Assessment of Ta Vai spring water quality and the possibility for domestic water supply use

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Abtract

Ha Giang is a mountainous province on the northern border of Vietnam, the supply of clean water to people living is very difficult. Ha Giang has large streams and rivers originating from China and flowing into Vietnam. Ta Vai is a large stream, with a basin area of about 30 km^2 and it is formed on an area with complex terrain with many ranges of limestone, strongly dissected, elevation from 102m to 1181m. In order to meet the needs of the clean water of the people, we have studied to get Ta Vai stream water for living, in the key program to respond to Vietnam's climate change. This research was conducted to assess the water quality and water flow of Ta Vai stream in Ha Giang with criteria for domestic use. Stream water was taken and analyzed in 2 seasons, dry season and rainy season in 2017. Results at 09 monitoring points showed that there were 12/32 indicators did not meet the National Technical Regulation (QCVN 08-MT: 2015 / BTNMT and QCVN 02: 2009 / BYT) for drinking and eating water. Due to direct discharge of untreated waste from the toilets, cattle and poultry manure, agriculture waste by the custom of indigenous people, and illegal mining activities on the watershed, increasing organic substances (BOD, COD), suspended solids (TSS) and heavy metal (Fe, Mn) in Ta Vai stream. In addition, the presence of other parameters such as Coliform, e.coli, and grease also exposed the decline of dissolved oxygen amount in stream water. Therefore, Ultrafiltration membrane technology (UF) in combination with multi-functional filter material (ODM-2F) has proposed to treat Ta Vai spring water to become water supply for domestic use.

Key words: *Water, Ta Vai stream, material ODM-2F, ultrafiltration membrane.*

1. Introduction

Ha Giang is the Northernmost mountainous province in Vietnam with a number of large rivers flowing through the region such as Lo River, Chay River, and Gam River. This is the main water supply source which is inputted by streams and upstream from the Chinese side, supplying water for the majority of the local community.

In addition, there are smaller rivers such as Nho Que River, Mien River, Bac River, Chung River, and many other streams providing water for production and indigenous residents here. Ta Vai is the largest stream system, including 3 branches. In which, the main branch is distributed in the south, two sub-branches supplied water for the main branch in the middle side and North of the basin.

Ta Vai stream originates from Vi Xuyen district, flowing through Kim Thach commune then Ha Giang's city region, going through Ngoc Duong commune and Ngoc Ha ward and then flowing into the Mien River. Ta Vai spring is a source of water for daily life and agricultural production activities and residential areas on both sides of the stream, Army barracks of Regiment 877 and Military School under the Military Command of Ha Giang Province. The stream has small, and unstable flows, affecting by flash floods, storms, etc. Especially, water quality is always fluctuating between rainy days and without rainy. The watershed has a chemical composition that changes seasonally, especially the content of suspended sediments and organic matter. The boundary between Kim Thach and Ngoc

Duong commune has a Ta Vai small dam, which is responsible for providing irrigation water and distribution water periodically. The dam was designed and built-in 1996 [2,4]

The whole area of Ta Vai stream basin is about 30 km2 and located in the area with erosion terrain, strong dissection, the height from 102m to 1181m (Da Dau mountain peak in the East) - Figure 1. Surrounding the basin is high mountains: the West is Mo Neo mountain with764m high; North - Ban Tuy mountain is 315m high; East - Khuoi Veu mountain range with 746m high, Da Dau mountain - 1181m; South - Kim Thanh mountain peak with 612m high. The mainstream (also the topographic bottom) flows on an average height of 140 to 170 meters [1,4]. The total length of the stream is 13.5km.

Currently, the management and environmental protection activities in Ta Vai stream basin have been attracted much attention based on its affection by different sources of waste, such as from agricultural production, grazing livestock and poultry according to the custom of indigenous people[2]. In order to contribute information for the management and planning of Ta Vai spring water source, Viet - Sing Trading and Technical Joint Stock Company have built a project on treating water for domestic use in 2017. The project name is "Research and application of membrane filtration technology combined with multi-functional filter material to treat spring water in the Northwest border area for domestic use". This project has directly addressed the needs of local residents in Ngoc Duong commune and 877 Regiments ". It is necessary to have water quality assessment and appropriate treatment methods of Ta Vai spring water for domestic use.

