts (nearby area). Nine water samples were collected from four residences, four religious places, and one municipality waterworks authority. All samples were analyzed in comparison to the drinking water quality criteria of the Department of Health published in 2010. Results showed that most water samples passed all standard parameters except for three water samples from two mosques and one residence at Sumnakkham subdistrict where the amounts of coliform and fecal coliform bacteria and the concentrations of iron, fluoride and turbidity exceeded the standard. In addition, the water pH and iron concentration of well water in a residential area were found to be beyond an unsuitable range. To improve the quality of life of the residents, necessary improvements and continuous monitoring must be undertaken to ensure the quality of the drinking water in these communities.

Keywords: Songkhla Special Economic Zone, Sumnakkham subdistrict, Water supply, Well water, Drinking

Introduction

The Songkhla Special Economic Zone in Sadao district is located at the Thailand - Malaysia border crossing and designated as a bilateral project area targeting a range of activities like infrastructure development, transport and logistics hub construction, and the overall facilitation of cross-border trade and investments (Anuar & Harun, 2018, p.119). Four subdistricts comprise this special economic zone, namely Sadao, Samnak Kham, Samnak Taeo and Padang Besar (Thailand Board of Investment, 2018, p.7). Moreover, Sadao Industrial Estate is being established at Sumnakkham subdistrict. Therefore, the people in Sadao district may be affected by the industrial expansion in the area, not only in terms of the residents' well-being but also the environmental changes in their communities, especially their water supply.

Drinking water quality is a global concern and has become a major environmental health problem that has a great impact on human health (Fiebelkorn *et al.*, 2012, pp. 622-623; Farhadkani *et al.*, 2014, pp. 674-675), as evidenced by frequent outbreaks and deaths in developing countries (Daud, M. K. *et al.*, 2018, p. 2). Therefore, adequate and safe drinking water is an essential basic requirement for human health. Effective water processing has significantly increased the quality and safety of drinking water in many communities. However, microbes and toxic chemicals may still contaminate the processed water as it goes through the distribution system (service lines and home devices), or during storage and handling by the consumer (Farhadkani *et al.*, 2014, pp.674-675). In addition, Sadao Industrial Estate is being established at Sumnakkham subdistrict, Sadao district, Songkhla province. Prik subdistrict is a nearby area that maybe affected by changes in the area due to pollution that occurs after the operation of the industrial estate. Pollution from industrial estate operations may occur and affect the change in water quality in the area. Such as, wastewater may contaminate groundwater sources, as well as, air pollution

that may be absorbed into the groundwater from contaminated rainwater. Therefore, it leads to observations or suspicions of the well water, supply water and drinking water in the area. Furthermore, the water quality information of this area has not been released to the public.

The main purpose of this study was to analyze the quality of water supply water, groundwater and shallow well water in Songkhla Special Economic Zone and nearby area. This will be used as a preliminary data to study the change in water quality that people consume before and after the operation of the Sadao Industrial Estate in the future.

Objective

To assess the water supply and well water suitability for drinking of Sumnakkham subdistricts in Songkhla Special Economic and Prik subdistricts.

Methodology

Sampling sites

The study was conducted in nine sample sites by purposive sampling that consisted of four residences (RE1, RE2, RE3 and RE4), one municipality waterworks authority (MWA), and four religious places - three mosques (RPM1, RPM2 and RPM3), and one house of priest (RPH1) - located in the subdistricts of Sumnakkham and Prik in Sadao district, Songkla Province, Thailand. (Figure 1)

Sampling Methods

Nine water samples were taken from tap water at each sampling site. Water collection was carried out in accordance with standard methods. All water samples were collected in sterile glass bottles and polyethylene sampling bottles for biological and chemical analysis, respectively. The samples were stored in an ice box and transported to the laboratory. This study was conducted between March-August 2019.

