

Surface Water Quality of Selected Tributaries Flowing Through Two Districts, Ho Chi Minh City, Vietnam

L.D. Vu, M.C. Tuan, D.T.M. Duyen, H.T.L. Anh, Tran Thanh, L.Q. Tuong*

Faculty of Food and Environmental Engineering, Nguyen Tat Thanh University, Ho Chi Minh City, 70000, Vietnam

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Tributaries serve as essential features of the Saigon River. The work consists of a case study on the selection of sites for tributaries of the Vam Thuat River flowing through Go Vap District and District 12, Ho Chi Minh City, Vietnam. An objective is to assess its pollution status and risks of those pollutants by using Nemerow's Pollution Index (NPI) for water quality assessment and Pearson's correlation (*r*) values, indicating a significant and positive correlation between variables of the same group. There are ten research sites to study the surface waters of the tributaries from upstream to downstream. Grab samples of surface water sources were collected on October 19, October 26, November 2, and November 9, 2017, based on the national technical regulation on water quality standards of Vietnam. The monitoring parameters include temperature, pH, total suspended solids (TSS), chemical oxygen demand (COD), ammonium-nitrogen (NH_4^+-N), nitrate-nitrogen (NO_3^--N), phosphate (PO_4^{3-}), sulfate (SO_4^{2-}) and total iron (Fe). According to the measurement results and statistics, the mean values of the samples from ten research sites were compared with the Vietnam national standard system and WHO guidelines. Contaminants of TSS, COD, NH_4^+-N, SO_4^{2-}, and Fe should be specifically discussed and compared with previous studies to update available data for management and suggestion of industrial monitoring of these tributaries using water quality sensors.

Keywords: Tributaries, Surface water quality, Water pollution.

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1. INTRODUCTION

In fact, freshwater constitutes just 2.5 % of the total quantity of water on Earth. Surface water is important in managing environmental sustainability, increasing economic growth, and realizing the social welfare of communities. In most developing countries, nutrient discharge to surface water will unequivocally increment and then water eutrophication will remain a challenge in the next many years. Water resource becomes scarce, exhaustion and threatening the development of human activities because human activities make catchments of water are becoming polluted, including littering and industrial discharges. Wastewaters have changed the natural water, sediment chemistry and affect the biota extensively. There are a lot of rivers in Vietnam including Sai Gon River which presents 256 km long with a basin area of 4,710 km^2 by Environmental Report of Vietnam and this river belongs to the Dong Nai River basin area. Saigon River is important to Ho Chi Minh City (Herein: HCMC), the biggest city in Vietnam with a populace of 8.637 million in 2019. From meteorological conditions suitable for development economic, the renovation policy was sent off in 1986, HCMC, Vietnam, has conducted the quickest urbanization and industrialization process. And then the activities used the water resources have put managements on the executive capacity of administration units (i.e., the local government). Many tributaries of the Saigon River receive wastewater from industrial, agricultural, residential activities. The quick increment of water use in HCMC has caused the extreme contamination and depletion of groundwater and surface water and many districts are facing water eutrophication. Particularly, Go Vap District and District 12 of HCMC have significantly used the noteworthy amount of groundwater extraction despite lying completely inside the service area of the service area (e.g., supplying the piped water) based on a report published by DNRE of Vietnam in 2013. Our previous studies provided several concerns to this practice related to the potential contamination from groundwater resources that are investigated via a mixed-method study combining water sampling, social surveys, a groundwater quality index [1] and heavy metals previously reported [2]. The present study introduces a simplified pollution index (NPI) which is also known as Raw's pollution index [3, 4] and Pearson's correlation (r) values for water quality assessment. Due to the need for data on supplement use, we are continually working on "Surface Water Quality of Selected Tributaries Flowed Through Two Districts, Ho Chi Minh City, Vietnam" to explain and represent water pollution conditions concerning surface quality.

2. MATERIALS AND METHODS

2.1 Descriptions of Study Area

Ho Chi Minh City is a megacity, located in the southern part of Vietnam 2.095 km^2 and ranks the first for socioeconomic development. It is clearly affected by equatorial climate with two seasons: dry season (December-April) and wet season (May-January) (https://www.asiahighlights.com/vietnam/ho-chi-minh-city/weather). Selected tributaries (i.e., from site 1 to site 10) of this study are part of Vam Thuat River [5] with a distance around 11.67 km crossing particularly in Go Vap District and District 12.