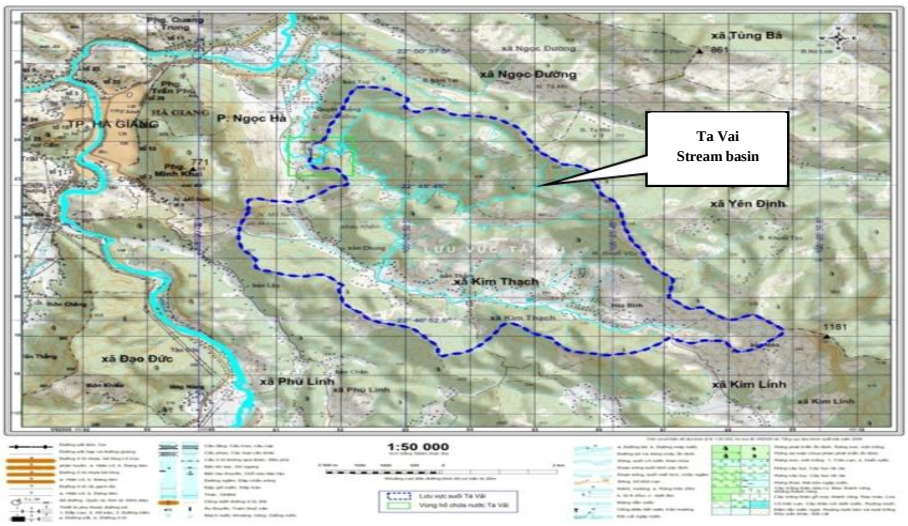


Figure 1. Topographic map of Ta Vai stream basin

(Ngoc Duong commune - Ha Giang city and Kim Thach commune - Vi Xuyen district)

2 Subjects and research method

2.1 Research Subjects

- Ta Vai stream water
- Pollutants in Ta Vai stream water: Organic substances; suspended sediment (TSS); Nitrate (NO_3^- calculated by N), Nitrite (NO_2^- calculated by N), Mn, Fe, grease, Coliform, E.Coli ...

2.2 Research Methods

- Method of collecting secondary data
- Method to determine the size and area of Ta Vai reservoir

Ta Vai reservoir is defined as the reservoir bed area with an average water level rising from the high discharge core (at the main dam) to the upstream of Ta Vai mainstream and small branches. The image of Ta Vai reservoir is taken by satellite. In order to determine the size and area of Ta Vai reservoir, we used good quality, high resolution and large scale

satellite images of Google Map. Therefore, the lake bed was determined exactly with the following main dimensions:

Measuring the distance calculated by the bird path from the dam to the upstream of the lake with 650 m length.

Measuring the distance calculated by stream flow from the dam to the upstream of the lake with 1150 m length

Measuring the largest width of the reservoir at the dam was 50m.

Measuring the narrowest width of the reservoir was 10m.

- Sampling method: taking samples according to TCVN 6663-6: 2018 [3] - Water quality - sampling - part 6: (Instructions for sampling rivers and streams).

Spring water was taken according to TCVN 6663-6: 2018 and stored then delivered to the laboratory for analysis (criteria compared with QCVN 08-MT: 2015 / BTNMT; according to the corresponding TCVN)

Sampling locations and sample conventions (numbered samples) were given in Table 01. Samples were taken in 2 seasons: dry season (9 samples denoted as NM01 - NM09) and rainy season (09 sample denoted as NM10 - NM18). A total of 18 samples represented the dry season at the end of March and the rainy season of July in 2017. Water samples taken at the following locations:

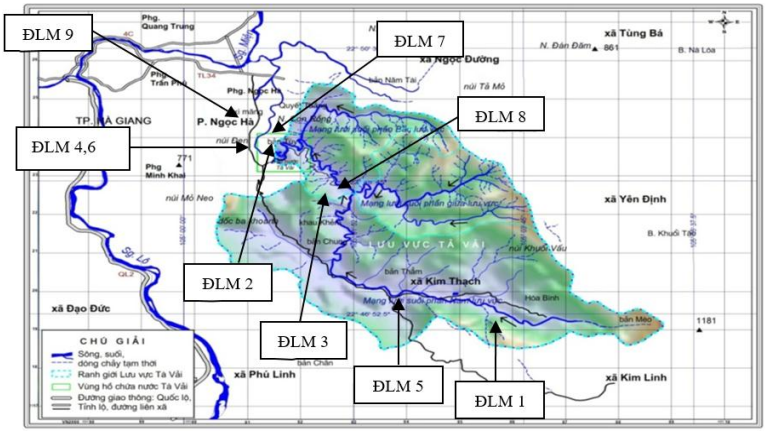


Figure 2. Distribution of sampling points in Ta Vai stream basin

Sampling:

- *Prepare sampling materials:*

Tools: Tools used for sampling include: Can, bucket, Glass bottle 200ml, 500ml, gloves, medical mask, goggles, emergency kit and pH meter (we all used sampling tools which were opened the cap to collect water from the surface).

- Sampling locations:

We chose 9 different points to get specific samples as follows:

Table 1. Sampling locations and sample symbols.

#	Location	Sample symbols
1	Ta Vai stream, Watershed point, Kim Thach, Vi Xuyen	NM (01;10)
2	Ta Vai stream, first confluence point in front of the dam	NM (02;11)
3	The first branch flows into Ta Vai stream.	NM (03;12)
4	Ta Vai stream, in the middle of irrigation dam	NM (04;13)

5	Ta Vai stream, at Chang village, Kim Thach commune, Vi Xuyen district.	NM (05;14)
6	Ta Vai stream, overflow door of the dam	NM (06;15)
7	Ta Vai stream, North-West stream branch of the main stream (2nd branch).	NM (07;16)
8	Ta Vai stream, the second confluence point infront of the dam	NM (08;17)
9	At the irrigation ditch behind the dam body.	NM (09;18)

- *Take specific water samples:*

How to collect: At each point, took 3 samples at 3 different depths, the first sample was to collect water on the surface of depth about 0.5m, the second sample was taken in the middle, the third sample was near the bottom about 0, 5m then mix these samples into a single sample. Each sample will be re-labeled with the sample, including sample name, sampling time, sampler to be easy to distinguish when testing. After that, we measured immediately the pH value in the field by pH meter: HI98127 No. 02210658991, HANNA, measuring range (-2 ÷ 16), resolution 0.1

- *Sample capacity:* Depending on the testing criteria to calculate the amount of samples to take.

+ Physicochemistry test: 18 cans (9 sample cans + 9 acidified cans), each can contained 5 liters of sample water.

+ Microbiological test: 9 bottles, each one contained 500ml sample and kept cold (no more than 24 hours).

+ All cans and bottles were filled full then covered it tightly.

- *Sample preservation:* For microbiological samples, sterilized and dried glass bottles used to store water samples (9 water samples stored in cold environment and 9 water samples stored in an acid environment (pH = 2) and then delivered to the analytical lab)

- *Analysis method:* Determined surface water quality parameters according to the guidelines of the National standards or corresponding analytical standards of international organizations, water samples analyzed at the environmental analysis lab (VILAS). 995 - VIMCERTS 112) - Institute of environmental engineering and technology, the results controlled at the Vietnam Institute of Chemistry.

- *Data processing method:* Using mathematical statistical methods, Exell software 2016 to assess the reliability of the results.

3. Research results and discussion

3.1 Determine the area of Ta Vai reservoir

The area of Ta Vai reservoir was maximized by the total area of the main reservoir (Ta Vai mainstream) plus the area of the sub-reservoir (located at the south of the main dam), plus the area of all other branches streams in the basin:

$$S_{(Ta\ Vai)} \approx S_{(main\ reservoir)} + S_{(sub\ reservoir)} + S_{(\sum area\ of\ small\ branches)}$$

Assume $S_{(\sum area\ of\ small\ branches)}$ is negligible (= 0),

we have:

S (Ta Vai) ≈ 0.03482 km^2 + 0.001338 km^2

S (Ta Vai) ≈ 0.036158 km^2

** S : Basin area*

3.2. Determine the amount of water involved in the surface flow (provide water for the stream) in the dry season:

Average rainfall of 4 months in dry season (from December to March of the following year) of 7 consecutive years was: 40.9 mm [2].

