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Evaluation of Land Use Effects on Surface Water Quality in the Upper Yom River Basin, Phayao Province

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Abstract

Although water quality in Upper Yom River Basin, Part 1, has been monitored, it has not yet covered land use patterns. Therefore, this study aims to monitor and evaluate surface water quality from land use in Upper Yom River Basin, Part 1, Pong District, Phayao Province, by classifying land use in order to collect specific water samples and analyze them. Physicochemical and biological water quality found that water quality in lower Yom watershed was mostly within the water quality standards for surface water sources, with the highest TCB and FCB detected in dense residential areas. As for the rural conservation and agricultural areas along the Khuan, Ngim, and Yom rivers, TCB and FCB were detected in low amounts, but there were high levels of NO_3-, indicating the result of farmers' use of chemical fertilizers and surface runoff into natural rivers. This affects the assessment of the overall status of Upper Yom River Basin, Part 1, at the Warning level (mean score = 2.92), showing that the water quality has begun to deteriorate from its common condition, requiring monitoring of the EC, TCB index., Turbidity, FCB and PO_4^{3-} periodically and selectively to keep up to date with situations that may occur in the future.

Keywords : Upper Yom River Basin; Surface Water quality; Water resources

Introduction

The Upper Yom River Basin is 1 of 11 sub-watersheds of the Yom Watershed located in the northern region of Thailand. It has an area of 2,113 sq.km. Its topography is high mountains with narrow plains near the river. It originates from Doi Khun-Yuam in Phi-Pan-Nam mountain range, located in Pong District, Phayao Province [1]. The Upper Yom River Basin, Part 1, in addition to being a risky area due to regular flooding or drought problems, encroachment of forests for agriculture and tourist attractions has also been found. In particular, growing monoculture crops causes soil erosion in the slopes and riverbanks including the problem of chemical contamination in water sources. This is caused by the use of chemicals such as chemical fertilizers, pesticides and herbicides in agriculture and washes into natural water sources. Until causing water pollution problems, affecting water shortages for consumption and subsequent consumption [2]. From annual report of state of surface water quality 2023, it was found that the overall water quality of Yom river is deteriorated with an average Water Quality Index (WQI) value is of 60.16 all year which should be monitored of dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), Total Coliform Bacteria (TCB) and Fecal Coliform Bacteria (FCB) due to low water volume and slow flow as well as surrounding areas along the river are communities and agricultural fields (Environment and Pollution Control Office 4, 2023). Especially, in areas with expanding population, agricultural production, construction and urbanization as well as human activities soil erosion is the major problem [3-5]. Erosion causes both on-side and off-side effects on land and also on water bodies thereby affecting its quality [6]. It shows that changes in area conditions or land use have an impact on water quality. Therefore, this study aims to monitor and evaluate surface water quality from land use in

Upper Yom River Basin, Part 1, Pong District, Phayao Province.

Methodology

This research was designed water sampling twice a year during rainy (May 2022) and dry seasons (November 2022). Then, water samples were randomly collected using the grab sampling method and the water samples were maintained according to the guideline of Pollution Control Development (2010) for physicochemical and biological properties analysis according to APHA method (1992) [7] and US.EPA (1971) [8]. (Table 1)

Sampling points were determined from the classification and size of land use in Upper Yom River Basin, Part 1 using the Q-GIS 3.30.1system (GNU General Public License) and using land use data sets from the Department of Public Works and Town & Country Planning which is divided into 8 types: Y1: rural and agricultural land, Y2: rural and agricultural conservation land in Khuan Sub-Watershed, Y3: rural and agricultural conservation land in Ngim Sub-Watershed, Y4: rural and agricultural conservation land in Yom Sub-Watershed, Y5: less dense residential areas, Y6: medium-density residential areas, Y7: very dense residential areas and Y8: government agency offices and commercial areas (Figure 1).

Field measurements

T were measured with an APHA, AWWA, WEF (2012), 2550B and EC were measured with an APHA, AWWA, WEF (2012), 2520B, pH with a standard method for the examination of water and waste water (APHA, AWWA, WEF, 22nd Ed., 2012 Part 4500-H+), Tb with a APHA, AWWA, WEF (2012), 2130B. Instruments were calibrated prior to use according to the manufacturer's directions.

