

CURRENT SITUATION OF SALINIZATION AND WATER EXPLOITATION AT THE LOWER SECTION OF MA RIVER SYSTEM, THANH HOA PROVINCE IN THE PERIOD 2005 - 2015

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Abstract: *The lower section of Ma river system is facing complicated salinization, depending on its morphology, slope, tide regime and the increasing effect of climate change. As a result, for effective exploitation of fresh water (salinity $\leq 1.0\text{‰}$) it needs to take care of the impact of tide regime on rivers' salinization. Using data of "History of the tide" of Thanh Hoa Hydrometeorology center in some details to limit damages in water supply for irrigation and living of residents in coastal districts of Nga Son, Hau Loc, Hoang Hoa, Quang Xuong, Sam Son city and Thanh Hoa city.*

Keywords: *Salinization, lower section of Ma River, water resource, Thanh Hoa.*

1. Rationale for the study

Thanh Hoa province is a bridge between the Northern Delta and the South Central Coast. On the territory of the province located the third largest river system of the country, that is Ma river system. Ma river system plays an important role in the formation of natural landscape as well as socio-economic development of Thanh Hoa province. The total amount of water flows in the river system is 20.1km^3 per year, which is a significant source of water supply for living and production of residents. Alluvium of the river is the main source to raise the level of Thanh Hoa plain, the third largest plain of Vietnam. Moreover, Thanh Hoa province is bounded by the South Bien Dong in the east with the coastline of 102km long. Thus, there is a high risk of salinization at the river mouth of Ma river system. Evaluating current situation of salinization at the lower section of this river system not only serves water management and exploitation for living of people in Thanh Hoa plain, but also forecasts and prevents salinization risk, diminishes potential damages.

The study "*Current situation of salinization and water exploitation at the lower section of Ma river system, Thanh Hoa province in the period 2005 - 2015*" is a significant basis for water management and exploitation in Thanh Hoa's territory.

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2. Literature review

Surveys on water resource in Thanh Hoa province have been carried out since the late 1970s by agencies, such as the Northern Water Resources Planning and Investigation Federation; National Center for Meteorology and Hydrography; Water Resources Planning and Investigation Organization 2F; Department of Natural Resources and Environment of Thanh Hoa province; Thanh Hoa Department of Agriculture and Rural Development. Research of these agencies were presented in the form of written reports. In recent years, the number of studies on water resource and salinization in Thanh Hoa's territory is small and they were mostly taken by Department of Natural Resources and Environment of Thanh Hoa province. Studies focusing on salinization at the lower section of the river system are more uncommon and dispersed, except data annually collected by Thanh Hoa Hydrometeorology Center. Besides, there are several studies of Thanh Hoa's territory such as Thanh Hoa Geography (2005) by Assoc. Prof Le Van Truong [3], Thanh Hoa Monograph, volume 1 (2006). However, these studies only presented generally about natural and socio-economic conditions of Thanh Hoa province without assessing the detail of water resource and salinization at the coastal areas.

3. Methodology

3.1. Data collecting, analyzing and processing method

Data for this study was collected from Department of Natural Resources and Environment of Thanh Hoa province and Thanh Hoa Hydrometeorology Center. Collected figures were classified, then processed into tables, charts and maps.

3.2. Cartographic method - GIS

Based on the data of water resource and salinization at the river mouth of Thanh Hoa's territory; cartographic method has been used for contributing a map of salinization at the river mouth of Thanh Hoa province.

3.3. Field-work method

Some field trips were carried out to the lower section of Ma River system to collect data and take water samples for salinity investigation. In addition, these observations are necessary to give objective and practical conclusions.

3.4. Assessment method

This method was used when comparing salinization figures of Ma river system, Thanh Hoa Province with national environmental standards. Thereby, current situation of salinization in the Province would be clear and recommendations could be given for management and sustainable exploitation of water resource.