After referring to researches in similar regions in Vietnam, it is estimated that about 20-30% of the dry season water (≈ 10 mm) can be supplemented for the stream network in the basin (30 km^2).) is:

$\mathbf{V_{bc\ dry}}$ = 0,01 m x 30 x 10^6 m^2

= **300.000 m^3**

*** ($\mathbf{V_{bc\ dry}}$:** Additional water volume in the dry season)

Determining the amount of water involved in the surface flow (provide water for the stream) in the rainy season:

The average precipitation in 8 months of the rainy season (April to November) of the continuous year is: 246.7 mm [2].

After referring to research works in similar regions in Vietnam, it is estimated that about 20-30% of the water in the rainy season (≈ 54 mm) can be supplemented for the network of streams in the basin (30 km2).) is:

$\mathbf{V_{bc\ rainy}}$ = 0,054 m x 30 x 10^6 m^2

= **1.620.000 m^3**

*($\mathbf{V_{bc\ rainy}}$**:** Additional water volume in the rainny season)

By analyzing the area, capacity and flow of Ta Vai stream, the results showed that this stream is a useful water source for domestic water supply and production activities of indigenous people and Regiment 877 in stream basin. Thereby, it is important to assess the water quality, develop water treatment plan to meet the permitted standards for domestic water supply, saving costs for people as well as military zones and ensuring safety and security of clean water in the area.

3.3 Research results of analyzing Ta Vai lake water samples:

Analysis results of 09 dry season samples of Ta Vai spring water are shown in Table 02.

Table 02: Analysis results of dry season samples, March 21, 2017, at the laboratory.

#	Parameters	Unit	Analysis results									QCVN 08 (Colum A1)
			NM1	NM2	NM3	NM4	NM5	NM6	NM7	NM8	NM9	
1	pH[(b)]	-	6,88	6,77	7,3	6,8	6,8	6,82	6,9	7,1	6,8	6 - 8,5
2	BOD_5[(b)]	mg/l	**9,0**	**16**	**15**	**13**	**11**	**9,0**	**9,0**	**15**	**15**	4,0
3	COD[(b)]	mg/l	**15**	**26**	**24**	**21**	**24**	**16**	**19**	**27**	**28**	10
4	DO[(a,b)]	mg/l	7,0	8,0	8,0	8,0	7,0	8,0	7,0	7,0	8,0	≥ 6
5	Total suspended solid[(a,b)]	mg/l	**96**	**109**	**101**	**111**	**84**	**87**	**91**	**94**	**106**	20
6	Nitrate (NO_3^- calculated according to N)[(b)]	mg/l	**5,2**	**3,6**	**4,9**	**3,4**	**5**	**4,6**	**4,83**	**3,9**	**3,5**	2,0
7	Nitrite (NO_2^- calculated according to N)[(b)]	mg/l	**0,07**	**0,051**	**0,06**	0,05	**0,06**	0,047	**0,064**	**0,056**	**0,07**	0,05
8	Total hardness ($CaCO_3$)[(a,b)]	mg/l	341	246	308	310	325	312	308	305	98	-

9	Mn[a,b]	mg/l	**0,27**	**0,32**	**0,21**	**0,31**	**0,34**	**0,26**	**0,31**	**0,27**	**0,13**	0,1
10	Fe[a,b]	mg/l	**0,56**	**0,64**	0,36	**0,53**	**0,54**	**0,57**	**0,64**	0,49	0,48	0,5
11	Total oil , grease[c]	mg/l	0,23	**0,72**	**0,52**	**0,40**	0,23	0,27	**0,33**	0,22	**0,67**	0,3
12	Coliforms[b]	MPN/100	230	**4300**	2400	460	230	2100	2400	**4300**	930	2500
13	E. coli[b]	MPN/100	7	**230**	4	9	7	7	4	**230**	11	20

Table 03: Analysis results of rainy season sample, July 17, 2017, at the laboratory.

