Water Quality Analysis for Agriculture: A Case Study of Nong Khon Saen Community Area, Udon Thani, Thailand

C. Wangka-orm, S. Phitaktim, S. Wisetsri, A. Bootwong, R. Khunphonoi, and M. Wongaree*

***Abstract*—This work aims to assess the water quality in the Nong Khon Saen community area in Udon Thani for agriculture purposes and its suitability for direct use in water consumption. The sample was collected annually from January to March during the period 2019–2022. The work was undertaken to investigate two different water resources (Huai Luang River and Nong Khon Saen reservoir) for the parameters of pH, temperature, electrical conductivity (EC), dissolved oxygen (DO), and biochemical oxygen demand (BOD). The results showed that all parameters of Huai Luang River were within the acceptable limits of Type 3 surface water quality standards from the Pollution Control Department (PCD), Thailand. The average pH was 6.59±0.18 (Std. pH 5–9), temperature was 27±0.01 °C (Std. Natural), EC was 679±12.11 µS/cm (Std. None), DO was 5.39±0.63 mg/l (Std. > 4.0 mg/L), and BOD was 1.71±0.70 mg/L (BOD Std. < 2.0 mg/l). The acceptable water quality parameters were caused by general flushing of rainfall, river water flow, and runoff from agricultural fields. Moreover, the water quality of the Nong Khon Saen reservoir showed a higher BOD concentration (2.61±0.54 mg/L) beyond acceptable limits. The high concentration of BOD was caused by the water plants and the decomposition of animals in the surface water area. For other parameters, the average pH (7.11±0.42), Temperature (28±0.01 °C), EC (689.58±24.18 µS/cm) and DO (8.39±1.13 mg/L) were shown within acceptable limits. Therefore, the water quality is a requirement concerned with agricultural activities that are dependent on water resources.**

***Index Terms*—Water quality, agricultural activities, water supply, water resources, Udon Thani**

I. Introduction

Nong Khon Saen Community is located in Sam Phrao Subdistrict, Mueang District, Udon Thani Province, Thailand. The community is situated near Udon Thani Rajabhat University, which is the target area for providing academic services in environmental management. At present, most people in the community are engaged in agriculture, including rice farming, field crops, garden crops and vegetable gardens. As the community's demand for agricultural productivity increases, the demand for soil and water resources also increases and leads to problems of soil and water pollution [1, 2]. For the consumption of water resources for agricultural activities in Nong Khon Saen community, raw water is produced for use in agriculture and the water source used will be pumped from the Huai Luang River from the floodgate station to store it in the Nong Khon Saen reservoir before pumping it up into a high tank and releasing it into the agricultural plot. The Huai Luang River that flows through the Nong Khon Saen community is a Type 3 surface water source that is categorized according to the utilization of surface water sources of the Pollution Control Department (PCD) [3, 4]. It can only be used for consumption after undergoing regular disinfection and the process of improving water quality and can also be used in fisheries and agriculture as well. People in the community who are farmers still lack information and knowledge about water quality suitable for use in agriculture. As the quality of the surface water used varies from season to year, water quality is an important factor. If the water is contaminated by various pollutants, it can affect agricultural productivity [5, 6].

Currently, it is widely known that, regarding the issue of environmental problems, people have only a limited amount of unpolluted water available for their usage, including Nong Khon Saen Community. Due to Thailand's economic and technological development, the growing number of urban areas and increased population have negatively influenced the quality of water [7, 8]. Water resource quality is the one of the most serious issues that Thailand is currently facing, especially due to the concerns regarding water consumption in the future. In Udon Thani province, the irrigated agriculture cannot exist without an appropriate quality water supply. It has an impact on plants, soil, irrigation equipment, domestic use, and general farming activities [9, 10]. Moreover, water quality research was previously not a priority because there was no fear of losing the water supply; however, now it is becoming a real threat in many regions [11]. This has resulted in using lower quality and somewhat inappropriate sources of water supply for irrigation projects. Thus, water quality used for irrigation and proper irrigation management are crucial for successful agricultural production, as it affects the yield of the products [12].

Therefore, the objective of this work was to investigate the water quality for agricultural use in Nong Khon Saen community, Udon Thani province. The samples were collected and analyzed from January to March each year during the period 2019–2022, according to the standard methods. The water quality was investigated to monitor the different water resources between the Huai Luang River and the Nong Khon Saen reservoir regarding the parameters of pH, temperature, EC, DO, and BOD. The resulting data were compared to determine whether they were within the acceptable limits of Type 3 surface water quality standards from the PCD, Thailand. Additionally, the obtained data will

Manuscript received June 29, 2022; revised August 2, 2022; accepted September 5, 2022.