In experimental design, 10 research sites are selected from upstream to downstream on October 19, October 26,

* lqtuong@ntt.edu.vn
The results were presented at the 2nd International Conference on Innovative Research in Renewable Energy Technologies (IRRET-2022)

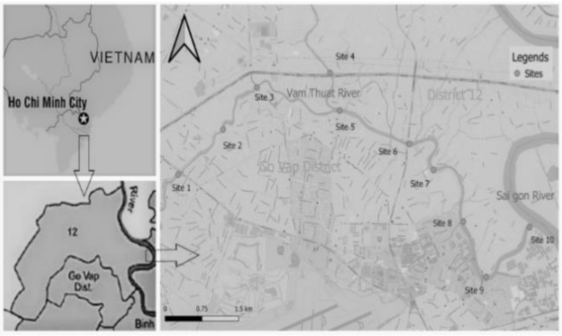

Fig. 1 – Sample site locations in the selected tributaries, Ho Chi Minh City, Vietnam

November 2, and November 9, 2017, because its highly notable time of season delivery period between the dry and wet seasons. Second, it represents pollution conditions associated with freshwater and several concerns to this practice related to the potential contamination from groundwater previously reported in a Phu Dong Ward, Thanh Loc Ward, Thoi An Ward, Thanh Xuan Ward, District 12 [1], where the selected tributaries across in the study area.

2.2 Samples Collection and Analysis

Grab samples of surface water sources were collected from 10 sites, as shown in Fig. 1. The water was directly collected from the tributaries which admittedly adds storage and handling certainty into the analysis and the samples do represent point-of-use conditions. After collection, the analyzed parameters consisted of those from the Vietnamese water quality standards (QCVN 01-1:2018/BYT), the method also were included based on our previous study investigating the groundwater quality of HCMC [1]. We prefer the NPI methods because it can cater to the locality by referring to the water quality standards of the country of interest. Nemerow's pollution index NPI is calculated with the help of following equation given as:

$$\mathrm{NPI} = \frac{C_i}{L_i},$$

where C_i is the observed concentration of the i^{th} parameter; L_i is the permissible limit of the i^{th} parameter. Each NPI value represents the relative pollution contribution of each parameter [3, 4]. NPI classifies six classes of pollution degree [6, 7]: no pollution ($\mathrm{NPI} \leq 0.5$); safe ($0.5 < \mathrm{NPI} < 0.7$); precaution ($0.7 < \mathrm{NPI} < 1.0$); slight pollution ($1.0 < \mathrm{NPI} < 2.0$); moderate pollution ($2.0 < \mathrm{NPI} < 3.0$); severe pollution ($\mathrm{NPI} > 3.0$). Second, the correlation examination result is respected in the interpretation of the physicochemical characteristics in each water test. A high positive relationship between two variables will have occurred, when its relationship coefficient in the interval $-1 \leq r \leq +1$. The broad interpretations of Pearson's correlation coefficient are explained as following: Little or no linear association ($|r| \leq 0.3$), weak linear association ($0.3 \leq |r| \leq 0.5$), moderate linear association ($0.5 \leq |r| \leq 0.7$), and strong linear association ($0.7 \leq |r| \leq 1$). The correlation between two factors was estimated at a level of $p < 0.05$.