#	Parameters	Unit	Analysis results									QCVN 08 (Column A1)
			NM10	NM11	NM12	NM13	NM14	NM15	NM16	NM17	NM18	
1	pH[b]	-	6,95	7,3	7,6	6,85	6,82	6,92	6,79	7,01	6,94	6 - 8,5
2	BOD_5[b]	mg/l	**14**	**18**	**26**	**19**	**11**	**15**	**10**	**13**	**13**	4
3	COD[b]	mg/l	**27**	**37**	**46**	**34**	**21**	**25**	**21**	**17**	**28**	10
4	DO[a,b]	mg/l	8,0	8,0	8,0	8,0	8,0	8,0	7,0	7,0	6,0	≥ 6
5	Total suspended solid [a,b]	mg/l	**106**	**120**	**125**	**99**	**112**	**102**	**96**	**104**	**110**	20
6	Nitrate (NO_3^- caculated according to N)[b]	mg/l	**4,4**	**2,5**	**3,1**	**3,7**	**4,02**	**4,93**	**3,67**	**3,19**	**2,45**	2
7	Nitrite (NO_2^- caculated according to N)[b]	mg/l	0,036	**0,071**	0,04	**0,069**	**0,053**	0,047	**0,071**	**0,066**	**0,059**	0,05
8	Total hardness ($CaCO_3$) [a,b]	mg/l	275	284	296	301	284	317	306	286	307	-
9	Mn[a,b]	mg/l	**0,22**	**0,12**	**0,37**	**0,3**	**0,36**	**0,41**	**0,32**	**0,41**	**0,42**	0,1
10	Fe[a,b]	mg/l	**0,53**	0,41	**0,63**	0,41	**0,63**	**0,74**	**0,58**	**0,69**	**0,66**	0,5
11	Total oil , grease [c]	mg/l	**0,65**	**0,6**	**0,62**	0,27	**0,51**	0,24	0,37	0,22	0,22	0,3
12	Coliforms[b]	MPN/100	930	930	**9300**	430	2300	2400	970	**4300**	**4300**	2500
13	E. coli[b]	MPN/100	4	43	7	4	**43**	**23**	**23**	17	17	20

From the analysis results shown on the table, compared with QCVN 08: 2015 / BTNMT National technical regulation on surface water quality, average value of samples in two seasons are shown as following:

- **BOD5** value (b) in all samples exceeds 2 to 6 times, COD value (b) exceeds 2 to 4 times
- Total suspended solid exceeds 4 to 6 times
- **Nitrate** (NO_3^- caculated according to N)[b], vượt từ không đáng kể đến 2,5 exceeding from negligible to 2.5 times
- **Mn[a,b]** value of several samples exceeds from 1 to 4 times
- The highest value of **Fe [a,b]** exceeds to 1.38 times
- Total oil, grease [c] exceeds 2.06 times
- **Coliforms[b]** detected in samples NM12, NM17,NM18 in rainy season exceeds 1 to 3 times.
- **E.Coli[b]** detected in samples NM2, NM8 in dry season and NM14, NM15, NM16 in rainny season exceed from 1 to 11 times.

Evaluation of the above results showed that in the rainy season, several indicators as BOD5; COD; TSS had higher value than that in dry season. All samples showed signs of heavy metal in spring water. Some samples had E.Coli, Coliforms value high suddenly. Base on these results and field surveys, it was found that the values of some polluted indicators are caused by the impact of nature and geology in combination with stone exploitation activities and agriculture production of local people in the basin. Besides, the practice of grazing cattle and poultry around the stream bank and exploiting aquatic resources led to a slight decline in the surface water quality of Ta Vai stream. As a result, the source of spring water was no longer guaranteed for use as domestic water according to QCVN 02: 2009 / BYT (National technical regulation on domestic water quality by the Ministry of Health. Herein, the research team proposed a water treatment line for Ta Vai spring, meeting the demand for water supply in daily life.