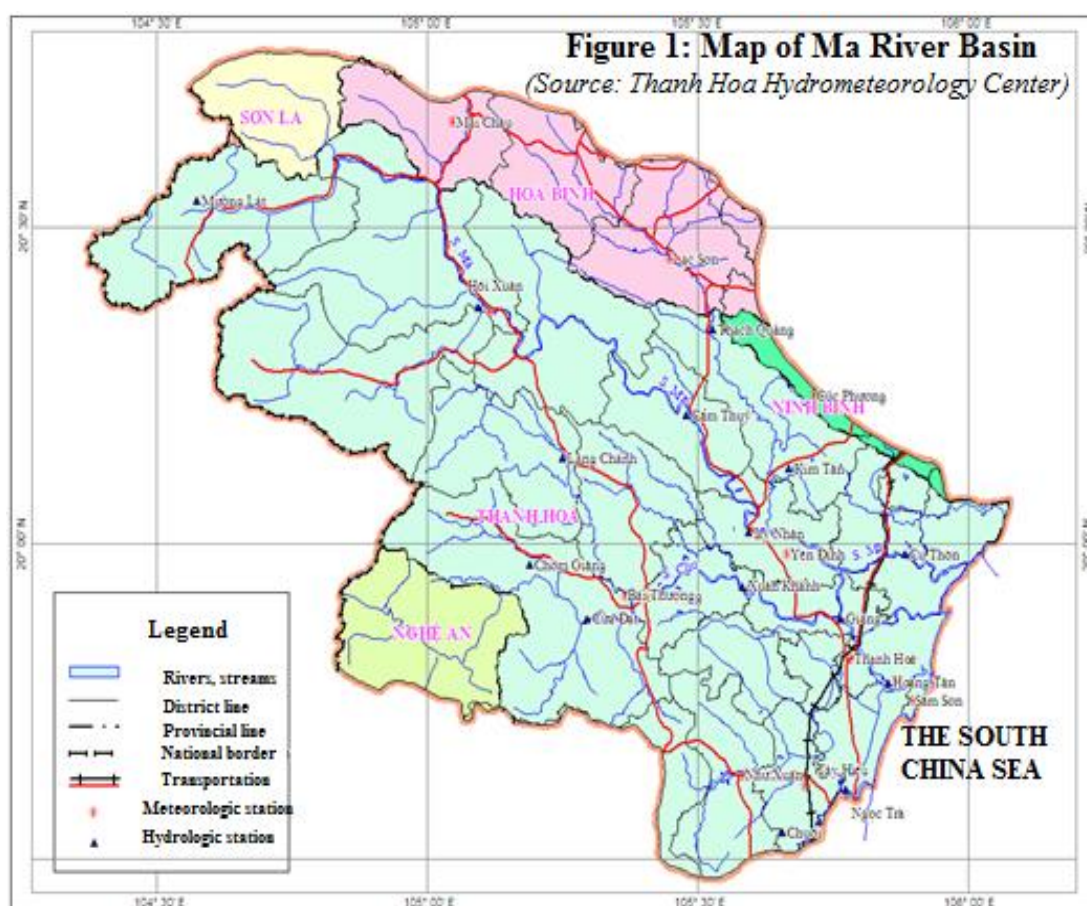
4. Result of study

4.1. Tidal characteristics at the lower section of Ma river system

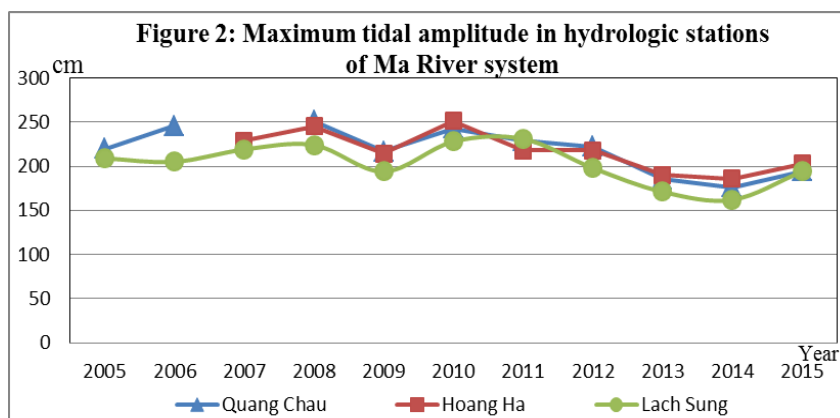
Tidal characteristics at the tidal section of Ma river system are similar to the tidal regime's of Thanh Hoa's coastal area, it is inhomogeneous diurnal tide. There is one flood-tide and one ebb-tide in most days of a month. The time for a flood-tide is 8 - 9 hours and an ebb-tide is 16 - 17 hours in average. The tidal movement is uninterrupted over space and time.

By time, a tidal cycle lasts averagely 13 - 14 hours and includes three periods:

- The ebb-tide period: 2 - 3 days, the crest of tide is low, the ebb-tide is high, the tidal amplitude is small.
- The flood-tide period: 3 - 5 days, the crest of tide is high, the ebb-tide is low, the tidal amplitude is high.
- The transition period: 4 - 6 days, all the crest of tide, the ebb-tide and the tidal amplitude are medium.



By space, the tidal amplitude decreases gradually from the river mouth to the upstream. Ebb-tide and flood-tide appear slowly from the sea to inland.



(Data source: Department of Natural Resources and Environment of Thanh Hoa province)

4.2. Current situation of salinization at the lower section of Ma river system