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doi: 10.18178/ijesd.2023.14.3.1432

be used by farmers to plan their water resource management for agricultural purposes and its suitability for direct use in water consumption.

II. Methodology

A. Study Area

Water samples were collected from the different water resources between Huai Luang River at the pumping station and a surface water reservoir in the Nong Khon Saen community. Nong Khon Saen community is located at latitude 17°27'56.6" N and longitude 102°57'12.9" E in Meuang Udon Thani District, Udon Thani province, Thailand. The location of the study is within areas of agriculture and housing drainage, as shown in Fig. 1. The Huai Luang River is vital for the life of the people in the Nong Khon Saen community, and it is the main freshwater resource for many villages, meeting nearly all the demands for consumption such as irrigation and agriculture. The route of the river starts from Huay Luang reservoir and flows past Udon Thani city until reaching the Nong Khon Saen community area. The width of the river in the pathway of the Nong Khon Saen community area is 5–10 m, and the length is 5 km with around 100 households. Nong Khon Saen reservoir is used as a storage and water reserve for the agriculture of the Nong Khon Saen community, as shown in Fig. 2. The sampling of water was varied for the different water sources. For the sampling of the Huai Luang River, the samples were randomly collected from W/2 with a depth of 1.0 m from three points, where W and D were the width (5 m) and depth (3 m) of the river, while water sampling of Nong Khon Saen reservoir was collected from one point (W/2) with a depth of 1.0 m in the middle of the reservoir. The sampling was repeated three times, then the results were averaged and evaluated.

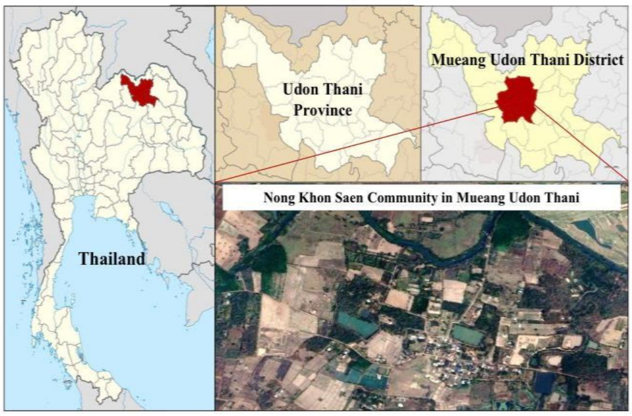

Fig. 1. Nong Khon Saen community study area.

B. Water Sampling

The water samples were analyzed using five parameters, namely pH, temperature, EC, DO, and BOD. The measurement of pH, temperature and EC was taken in the field by a multi-digital water quality meter (WQ-300 Series, Horiba), while DO and BOD were analyzed in a laboratory using the azide modification method and the 5-day BOD test 5210B [13]. Water from each sampling site was collected manually using polyethylene bottles (1L), which were cleaned with 2% HNO_3, and then rinsed with distilled water before use. All samples were analyzed by repeating them three times.

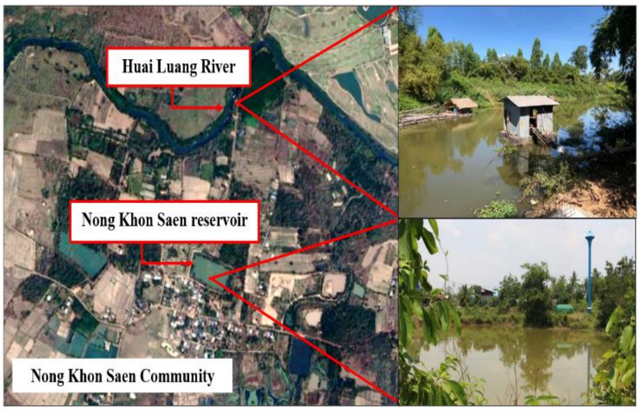

Fig. 2. Water sampling sites area.

C. Statistical Analysis

The average and standard deviation of the parameters in each study area were calculated. The results of the analysis were evaluated by statistical difference in order to evaluate the water quality analysis of the period from 2019 to 2022 (4 years). The effects of each year's changes in water quality and among the sampling sites were evaluated with one-way analysis of variance (ANOVA), processed by the SPSS program. The results of the testing were considered significant if the calculated p-values were <0.05.