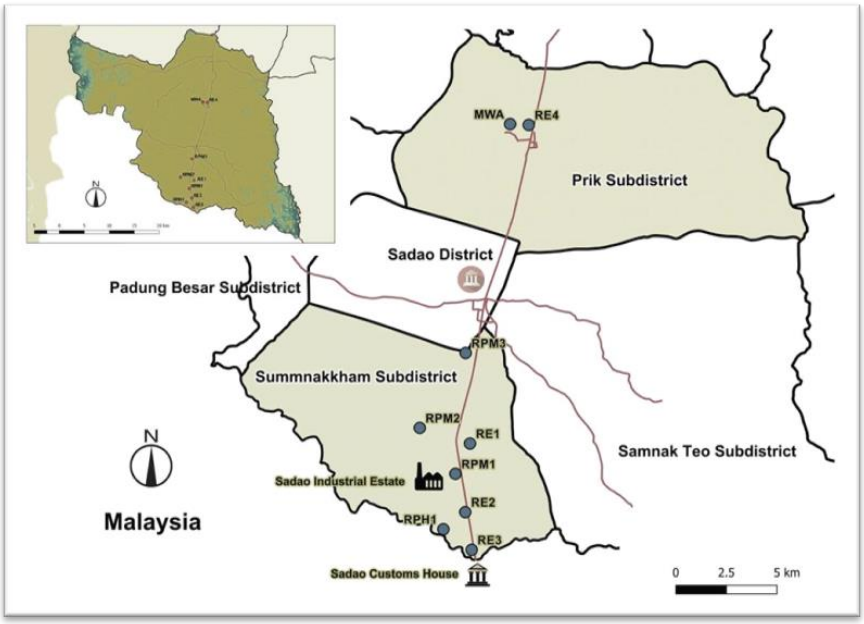

Figure 1 Location of sampling sites (RE=Residences, RPM= Religious Place (mosque), RPH = Religious Place (house of priest), MWA= Municipality Waterworks Authority and PWA = Provincial Waterworks Authority)

Analysis

All water samples were analyzed at the Laboratory Center (Department of Health, Ministry of Public Health, Nonthaburi province, Thailand) using standard methods for the examination of water and wastewater (APHA, AWWA & WEF, 2017, pp. 2-117) (Table 1). All samples were analyzed in comparison to the drinking water quality criteria of the Department of Health (2010, pp. 1-3)

Table 1 Methods utilized for water quality analysis

Parameters	Unit	Method
pH (at 25 °c)	-	Electrometric method
Color	Platinum-cobalt	Spectrophotometric-single-wavelength
Turbidity	NTU	Nephelometry
Hardness	mg/l	EDTA Titration
Total dissolved solids (TDS)	mg/l	Drying at 180 °C
Iron (Fe)	mg/l	Inductively coupled plasma (mass spectrometry) (ICP-MS)
Manganese (Mn)	mg/l	ICP-MS
Copper (Cu)	mg/l	ICP-MS
Zinc (Zn)	mg/l	ICP-MS
Lead (Pb)	mg/l	ICP-MS
Chromium (Cr)	mg/l	ICP-MS
Cadmium (Cd)	mg/l	ICP-MS
Arsenic (As)	mg/l	ICP-MS
Mercury (Hg)	mg/l	ICP-MS
Sulfate	mg/l	Ion Chromatography
Chloride	mg/l	Ion Chromatography
Nitrate (NO_3)	mg/l	Ion Chromatography
Fluoride (F)	mg/l	Ion Chromatography
Coliform bacteria	MPN/100 ml	Multiple-Tube Fermentation Technique
Fecal coliform bacteria	MPN/100 ml	Multiple-Tube Fermentation Technique

Data management

The data were analyzed and described using descriptive statistics, i.e., mean.

Results

The mean values of each water quality parameters from different sampling sites are shown in Table 2. Based on the measured values of the various parameters, only three from nine water samples passed the drinking water quality criteria of the Thai Department of Health.

Table 2 Mean values of the parameters from different sampling sites in Sadao District, Songkhla Province compared with the drinking water quality criteria[1].