Salinity movement at the lower section of Ma river system is similar to tidal level. Collected data shows that in a tide the maximum salinity occurs at the same time or 1 - 2 hours later than the crest of tide; the minimum salinity occurs simultaneously with the ebb-tide. By the water depth, salinity increases steadily from the surface to the bottom. Salinity of river water in Ma river system was given in table 1.

Table 1. Salinity of river water in some hydrologic stations of Ma River system (in ‰)

| Year | Giang | | Ham Rong | | Nguyet Vien | | Quang Chau | |
|---------|-------|------|----------|------|-------------|------|------------|------|
| | Max | Min | Max | Min | Max | Min | Max | Min |
| 2005 | | | | | 14.7 | | 29.7 | |
| 2006 | | | | | 12.0 | | 28.1 | |
| 2007 | 2.3 | 0.1 | 9.2 | 0.1 | 14.4 | 0.5 | | |
| 2008 | 1.2 | 0.1 | 9.0 | 0.1 | 12.6 | 0.1 | 27.2 | 1.9 |
| 2009 | 0.2 | 0.1 | 6.7 | 0.1 | 9.8 | 0.1 | 26.7 | 1.3 |
| 2010 | 6.1 | 0.1 | 12.3 | 0.2 | 17.5 | 0.3 | 28.3 | 3.9 |
| 2011 | 0.7 | 0.1 | 6.5 | 0.1 | 9.8 | 0.1 | 24.0 | 0.3 |
| 2012 | 0.2 | 0.1 | 5.6 | 0.1 | 10.2 | 0.1 | 25.0 | 0.7 |
| 2013 | 0.6 | 0.1 | 7.0 | 0.1 | 9.5 | 0.1 | 26.1 | 1.0 |
| 2014 | 0.4 | 0.1 | 5.2 | 0.1 | 7.5 | 0.1 | 21.9 | 1.1 |
| 2015 | 0.7 | 0.1 | 3.0 | 0.1 | 5.6 | 0.1 | 21.6 | 0.4 |
| Average | 1.2 | 0.1 | 5.7 | 0.1 | 10.2 | 0.3 | 25.9 | 1.3 |
| Maximum | 6.1 | 0.1 | 13.5 | 0.3 | 17.5 | 2.5 | 29.7 | 3.9 |
| Year | 2010 | 1990 | 1999 | 1999 | 2010 | 1999 | 2005 | 2010 |