III. Results and Discussion

The physico-chemical parameters were considered the important principles in the identification of the quality of the water. Means, standard deviations, and ranges of measured parameters at two sampling sites throughout four years are shown in Table I. According to the obtained results in Table I, the color, odor and taste of the water from Huai Luang River and Nong Khon Saen reservoir were within the natural criteria. The average temperature in the water of the river was 27.0±0.12 °C, while the reservoir was higher at 28.0±0.01 °C. The statistical results showed no significant difference ($p <$ 0.05) among the sites and years. All results of water temperature values corresponded to the generally natural temperature.

pH is one of the most important parameters and is frequently used as a test in water chemistry to basically monitor the quality of water [14]. Natural freshwater usually has an average pH range between 5.0–9.0 [3]. pH of the water is important because it affects the solubility and availability of nutrients which can be utilized by aquatic organisms. The pH values of the river ranged from 6.46 to 6.85 during 2019–2022, while the pH values of the reservoir ranged from 6.52 to 7.50 during 2019–2022, as shown in Fig. 3. The average pH of the river was 6.59±0.18, while the average pH from the reservoir was higher (pH 7.11±0.42). However, all samples were within the accepted limits of the surface water quality standards of Thailand (PCD) (pH 5.0–9.0) [4].

Statistical results did not show significant differences ($p < 0.05$) among the sites and years. This result indicates that the water quality is good, which might be caused by the general flushing of rainfall, river water flow, and runoff from agricultural fields.

TABLE I: WATER QUALITY ANALYSIS OF HUAI LUANG RIVER AND NONG KHON SAEN RESERVOIR

Sampling sites area	Standard	Huai Luang River					Nong Khon Saen Reservoir				
Latitude and Longitude		17°28'21.8" N 102°57'19.5" E					17°27'59.7" N 102°57'14.6" E				
Year		2019	2020	2021	2022	Average	2019	2020	2021	2022	Average
pH	5.0-9.0	6.46	6.46	6.85	6.60	6.59±0.18	7.50	6.52	7.12	7.30	7.11±0.42
Color, Taste, and Odor	natural	natural	natural	natural	natural	natural	natural	natural	natural	natural	natural
Water temperature (°C)	natural	27.0	27.0	26.9	27.1	27.0±0.12	28.0	28.2	27.8	28.0	28.0±0.01
Electrical conductivity (EC, µS/cm)	None	672	688	666	690	679±12.11	701	665	675	717	689±24.18
Dissolved oxygen (DO, mg/L)	> 4.0	5.52	5.52	4.50	6.00	5.39±0.63	9.44	7.16	8.94	8.01	8.39±1.13
Biochemical oxygen demand (BOD, g/L)	< 2.0	0.80	1.75	1.80	2.50	1.71±0.70	2.10	2.45	2.36	3.51	2.61±0.54

*The correlation is statistically significant at *p*-value < 0.05.
**Standard surface water quality of Type 3 by the Pollution Control Department (PCD), Thailand.

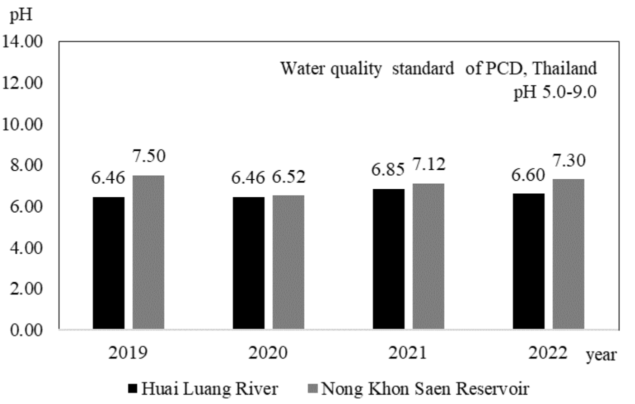

Fig. 3. pH concentrations between 2019 and 2022.

The electrical conductivity (EC) parameter is the ability of the water to conduct an electrical current and is an indirect measure of the ion concentration [14]. In this work, EC values from the river ranged from 666 to 690 µS/cm (Table I), while EC from the reservoir ranged from 665 to 717 µS/cm during 2019–2022, as illustrated in Fig. 4. Although all the sampling sites' EC were very high, the values were acceptable for the limits regarding water supply. Statistical testing of the results also showed no significant differences among sampling sites. When considering the average EC from the river and the reservoir, it was observed as 679±12.11 µS/cm and 689±24.18 µS/cm, respectively, which corresponds to the standard of water quality for agriculture. Furthermore, the suitability of EC for irrigation and agriculture was less than 700 µS/cm as specified by the Food and Agriculture Organization of the United Nations [15]. Therefore, the results indicate that the water quality is suitable for use in agricultural activities.