Location	Sumnakkham Subdistrict							Prik Subdistrict		Drinking water quality criteria[1]
Parameters	RE1	RE2	RE3	RPM1	RPM2	RPM3	RPH1	RE4	MWA	
Water source	Water supply[2]	Groundwater	Well water	Water supply[2]		Well water	Water supply[2]	water supply[3]		
pH	7.3	6.2	4.7	7.4	7.4	6.4	7.4	7.4	7.4	6.5-8.5
Color	ND	ND	ND	ND	ND	1	ND	3	3	≤15
Turbidity	0.59	0.43	0.21	0.42	0.82	7.98	0.46	0.17	0.67	≤5
Hardness	19	14	8	20	19	19	20	33	33	≤500
TDS	39	49	54	38	53	63	44	117	149	≤1,000
Fe	0.019	ND	0.863	0.026	0.022	0.968	0.013	0.055	0.086	≤0.5
Mn	0.003	0.176	0.026	0.007	0.005	0.048	0.001	0.001	0.003	≤0.3
Cu	ND	ND	ND	0.013	ND	ND	ND	0.010	ND	≤1.0
Zn	ND	0.038	ND	0.163	ND	ND	ND	0.063	0.953	≤3.0
Pb	ND	ND	ND	ND	ND	ND	ND	ND	ND	≤0.01
Cr	0.001	ND	ND	0.001	0.001	ND	0.001	0.001	0.001	≤0.05
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	≤0.003
As	ND	ND	ND	ND	ND	0.002	ND	ND	ND	≤0.01
Hg	ND	ND	ND	ND	ND	ND	ND	ND	ND	≤0.001
Sulfate	8	1	1	8	26	9	8	22	23	≤250
Chloride	6	6	10	6	42	16	6	23	23	≤250
Nitrate as Nitrate	1.12	3.84	7.59	1.08	0.27	0.80	1.10	15.5	13.9	≤50
Fluoride	ND	ND	ND	ND	0.78	ND	ND	ND	ND	≤0.7
Coliform bacteria	<1.8	<1.8	<1.8	<1.8	<1.8	79	<1.8	<1.8	<1.8	ND
Fecal coliform bacteria	<1.8	<1.8	<1.8	<1.8	<1.8	49	<1.8	<1.8	<1.8	ND

* RE=Residences, RPM= Religious Place (mosque), RPH= Religious Place (house of priest) HO= Hospital, PS=primary school, MWA= municipality waterworks authority and PWA=Provincial Waterworks Authority

** Highlighted values mean exceed drinking water quality criteria value

*** ND=Not Detected, Coliform bacteria and fecal coliform bacteria <1.8 MPN/100 ml means that these bacteria were not found from samples.

[1] Drinking water quality criteria, Department of Health 2010

[2] Water supply from the Provincial Waterworks Authority

[3] Water supply from Municipality Waterworks Authority

At residence site 3 (RE3) in Sumnakkham Subdistrict, which uses well water, the measured pH value (4.7) was below the appropriate range for drinking water. We also found that the amounts of coliform and fecal coliform bacteria, as well as the iron concentration, in the water sample (RPM3) collected from a mosque (well water) exceeded the standard. Furthermore, the water sample from another mosque, RPM2 (water supply from the Provincial Waterworks Authority) was found to exceed the standard fluoride value (0.78 mg/l).

Discussion

Water analysis indicates that various factors affect the suitability of water for drinking, such as the water supply production, processing and distribution systems. Specifically, the sampling sites that did not pass the drinking water quality standards are as follows:

RE3 (Residential)

Sampling point RE3 is a residential area located in Sumnakkham subdistrict. The water sample was collected from a faucet that is directly connected to a shallow well and untreated. The pH value of the water sample was 4.7, which is below the standard (6.5 – 8.5) (Department of Health, 2010). The low pH of this water may be related to its geographical location. Alkaline additions to raw water sources with a low pH value must be done to adjust the pH to the appropriate range. Exposure to low pH values results in irritation to the eyes, skin, and mucous membranes, especially in sensitive individuals (WHO, 1986, pp.157-189; WHO, 2007, pp.1-2).

RPM2 (Religious Place)

RPM2 is a mosque in Sumnakkham subdistrict. In this sample, we found high fluoride concentration (0.78 mg/l) exceeding the drinking water quality standard of 0.70 mg/l (Department of Health 2010). The RPM2 water sample was collected from tap water in the mosque, which is distributed by the Provincial Waterworks Authority. Fluoride primarily affects skeletal tissues. It can also have an adverse effect on tooth enamel and may give rise to mild dental fluorosis at drinking water concentrations of 0.9-1.2 mg/l (WHO, 2004, pp. 5-6).