3. RESULTS AND DISCUSSION

The water samples were analyzed and compared with respective national standards [9, 10] and WHO guidelines [11, 12]. Table 1 summarized the maximum, minimum, and mean values for every parameter and note that all values are arithmetic. The pH values in this study were genuinely acidic and stands in the 6.0 to 7.4 range with a mean value of pH around 6.8. It should be noticed that the recorded pH values have no direct human health impacts on the inhabitants, yet the low pH can bring about metal dissolvability, prompting contamination of the surface water. NPI results in Fig. 2 could be qualitatively categorized based on the permission limit of national standards [9-10]. According to the NPI classification, the tributaries in the study were characterized as polluted for several elements measured, but there were differences in ranked NPI values between them. In the irrigation purpose of National Standards (i.e., Vietnam), NPI values called precaution ($\mathrm{NPI} > 0.7$) in the sequence NH_4^+-N > Fe > TSS > COD > SO_4^{2-} > pH values. Table 2 presented that the Pearson correlations between concentrations of individual parameters are very strong positive correlations ($p < 0.05$). The analysis revealed that for the water samples studied, there are medium and strong positive correlations between the following pairs of parameters in water: pH-TSS (0.36), TSS-Fe (0.32), COD-NH_4^+-N (0.37), COD-PO_4^{3-} (0.31), COD-SO_4^{2-} (0.50), NH_4^+-N-SO_4^{2-} (0.65), NH_4^+-N-Fe (– 0.34), and PO_4^{3-}-SO_4^{2-} (0.36), indicating strong differences of parameters in water samples of the selected tributaries. The current investigation ranged of TSS, COD, NH_4^+-N, Fe were higher than the range of Vietnam standards and WHO standards. According to the greatest number of complaints about the watercolor and smells in District 12 [13] and results of study [14], the overview surveying mentioned the impact level of the canal system Tham Luong – Ben Cat – Nuoc len (three specific names in Vietnamese). Given that the life of nearby families shows a high percentage of households (around 75.38 %) answered pollution status of the canal system that directly influenced their living activities. Among these, the elevated rate is in Go Vap District, representing 97.08 %; and 96.77 % is for District 12 (the greater part of these families is living along the channel or 50 m away from the channel). Current issues presented that numerous households in District 12 like to draw water from the lower-quality groundwater source. One reason behind this activity potentially was the restricted local areas understanding regarding the negative effects of microbial contamination and healthcare. The second one was that the practice may be connected with the economic status of the households who generally are laborers coming from provincial regions [1]. Groundwater and surface water interaction is an essential component of the hydrological cycle and rainwater plays a central role in connecting processes on the ground. The pollution creating parameters as per Nemerow's Pollution Index (NPI) at each station was determined and presented in Fig. 2. Table 1 and Table 2 demonstrate the results of NPI of the studied parameters in the study area in a period from October 9 to November 9, 2017. Challenges men-

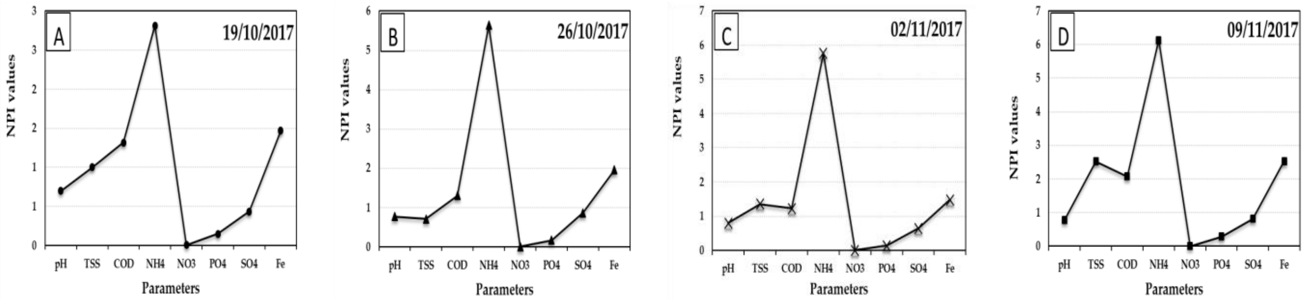

Fig. 2 – Nemerow's Pollution Index (NPI) values of the physico-chemical properties of water samples in the study period as: (a) 19 October 2017; (b) 26 October 2017; (c) 02 November 2017 and (d) 11 November 2017

Table 1 – Summary of descriptive analysis of water quality in selected tributaries, HCMC, Vietnam

Parameters	**Max. value**	**Max. value**	**Mean value**	**Water use**	**National standards**	**WHO guidelines**	**Source**
pH	6.0	7.4	6.82	Irrigation	5.5-9.0 [1]	6.5-8.5 [3]	
TSS (mg/l)	10	532	70	Irrigation	< 50 [1]	< 50 [4]	
COD (mg/l)	6.4	160	74.0	Irrigation	< 30 [1]	< 50 [4]	
NH_4^+-N (mg/l)	0.2	9.1	4.6	Irrigation	< 0.9 [1]	< 0.2 [3]	
NO_3^--N (mg/l)	0.03	0.10	0.05	Irrigation	< 10 [1]	< 3 [3]	
PO_4^{3-} (mg/l)	0.01	0.36	0.06	Irrigation	< 0.3 [1]	*	< 0.1 [8]
SO_4^{2-} (mg/l)	52	315	177	Irrigation	< 400 [2]	< 250 [3]	
Fe (mg/l)	1.63	7.23	2.79	Irrigation	< 1.5 [1]	< 0.3 [3]	

[1] Group B1 (QCVN 08-MT:2015) National Technical Regulation on Surface Water Quality, Vietnam [9].

[2] (QCVN 09-MT:2008) National Technical Regulation on Underground Water Quality [10].