Chemical and biological analysis

BOD5 was determined as the difference between initial and 5-day oxygen concentrations in bottles assayed by APHA, AWWA, WEF (2012), 5210-BOD G, B., Total Phosphate was assayed by persulfate digestion and the ascorbic acid method (APHA, AWWA, WEF (2005), 4500-P-E). TSS were assayed by filtering a suitable amount of sample through a pre combusted GF/C glass fiber filter according to standard methods (APHA, AWWA, WEF (2012), 2540D). All samples were pre-treated with HNO_3 according to standard methods (APHA, AWWA, WEF (2012), 3030 E). Nitrate-Nitrogen was determined by APHA, AWWA, WEF (2005), 4500 NO^-_3. We use standard methods, EPA 507 by GC-FPD and CG/μ-ECD. Total coliforms and Fecal coliforms were assayed according to standard methods for examination of wastewater (APHA, AWWA, WEF, 21st Ed., 2005-part 9221 A-C, E-F part 9225 D) [9].

Water quality assessment using the Water Quality Index

For the criteria for each index studied Water quality standards have been applied to surface water sources that are not seawater according to environmental quality standards set by the Office of the Commission national environment (1994) [10]. To see the overall of the water quality of Upper Yom River Basin, Part 1. A scoring method for each index was used according to the score criteria used to evaluate the physical and chemical properties status by applying the evaluation criteria from the Huai Bong River Basin. Phu Wiang District, Khon Kaen Province of the field of watershed management Department of Conservation Science Faculty of Forestry, Kasetsart University, 2005 (quote in Ananya, 2015) [9]. Evaluation with water quality index separately consider each aspect as follows:

(1) The criteria used for evaluation Physical properties include water temperature, Turbidity, and Total Suspended Solids and Electrical Conductivity (Table 1).

(2) The criteria used for evaluation Chemical properties include BOD pH Total Phosphate and NO_3 (Table 2).

(3) The criteria used for evaluation include coliform, total bacteria and fecal coliform bacteria (Table 3).

Table 1 Criteria used to evaluate the physical properties status

Status	Scores	Temperature C	Turbidity (mg/l)	TSS (mg/l)	EC (µs/cm)
Nature	4	20-35	0-25	<500	<150
Warning	3	15-19.9, 35.1-37.9	26-50	500-1,000	150-300
Risky	2	10-14.9, 38-40.9	51-100	1,000-1,500	300-600
Crisis	1	<10, >40	>100	>1,500	<600