Dissolved oxygen (DO) is also a parameter indicative of the ability of nutrients in the water to support aquatic life. The average concentration of DO from the river was 5.39±0.63 m/L, while the reservoir was higher at 8.39±1.13 m/L. This data can be considered to be within the standard as shown in Table I. It can be observed that the average DO concentration was found over the optimum concentration of DO in water for ensuring healthy aquatic life, which is 4.0 mg/L [15]. Similar reports were found, such as research on the rivers and canals that indicated an excess DO in comparison with the standard [12, 13]. When considering the DO value during 2019–2022, the concentrations of DO from the river ranged from 4.50 to 6.00 mg/L, as illustrated in Fig. 5, while the concentrations of DO from the reservoir ranged from 7.16 to 9.44 mg/L.

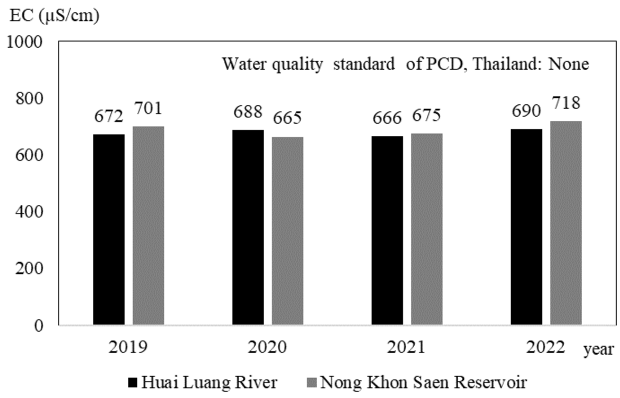

Fig. 4. EC concentrations between 2019 and 2022.

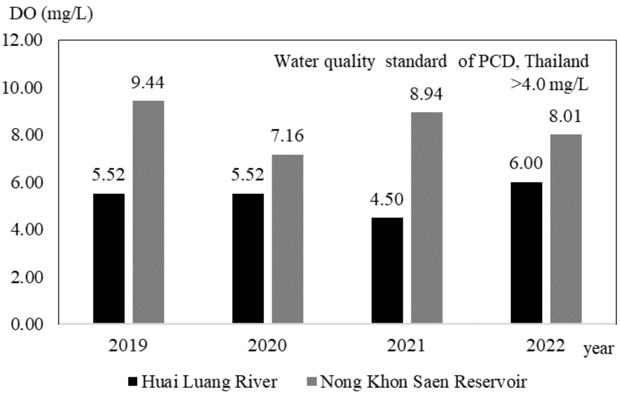

Fig. 5. DO concentrations between 2019 and 2022.

From the results, it was observed that the DO values from the river were lower than those of the reservoir. This is because weeds and plankton are found scattered throughout the water surface beside the river, which might cause poor air or oxygen flow. In addition, the process of photosynthesis or degradation of water microorganisms that occur on the water surface cause the amount of dissolved oxygen to be reduced as well. This is consistent with previous research [8, 10]. It may also be caused by the death of aquatic animals or phytoplankton, resulting in high BOD values. The low concentration of DO was observed by the moderate number of plankton and weeds scattered on the surface of the water, which is also one of the most significant pollutants. However, all samples were acceptable according to the limits of DO water quality standard of surface water quality in Thailand (PCD) (DO > 4.0 mg/L) [3]. Therefore, the preliminary water quality passed the standard for use in agriculture. Based on the statistical analysis, there was a significant difference ($p < 0.05$) among the different water resource sites and years. A similar previous report indicated that DO concentration in water from the reservoir or ponds mostly exceeded the standard [13, 15]. Thus, the obtained quality of water following the results was suitable for agriculture in the Nong Khon Saen community.

Results of water quality measurement by biological oxygen demand (BOD) have been used to determine the strength of oxygen required to stabilize domestic and agricultural use. It could be observed that the average BOD concentration was found to be within the surface water standard at 1.71 ±0.70 mg/L (BOD < 2.0 mg/L), which was within the overall BOD standard for good water quality. However, when considering the BOD value during 2019-2022, the BOD was in a range of 0.80–2.50 mg/L, as illustrated in Fig. 6. This may indicate that the results of BOD from some years were beyond the standard quality of Type 3 surface water of the PCD in Thailand. Additionally, the obtained value of BOD was similar to the previous study on the river and reservoir, which showed an excess BOD compared with the standard [15].