[3] (World Health Organization: 2011): Guidelines for Drinking-water Quality Fourth Edition [11].

[4] Group A (World Health Organization: 2006): a compendium of standards for wastewater reuse in the Eastern Mediterranean region from WHO, for Jordanian Standard [12].

* Not applicable: another source of Khanfar, A.R., 2008 [8].

tioned in the present study when the value of NPI exceeding 1.0, suggest the presence of an impurity in the water sample and therefore need some treatment before using it for irrigation purpose. Therefore, these NPI may showcase what described water quality that has contributed to the local data and most certainly the environmental conditions in administration units of Go Vap District and District 12, both of which are closely intertwined with historical, social, cultural, political, and economic conditions in HCMC. Given that R^2 is mentioned in high regression of water quality relation, and then the results in Fig. 3A illustrate a highly significant relationship between NH_4^+-N and SO_4^{2-} ($R^2 = 0.4055$, $p < 0.01$), it also agrees with known environmental preferences of sulfate and ammonium of Wang [6]. Fig. 3B illustrates a highly significant relationship between COD and SO_4^{2-} ($R^2 = 0.2673$, $p < 0.01$), the study of Binh [15] revealed that three pollution sources from anthropogenic activities in the urban, agricultural, and industrial areas in District 12, HCMC could mainly contribute to degrading groundwater quality with high percentage of Fe (29 %), NH_4^+-N (19.7 %), COD (14.6 %), and coliform (13.7 %) concentration higher than the maximum permissible limit. Another study of Wilhelm [16] showed that correlations was observed between ammonium concentration and appearance and growth of total coliforms. Our government also features the requirement for accessibility of water, and quality for generally useful utilizations, as well concerning the control of point and non-point contamination sources [17]. It is desirable in the present study that the discharge reach at least levels that clean used for consumption agriculture or irrigation purposes, which means NH_4^+-N and COD treatment also are important considerations and substantiated by each national standards [17] and therefore increased dissolved oxygen balance (i.e., DO) will be necessary for protecting the selected tributaries. The choice of suitable river water treatment techniques is significant for the restoration of river environments. Ecological floating beds are energetically suggested for their minimal cost, high adequacy, optimum aquatic plant development, and even requires urgent phytoremediation for removing high concentration of heavy metals in water of N. Vongdala [18]. The lessons learned may be addressed these contaminants by the potential of phytoremediation in natural wetland systems in terms of using plants seems a promising alternative to treat

Table 2 – Pearson correlation coefficient for the analyzed parameters

	pH	TSS (mg/L)	COD (mg/L)	$NH4^+$-N (mg/L)	$NO3^-$-N (mg/L)	$PO4^{3-}$ (mg/L)	$SO4^{2-}$ (mg/L)	Fe (mg/L)
pH	1							
TSS (mg/L)	0.36	1						
COD (mg/L)	-0.04	0.14	1					
$NH4^+$-N (mg/L)	0.15	0.08	0.37	1				
$NO3^-$-N (mg/L)	-0.16	0.06	0.22	-0.01	1			
$PO4^{3-}$ (mg/L)	0.17	0.14	0.31	0.24	0.00	1		
$SO4^{2-}$ (mg/L)	0.14	-0.03	0.50	0.65	0.12	0.36	1	
Fe (mg/L)	0.23	0.32	0.05	-0.34	-0.12	-0.07	-0.11	1

Both values were significantly different from 0 ($\alpha = 0.05$)

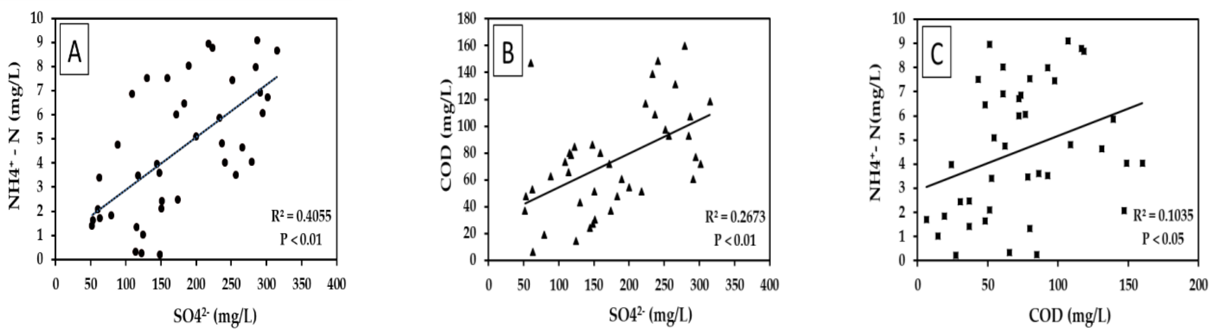

Fig. 3 – In linear regression analysis, R^2 was highly significant, $P < 0.01$ (or 0.05), $n = 40$. Description of the relationship were listed as: (a) between NH_4^+-N (x) and SO_4^{2-} (y); (b) between COD (x) and SO_4^{2-} (y) and (c) between COD (x) and NH_4^+-N (y)