RPM3 (Religious Place)

Sampling point RPM3 is a shallow well located at another mosque in Sumnakkham subdistrict. The water sample, which was collected from tap water sourced from a well, is found to be contaminated with coliform and fecal coliform bacteria. This water was also not treated and used directly for consumption. The Department of Health recommends that drinking water should be free from the coliform bacteria (Department of Health, 2010, pp. 1-3). Since the water is used by the congregants to clean their bodies and gargle before praying in the mosque, the people may be exposed to microorganisms via ingestion. When coliform bacteria contamination occurred, the water might have been contaminated by disease producing bacteria or pathogens or viruses existing in fecal material. The presence of high fecal contamination was an indicator that a potential health risk exists for people (Rangsayatorn N, 2006, p.6). In addition, the iron concentration and the turbidity of RPM3 water sample were 0.968 mg/l and 7.98

NTU, respectively, which exceeded the standards (0.50 mg/l and 5 NTU, respectively). Because the sample is untreated water from a well, the high iron concentration may come from the well's surroundings and geographical location. About 2 mg/l of iron concentration in drinking water does not present a hazard to a person's health. Only the taste and appearance of drinking water will usually be affected at iron concentrations of 1–3 mg/l (WHO, 2003, pp.3-4).

Conclusion and Suggestion

Most water samples that were analyzed in this work passed all standard parameters. Three water samples sourced from wells (one residence and two mosques) contained significant amounts of coliform bacteria and fecal coliform bacteria, high iron concentration, and low pH values that exceeded the standards for drinking water. Therefore, we suggest that the water quality at these sites be urgently improved in terms of the microbiological and chemical aspects of the water. For the microbiological aspect, congregants should clean the storage tanks, household piping (distribution system) and disinfect) before consumption. Furthermore, water quality monitoring needs to be organized to improve the quality of life of the people in these communities.

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References

Anuar, A. R. & Harun, A. (2018). Malaysia-Thailand Cross Border Trade and Cross Border Special Economic Zone Potential: A Case Study of Rantau Panjang-Sungai Kolok Cross Border Town. *Journal of International Studies*, *14*, 119-139.

APHA, AWWA & WEF (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd). Washington DC.

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., Malook, I. & Zhu, S. J. (2017). Drinking Water Quality Status and Contamination in Pakistan. *BioMed Research International*,1-18. https://doi.org/10.1155/2017/7908183.

Department of Health, Thailand (2010). *Drinking Water Quality Criteria* [Online]. Retrieved May 12, 2020, from: https://www.mwa.co.th/ewt_dl_link.php?nid=33083. (in Thai)

Farhadkhani, M., Nikaeen, M., Adergani, BA., Hatamzadeh, M., Nabavi, BF. & Hassanzadeh, A. (2014). Assessment of drinking water quality from bottled water coolers. *Iranian Journal of Public Health*, *43*(5), 674-681.

Fiebelkorn, AP., Person, B., Quick, RE., Vindigni, SM., Jhung, M., Bowen, A. & Riley, PL. (2012). Systematic Review of Behavior Change Research on Point-of-use Water Treatment Interventions in Countries Categorized as Low-to medium-development on the Human Development Index. *Social Science and Medicine*, *75*(4), 622-633.

Rangsayatorn, N. (2006). Shallow groundwater quality assessment in Muang drstrict, Phayao. Naresuan University Journal, *14*(2), 1-8.

Thailand Board of Investment (2018). *A Guide to Investment in the Special Economic Development Zones (SEZ)* [Online]. Retrieved May 15, 2020, from: https://www.nesdc.go.th/ewt_dl_link.php?nid=5197.

WHO (1986). Health Impact of Acidic Deposition. *Science of the total environment* 52, 157-187.

WHO(2003).*Iron in Drinking-water Background Document for Development of WHO Guidelines for Drinking-water Quality* [Online]. Retrieved May 22, 2020, from: https://www.who.int/water_sanitation_health/dwq/chemicals/iron.pdf.

WHO (2004). *Fluoride in Drinking-water Background Document for Development of WHO Guidelines for Drinking-water Quality* [Online]. Retrieved June 12, 2020, from: https://www.who.int/water_sanitation_health/dwq/chemicals/fluoride.pdf.

WHO (2007*). pH in Drinking-water Background Document for Development of WHO guidelines for Drinking-water Quality* [Online]. Retrieved May 12,2020, from https://www.who.int/water_sanitation_health /dwq/chemicals/ph_revised_2007_clean_version.pdf.