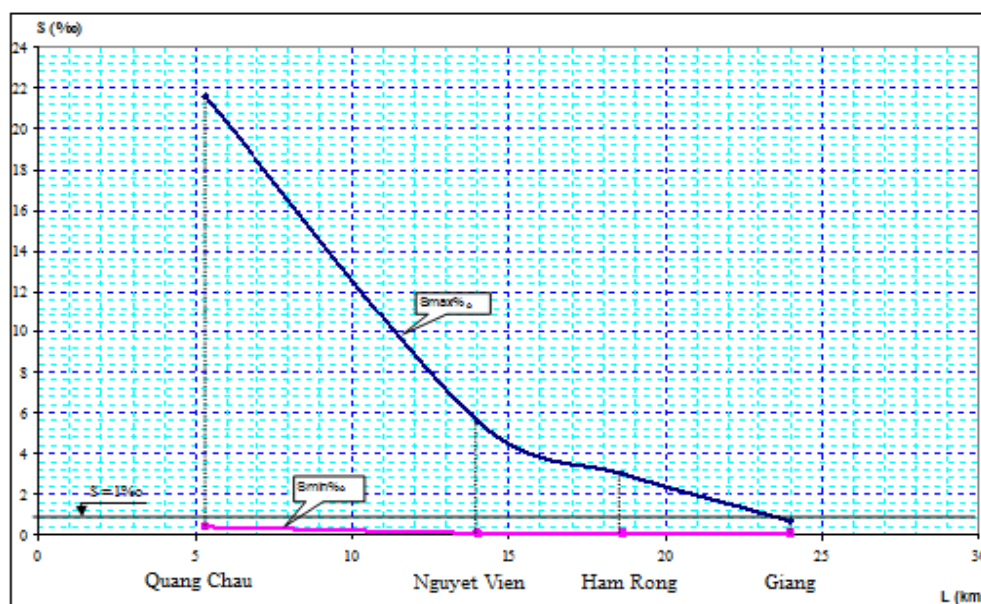
(Source: Department of Natural Resources and Environment of Thanh Hoa province)

The data in table 1 shows that the highest salinization occurred in 2010: in Ma river, salted water penetrated into land up to 29kms; in Len river was 22kms; in Yen river and Hoang river was 26kms; in Nhon river was 23kms; in Lach Truong and De channel, sea water broke into all rivers; in Hoat river, brine went up to My Quan Trang and in Bao Van river salted water infiltrated up to Bao Van. In comparison with in many years, salinity in some main rivers such as Ma and Len went to the highest in history in 2010. In particular, in Ma river, the highest salinity in Giang hydrologic station (24km from the estuary) is normally under 1.0‰, in some years, this salinity was above 1.0‰ such as 2007: 2.3‰; 2008: 1.2‰, only in 2010, salinity in this station reached 6.1‰. After 2010, salinity in all rivers of Ma river system has been decreased.