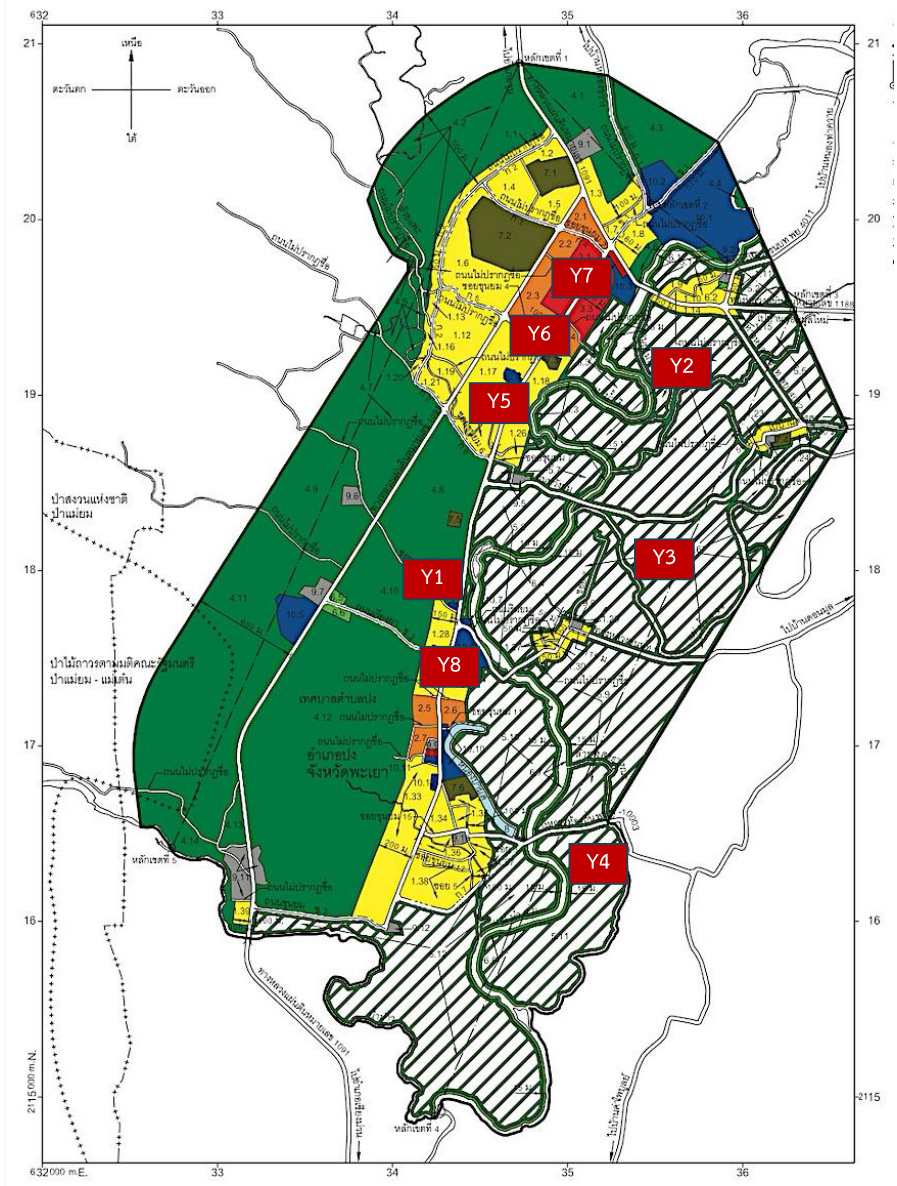

Figure 1 Map of water sampling sites in Upper Yom River Basin, Part 1
Source: Department of Public Works and Town & Country Planning, 2023

Table 2 Criteria used to evaluate the chemical water quality status

Status	Scores	pH	BOD (mg/l)	NO_3 (mg/l)	Total P (mg/l)
Nature	4	5-9	<1.5	<5	<0.1
Warning	3	4-5, 9-10	1.5-2	5-5.25	0.1-0.125
Risky	2	3-4, 10-11	2-4	5.25-5.5	0.125-0.15
Crisis	1	<3, >11	>4	>5.5	>0.15

Table 3 Criteria used to evaluate the biological water quality status

Status	Scores	Total coliform bacteria (MPN/100ml)	Fecal coliform bacteria (MPN/100ml)
Nature	4	0-2,500	0-400
Warning	3	2,500-5,000	400-800
Risky	2	5,000-10,000	800-1,600
Crisis	1	>10,000	>1,600

Then take the average of upper Yom River Basin, Part 1 at each station from Y1 to Y8, compare the scoring criteria and find the average. The total average obtained will be compared with Table 4 to lead to considering the status of water quality in the upper Yom River Basin, Part 1, and leading to the creation of further conservation guidelines.

Result and Discussion

Results of monitoring and evaluating surface water quality in the upper Yom watershed are shown in Table 5-7.

The results of the physicochemical and biological water quality examination found that water quality in the lower Yom Watershed was mostly within the water quality standard for surface water sources, except for FCB (4,500 MPN / 100 mL) that was detected in areas where land use was for residential density (Y7) exceeds the standard limit of 4,000 MPN / 100 mL and corresponds to the highest amount of TCB found (Table 3). This indicates that surface water in that area is not safe and may be contaminated with pathogens because FCB can only be found in the digestive system and excretions of warm-blooded animals. Therefore, it is used as an indicator of contamination of human and waste, such as *Escherichia coli* [15-16]. As for rural conservation and agricultural land use surrounding Kuan river and Ngim river which both are tributaries of Yom river and Yom river (Y1 – Y4) TCB and FCB were detected in low amounts, but there was a high amount of NO_3^- (1.68 – 2.24 mg/L), indicating the effects of famers use of chemical fertilizers and surface runoff, consistent with the classification results and the size of use. Land in the upper Yom River Watershed shown with green zones and green - and- white stripes on the map in Figure 1 was found to be 42.29% and 35.97% of the total area 12,952,386.79 square meters (m^3) with land use for conservation and agriculture. It is evident that on more than 50 % of nitrogen fertilizer can be directly used by plants [17]. Much of which is bound to organic matter in the soil and is lost through direct leaching into waterways including the present trends of nitrate pollution of surface water. Therefore, reflect legacies of current and past applications of fertilizers and manures [18-19].