3.3. Proposing Ta Vai spring water treatment line to supply water for daily life

According to the above analysis results, Ta Vai spring water cannot be used for living due to it did not meet QCVN 02: 2009 / BYT [5]. The quality of Ta Vai spring water was strongly influenced by season, the parameters of BOD, COD, TSS, DO, Coliforms ... clearly change by agricultural production and cattle grazing of local residents. Therefore, it has become essential to provide a technological line to treat Ta Vai spring water for living purposes (as shown in Figure 3)

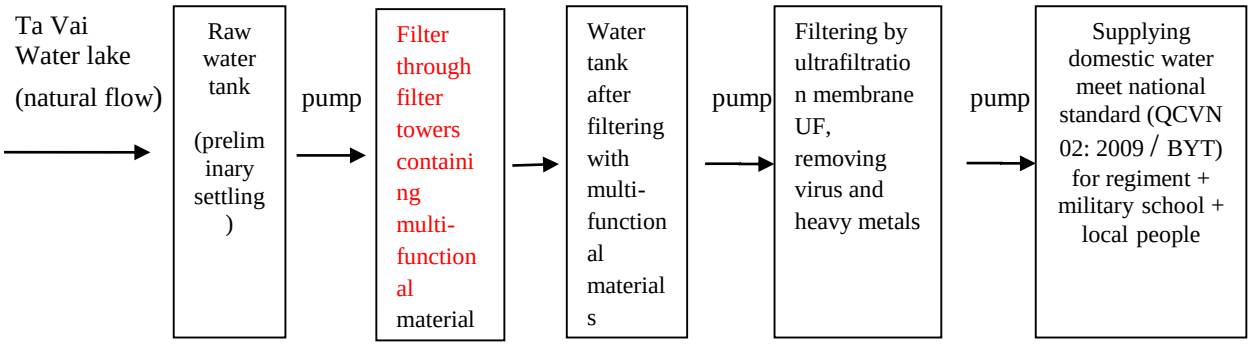
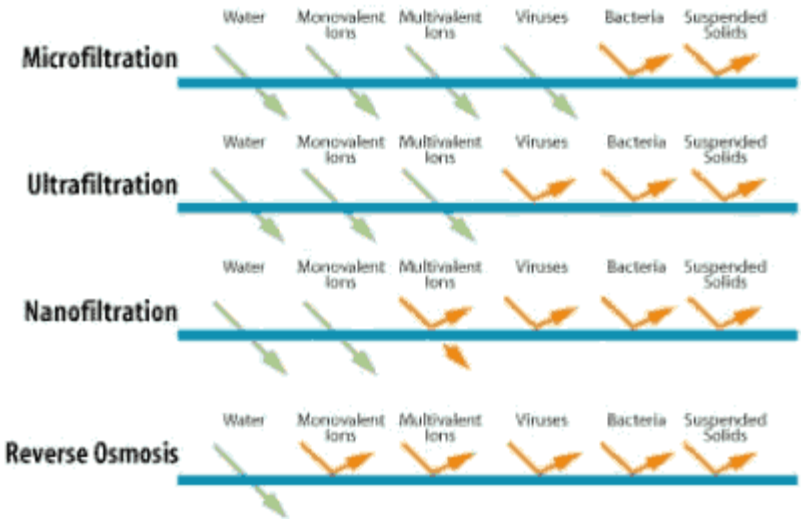


Figure 3. Ta Vai water treatment line into domestic water for 877 Regiment, Ha Giang province.

With the ultrafiltration membrane technology (UF) combined with multi-functional filter material (ODM-2F) will address this problem. The feature of UF ultrafiltration membrane (Ultra Filter) shown in Figure 4.



**UF: Filter Membrance [7]*

Figure 4. The ability to retain impurities (suspension, bacteria and viruses) of UF filter

UF filters can be used after 3-5 years with high filtration performance of material when combined with ODM-2F filter material. In some cases in the dry season, when the water quality is good, we can only use ODM-2F filter materials to filter Ta Vai spring water, which has achieved water quality according to QCVN 08-2015 / BTNMT

3. Conclusions

Through analysis of the catchment area (30km^2), capacity (The amount of water input into the reservoir in the dry season was: 300,000 m^3 and the rainy season was 1,620,000 m^3), and the flow of Ta Vai stream, the results showed that this was a useful water source for

domestic water supply and production activities of indigenous people and regiment 877 in the watershed area.

Ta Vai spring water was slightly polluted. Some indicators (BOD5, COD, Total suspended solids, Nitrate (NO3- calculated by N), Mn, total oil, grease, Coliforms and E.Coli (b) detected in both dry and rainy seasons.

The water treatment line consists of modules (multi-functional filter materials ODM-2F in combination with UF ultrafiltration membrane), which has been proposed to treat Ta Vai spring water to meet the standard of domestic water supply.

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