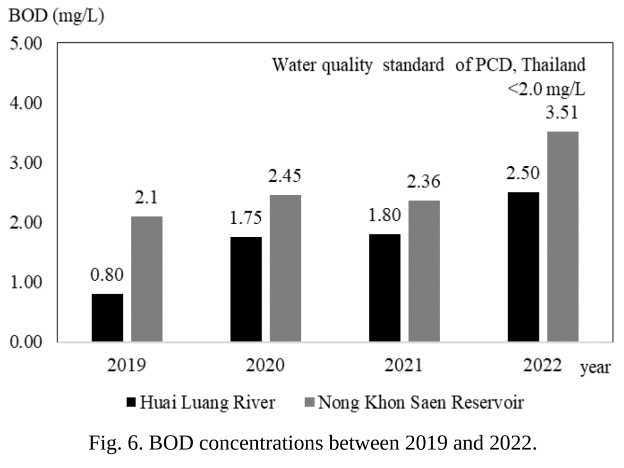

Fig. 6. BOD concentrations between 2019 and 2022.

According to the results, the water from the Huai Luang River can be used for consumption and agriculture but must be put through the process of improving water quality before use. On the other hand, a high BOD concentration indicates that the concentration of DO was decreased, with potentially dangerous implications for the biodiversity in the reservoir. Therefore, it could be concluded that increased BOD can be caused by high levels of organic pollution requiring a special water treatment process before using it for the domestic purposes based on the surface water quality standards of the PCD, Thailand. However, more data should be collected and analyzed because the obtained data in this work was sampled during only three months per year, which is representative of January to March; thus, additional water analysis results should be collected throughout the year and compared between seasons.

More obviously, the BOD concentration was observed at a higher trend compared with the years between 2019 and 2022. The highest BOD concentration (3.51 mg/L) in 2022 was observed from the Nong Khon Saen reservoir. This is an effect caused by seasonal changes and the highest domestic wastewater and sewage discharge reaching the reservoir. Domestic wastewater in the community is a significant source of water pollution in the study area. Based on the statistical analysis, there were significant differences ($p < 0.05$) among the different water resources sites and years. Additionally, when compared to the average BOD, the result of the BOD concentration (2.61 ±0.54 mg/L) was not acceptable according to the water quality standards (<2.0 mg/L) of the PCD, Thailand. To improve the quality of the water, the improvement process should be conducted before use in water conservation, fishing, and agriculture. Therefore, the obtained BOD data revealed that agricultural activities and domestic sewage discharge were the most important parameters contributing to water quality monitoring in the reservoir.

IV. Conclusions

The results of the measurement of the quality of water resources used for agriculture in the community of Nong Khon Saen, Udon Thani Province indicate that the water quality of Huai Luang River is good in terms of use for consumption and agriculture. The water of the river should be used in agriculture, which is the standard, and is not harmful to living things. In addition, the natural water source is considered to have good water quality, which is good for aquatic life and can be used for fishing and agricultural activities. Although the water quality from the Huai Luang River was acceptable for agriculture with the limitation of uses, it was considered poor in water quality for water supply and drinking purposes. Therefore, it was concluded from the results that the water quality of the river was in general suitable for irrigation and agriculture. For Nong Khon Saen reservoir, the water quality was poor to use for consumption and agriculture because of the higher BOD concentration. A high BOD concentration leads to a reduction of water quality. To improve the water quality in the reservoir, it is essential to stop the domestic waste and sewage discharge from reaching the reservoir, and this could be done by expanding the construction of treatment plants. Also, the regular monitoring of water quality is very important to detect the pollution fluxes and reduce their environmental effects. Therefore, the water quality is a requirement for agricultural activities that are limited in terms of water resources. This study provides noticeable results which can usefully applied for water resources management and planning.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

S. Phitaktim, C. Wangka-orm, and S. Wisetsri were mainly responsible for water sampling and laboratory analysis. A. Bootwong and R. Khunponoi were mainly involved with calculating and analyzing the data. M. Wongaree is the corresponding author of this paper. She was responsible for conducting the research and writing the paper. All of the authors have approved the final version.

Funding

This work was supported in part by the Department of Environmental Science, Faculty of Science, Udon Thani Rajabhat University.

Acknowledgments

The authors would like to thank the Department of Environmental Science, Faculty of Science, Udon Thani Rajabhat University for its sponsorship and financial support. We gratefully acknowledge the Department of Mechanical Engineering, Faculty of Technology, Udon Thani Rajabhat University for their support of tools and equipment. We also thank all members of the Nong Khon Saen community for their cooperation and support at the study area for collecting the samples of this work.

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