Table 4 Criteria used to evaluate the physical, chemical and biological status of water resources

Status of the upper Yom River Basin, Part 1	Scores
Nature	>3.33
Warning	2.35-3.32
Risky	1.68-2.34
Crisis	<1.68

Table 5 Evaluation of physical water quality in Upper Yom River Basin, Part 1 in Phayao province

Stations	Mean value of physical water quality parameters, n=6							
	Temp (^oC)	**Score**	**Turbidity (NTU)**	**Score**	**EC (µS/cm)**	**Score**	**TSS (mg/L)**	**Score**
Y1	25	4	12.75	4	161.00	3	23.00	4
Y2	25	4	48.55	3	156.95	3	64.50	4
Y3	25	4	56.01	2	166.15	3	48.50	4
Y4	25	4	51.90	2	169.55	3	55.50	4
Y5	25	4	52.65	2	165.65	3	49.00	4
Y6	25	4	35.80	3	166.50	3	51.50	4
Y7	25	4	40.85	3	170.60	3	40.50	4
Y8	25	4	52.20	2	171.55	3	55.50	4
Standards	Nature[1)]		< 5[1)]		< 1,000[2)]		99[2)]	
Evaluation	**Nature**	**4**	**Warning**	**2.63**	**Warning**	**3**	**Nature**	**4**

Note: [1)] Guidelines for drinking – water quality (WHO, 1996) [11]
[2)] National Storm Water Quality Database (Pitt et al., 2004) [12]

Table 6 Evaluation of chemical water quality in Upper Yom River Basin, Part 1 in Phayao Province

Stations	Mean value of chemical water quality parameters, n=6							
	pH	**Score**	**PO_4^{3-} (mg/L)**	**Score**	**NO_3^- (mg/L)**	**Score**	**BOD (mg/L)**	**Score**
Y1	7.35	4	0.10	3	1.68	4	1.20	4
Y2	7.40	4	0.25	1	2.24	4	1.95	3
Y3	7.40	4	0.31	1	1.68	4	1.05	4
Y4	7.50	4	0.29	1	2.24	4	1.00	4
Y5	8.05	4	0.46	1	1.96	4	1.35	4
Y6	7.45	4	0.43	1	1.68	4	1.05	4
Y7	7.45	4	0.43	1	1.40	4	1.20	4
Y8	7.45	4	0.54	1	1.68	4	1.10	4
Standards	5 – 9[1)]		< 0.1[2)]		< 5[1)]		2 – 4[1)]	
Evaluation	**Nature**	**4**	**Crisis**	**1.25**	**Nature**	**4**	**Nature**	**3.85**

Note: [1)] Water quality standards for surface water source types 3 and 4 [13]
[2)] Integrated Risk Information System (US.EPA, 1999) [14]

Table 7 Evaluation of biological water quality in Upper Yom River Basin, Part 1 in Phayao Province

Stations	Mean value of biological water quality parameters, n=6			
	TCB (MPN/100 mL)	**Score**	**FCB (MPN/100 mL)**	**Score**
Y1	4,000	3	1,325	2
Y2	3,200	3	1,565	2
Y3	2,650	3	1,525	2
Y4	3,310	3	1,715	1
Y5	2,905	3	2,600	1
Y6	4,822	3	1,850	1
Y7	7,800	2	4,500	1
Y8	6,575	2	3,600	1
Standards	20,000[1)]		< 4,000[1)]	
Evaluation	**Warning**	**2.75**	**Crisis**	**1.38**

Note: [1)] Water quality standards for surface water sources types 3 and 4 [13]

Results of assessment of the overall status of the upper Yom watershed are at the warning level with an average score of 2.92 showing that the water quality has begun to deteriorate from its original condition, and it requires surveillance and monitoring of the cause of problem. This is because the water quality index -values are in Warning to Crisis conditions including EC, TCB, Turbidity, FCB and PO_4^{3-} with average scores of 3.00, 2.63, 2.63, 1.38 and 1.25 respectively because the mentioned quality index indicates the agricultural land use and dense residential areas as well as the topography is a high-land with steep slopes and degraded forests, thus affecting the erosion of the soil surface. Sediment in water sources and landslides occurred in the upper Yom Watershed [20].

Conclusion

Assessment of surface water quality in the upper Yom Watershed from land use is at the Warning Level and EC, TCB, Turbidity, FCB and PO43- indices should be monitored periodically and at the specific points. This is the result of land use in agriculture and rural conservation surrounding Yom Watershed and Ngim river which is the tributary of Yom River including the very dense residential areas shows that water quality analysis according to land use pattern will reveal the status of water resources. Water quality index and precision in managing water resources to ensure water and sanitation are sustainably managed and available to all in line with the UN-SDGs.

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