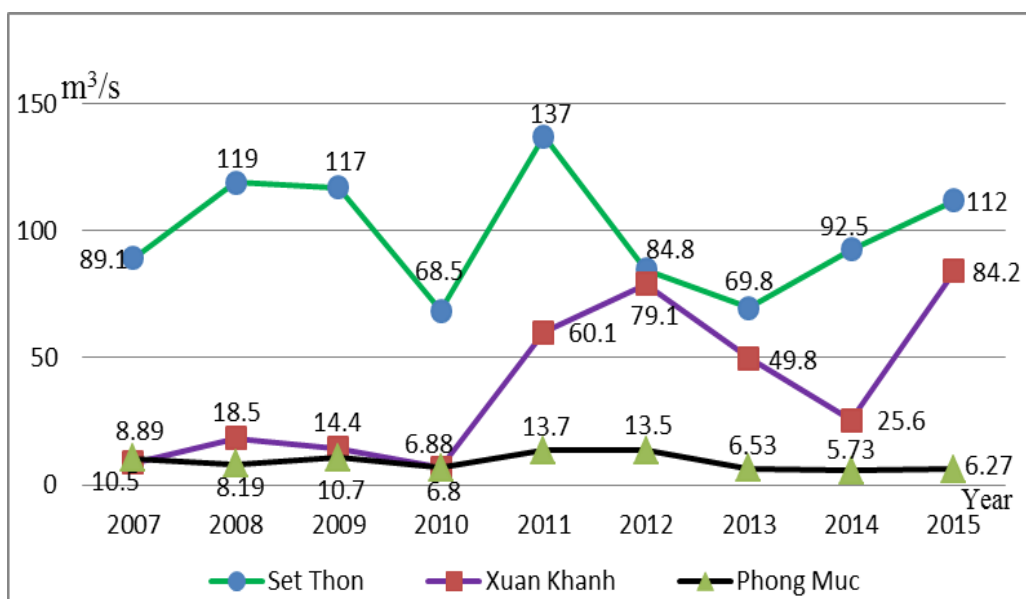
Because of seasonal water regime, salinization on Ma river system in studied period changed considerably by season. In dry season (from November to May), the rivers' flow dropped significantly, salinization penetrated further inland: salinity at rivers' mouths were high (26‰ - 28‰), the maximum exploitable salinity of 1‰ entered deeply (18 - 23kms). This phenomenon increased drought and salinization situation in dry season. In rainy season (from June to October), the rivers' flow rose and water level was high, salinity was not likely to infiltrate farther into the mainland. Additionally, the tide regime changed unpredictably in this wet season, especially in abnormal and harsh weather conditions caused by climate change.

By space, salinization in Ma river system fell slowly from river mouth to upstream due to the variation in the amount of water comes from upstream and the weakening of the tide. Salinity was at the highest in rivers' mouths which was equivalent to sea water (30‰ - 32‰). Figure 3 shows that salinization potential at the lower section of Ma river system was very high resulted from abnormal change on the rivers' flow (Figure 4) and high salinity in the rivers' mouths.

Figure 3. Changed salinity along Ma river, March 2015



(Source: Thanh Hoa Hydrometeorology center)

Figure 4. Average river's flow in hydrologic stations of Ma river system

(Data source: Department of Natural Resources and Environment of Thanh Hoa province)

Depending on tributaries, the level of salinity intrusion in rivers was also varied.

In Ma river: From Quang Chau (Quang Xuong district) to Giang Fork:

The crest of tide salinity: 0.7 - 21.6‰ (annual average: 1.3 - 26.9‰)

The ebb-tide salinity: 0.1 - 0.4‰ (annual average: 0.1 - 1.5‰)

Penetration of 1% salinity in river mouth: 23kms (Thieu Khanh commune, Thanh Hoa city).

In Len river: From Ganh Wharf (Hau Loc district) to Cu Thon (Ha Trung district):

The crest of tide salinity: 0.3 - 18.1‰ (annual average: 1.9 - 23.2‰).

The ebb-tide salinity: 0.1 - 0.4‰ (annual average: 0.1 - 1.7‰)

Penetration of 1% salinity in river mouth: 18.0kms (Ha Phu commune, Ha Trung district).

In Lach Truong river: From Hoang Ha (Hoang Hoa district) to Ma river distributary door:

The crest of tide salinity: 0.4 - 17.6‰ (annual average: 2.5 - 20.6‰)

The ebb-tide salinity: 0.1 - 0.5‰ (annual average: 0.1 - 1.6‰)