wastes of TSS (mg/l), Nitrogen (ammonia), and total coliform (MPN/100 ml) and an increasingly recognized to advance the treatment capacity of B.Y. Zhang [19] and need of decreasing plastic contamination in rivers is helpful to aquatic animals and social life. To limit the emission of TSS, Fe, and organic pollutants caused by runoff, it is important to build green corridors and stormwater retention ponds along the main tributaries of the Sai Gon River to prevent terrestrial particles which entering these tributaries [20] and to set up multiple sensors to check parameters of water quality as turbidity units (NTU) by Secchi disk, pH, temperature, dissolved oxygen. We have suggested potential methods (i.e., water quality sensors) in this study and the present study might be expected to draw up the situation of selected point pollution sources selected tributaries flows through Go Vap District and the development and management of water resources.

4. CONCLUSIONS

The results may be explained that high concentration of contaminants of TSS, COD, NH_4^+-N, SO_4^{2-}, Fe in a range (from October to November 2017) may cause the odor, and color of the surface water [1]. The main finding of the work showed that the comprehensive Nemerow`s pollution index (NPI) of NH_4^+-N in the surface water were higher than 3.2, and polluted by a high concentration of NH_4^+-N explained the strong positive correlations of Pearson's correlation (r) values between the following pairs of parameters NH_4^+-N and SO_4^{2-} (0.65) at a level of $p < 0.05$, and therefore the linear regression analysis was highly significant between NH_4^+-N and SO_4^{2-} ($R^2 = 0.4055$, $p < 0.01$). It agreed to the previous study that these families are living along the tributaries flows through Go Vap District and District 12, Ho Chi Minh City said their water had some sort of odor issues. The present study can seek to introduce an applicable workflow to practitioners to simply validate the results of water quality in this study for improving the community awareness and changing their behaviors toward the water resources for helping assess surface water resource health and to protect these tributaries.

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Якість поверхневих вод окремих притоків, що протікають через два райони, Хошимін, В'єтнам

L.D. Vu, M.C. Tuan, D.T.M. Duyen, H.T.L. Anh, Tran Thanh, L.Q. Tuong

Faculty of Food and Environmental Engineering, Nguyen Tat Thanh University, Ho Chi Minh City, 70000, Vietnam

Притоки є основними ознаками річки Сайгон. Робота складається з тематичного дослідження щодо вибору місць для притоків річки Вам Туат, яка протікає через район Го-Вап і округ 12 міста Хошимін, В'єтнам. Метою роботи є оцінка статусу забруднення та ризиків забруднювачів за допомогою індексу забруднення Немерова (NPI) для оцінки якості води та значень кореляції Пірсона (*r*), що вказує на значну та позитивну кореляцію між змінними однієї групи. Існує десять дослідницьких ділянок для вивчення поверхневих вод притоків від верхньої до нижньої течії. Відбір проб поверхневих вод проводився 19 жовтня, 26 жовтня, 2 листопада та 9 листопада 2017 року на підставі національного технічного регламенту про стандарти якості води В'єтнаму. Параметри моніторингу включають температуру, індекс pH, загальну кількість зважених речовин (TSS), хімічне споживання кисню (COD), амоній-азот (NH_4^+-N), нітратний азот (NO_3^--N), фосфат (PO_4^{3-}), сульфат (SO_4^{2-}) і загальне залізо (Fe). Відповідно до результатів вимірювань і статистичних даних середні значення проб з десяти дослідницьких ділянок порівнювали з національною системою стандартів В'єтнаму та рекомендаціями ВОЗ. Забруднюючі речовини TSS, COD, NH_4^+-N, SO_4^{2-} та Fe слід обговорити окремо та порівняти з попередніми дослідженнями, щоб оновити наявні дані для управління та запропонувати промисловий моніторинг цих притоків з використанням датчиків якості води.

Ключові слова: Притоки, Якість поверхневих вод, Забруднення води.