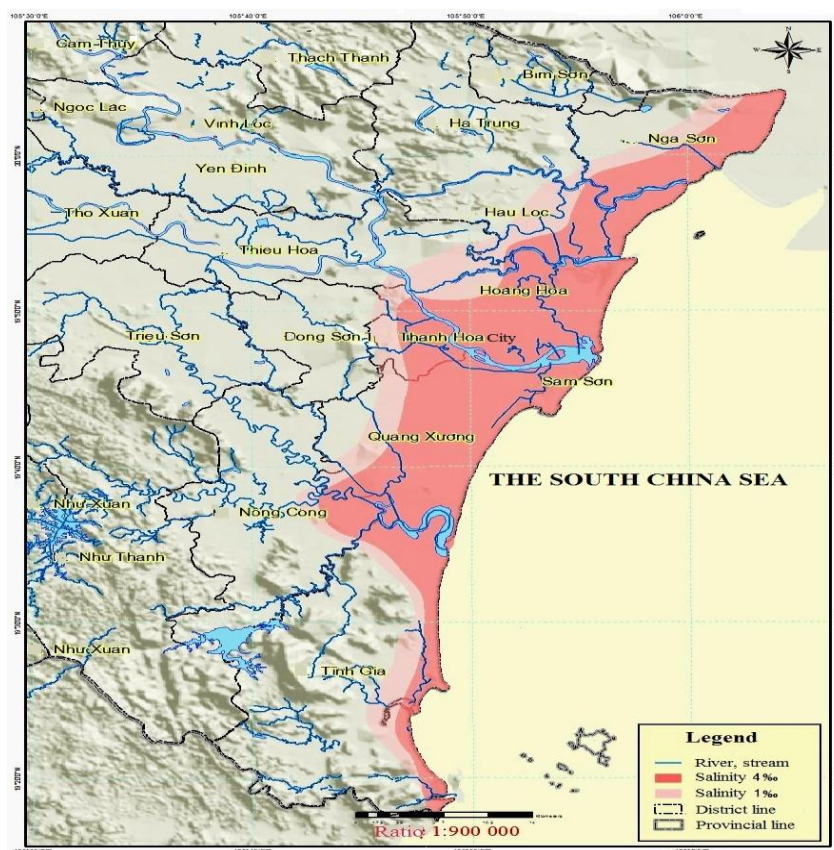
Penetration of 1% salinity in river mouth: 18kms (Hoang Hoa district)

In De channel: From Nam Huan wharf to De bridge (Hau Loc district):

The crest of tide salinity: 15.0 - 22.1‰ (annual average: 22.6 - 26.4‰)

The ebb-tide salinity: 0.2-3.9‰ (annual average: 0.8-5.3‰)

Penetration of 1‰ salinity in all the channel.

Figure 5. Map of salinization at the coastal area of Thanh Hoa province in March 2015

(Source: Thanh Hoa Hydrometeorology Center)

4.3. Impact of salinization to water exploitation at the lower section of Ma river system

The allowed salinity of water that can be exploited as freshwater is $\leq 1.0\%$. Based on the collected data, freshwater that can be exploited in Ma river system is as follows:

River sections that can be exploited freshwater continuously (Non-saline)

In these river sections, water can be exploited continuously without considering influences of tide. However, for the best use of water it is recommended to exploit water on the flood-tide.

| | |
|--------------------------|--|
| Ma river | From Giang to upstream : 23kms from the sea |
| Lach Truong river | From Van Ninh to upstream : 17.5kms from the sea |
| Len river | From Cu Thon to upstream : 18kms from the sea |
| Yen river | From Ben Mam to upstream : 25kms from the sea |
| Hoang river | From Quang Ngoc to upstream : 23kms from the sea |
| Nhom river | From Cau Lac to upstream : 23kms from the sea |

The range of freshwater use on these river sections is applied in flood-tide days in dry season; in the days of low tide, salinity cannot influence deeply on the rivers so that the range can be receded a little downstream. Nevertheless, due to complicated combining two-way flows at the lower section, it needs to be aware of tide - salinity rules in order to take advantage of river water in a reasonable manner.

River sections that can be exploited for freshwater (Saline)

| | |
|--------------------------|---|
| Ma river | Giang - Quang Chau : 6 - 23kms from the sea |
| Len river | Cu Thon - Tham Ferry : 9 - 18kms from the sea |
| Lach Truong river | Van Ninh - Hoang Ha : 12 - 18kms from the sea |
| Yen river | Ben Mam - Ngoc Tra : 12 - 25kms from the sea |
| Hoang river | From Quang Ngoc downward : < 23kms from the sea |
| Nhom river | From Lac Bridge downward : < 23kms from the sea |

In these river sections, the time for freshwater exploitation depends on tide - salinity development, location and river. It is recommended to exploit freshwater in ebb-tide days because in these days the tidal pressure is reduced; therefore, salinity is lower than in flood-tide days. Water can be also exploited before and after the ebb-tide when salinity is at the lowest.

River sections that cannot be exploited freshwater (Heavy saline)

| | |
|-------------------|--|
| Ma river | From Quang Chau to the sea : 0 - 6kms from the sea |
| Len river | From Tham Ferry to the sea : 0 - 9kms from the sea |
| Lach Truong river | From Hoang Ha to the sea : 0 - 12kms from the sea |
| Yen river | From Ngoc Tra to the sea : 0 - 12kms from the sea |

Because these river sections are next to the sea, tide and salinity are all highly penetrated. The lowest salinity is from 1.0‰ and above. Therefore, the tide - salinity development needs to be comprehended when exploiting water source.

5. Conclusion and recommendation

The tidal river section of Ma river system (the coastal plain) in the territory of districts: Nga Son, Hau Loc, Hoang Hoa, Thanh Hoa city, Sam Son city, Quang Xuong, Nong Cong and Tinh Gia, is a region with diversified socio-economic development potential and crowded population. Water supply for living and economic development of the region is very high and urgent. However, freshwater exploitation in this tidal area faced many difficulties because characteristic of tidal regime in dry season was affected by salinisation. Moreover, in recent years, the flows on main rivers in dry season decreased, leading to droughts and water shortages, deeper salinization inland, making it difficult for agricultural production.

In the studied period (2005 - 2015), the highest salinization occurred in 2010. Although salinity in recent years went down, especially on Lach Truong river (normally, sea water breaks into all the river, but in 2015, it went up only 17kms in Hoang Dat commune, Hoang Hoa district), this was not the general trend because the tide - salinity development would be even more complicated under impacts of climate change. This is another factor leading to salinization potential at the lower section of Ma river system has been threaten the living and production of residents. Besides tidal factor, penetration of salinity into rivers also depends on rivers' morphology, rivers' slope, weather conditions and human impacts. In order to effectively exploit freshwater of Ma river system (salinity $\leq 1.0\text{‰}$) in dry season, some points below need to be attended:

Exploiting freshwater at the tidal river sections is conditional exploitation (depending on tide - salinity development). The safe time for pumping water (under allowed salinity) bases on river section, tide, and time.

Taking advantage of ebb-tide days when salinity of rivers is low to exploit water. When pumping stagnant water in flood-tide days, it is necessary to check and monitor the salinity development because this time is quite short and the salinity often changes very fast.

Annually, Hydrometeorology Center has published "History of the tide" in some details; thus, freshwater exploitation process should apply this to seize the tidal regime on river systems of Thanh Hoa province to limit damages and take advantages of tide at the highest level.

References

- [1] Ban Cu XTN. *Ma River: Mother River* (2016) (Online) Available at: <https://xuthanhnet.wordpress.com/2011/11/05/dong-song-m%E1%BA%B9/>
- [2] Electronic portal of Thanh Hoa Province (2016), *Introduction: Natural conditions* (Online) Available at: <http://thanhhoa.gov.vn/portal/pages/dieu-kien-tu-nhien.aspx>
- [3] Le Van Truong (2005), *Thanh Hoa Geography*, Hanoi National University. Hanoi.
- [4] Department of Natural resources and Environment of Thanh Hoa province (2015), *Report on investigating tide - salinity development at the lower section of Ma River system, Yen River system and Lach Bang River system*.
- [5] Thanh Hoa Hydrometeorology Center (2016), *Report on Hydrology at the lower section of rivers in Thanh Hoa Province*.