ASSESSING THE GROUNDWATER SALINITY IN HAU LOC DISTRICT, THANH HOA PROVINCE FOR PROPER MITIGATION MEASURES

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Abstract: *Water is a vital resource for the survival and development of humanity. However, this resource is not endless. Today, water demand for domestic use and production is increasing in the context of climate change, natural disasters and pollution, significantly causing the depletion of water resources both in terms of quantity and quality. This research has analyzed, evaluated ground water salinity in Hau Loc district, Thanh Hoa province by determining the concentration Chloride-Silver nitrate titration with Chromate indicator (MO Method) and establishing a zoning map of salinity. The results showed the groundwater at researched areas was being saline over the allowable standards many times. The highest salinity concentration of Cl^- exceeded 15 times the allowable standards. This study consequently proposed some solutions for efficient using of water and reducing the groundwater salinity level in the region.*

Keywords: *Groundwater salinity, salinity mitigation measure, Hau Loc district groundwater.*

1. Introduction

1.1. Geographical location

Hau Loc district is a coastal plain located in the northeast of Thanh Hoa province, 25kmaway from Thanh Hoa city. Located in the coordinates from 19° North latitude, 105° East longitude.

It is bordered with Ha Trung and Nga Son district by the North respectively.

It is bordered with Hoang Hoa district by the West and South through Son Trang mountain.

East-side is adjacent to the sea.

With a total area of natural land is 141.5 km, Hau Loc is divided into 27 administrative units including 1 town (Hau Loc), 26 communes: Dong Loc, Dai Loc, Trieu Loc, Chau Loc, Tien Loc, Loc Son, Cau Loc, Thanh Loc, Tuy Loc, Phong Loc, My Loc, Van Loc, Thuan Loc,

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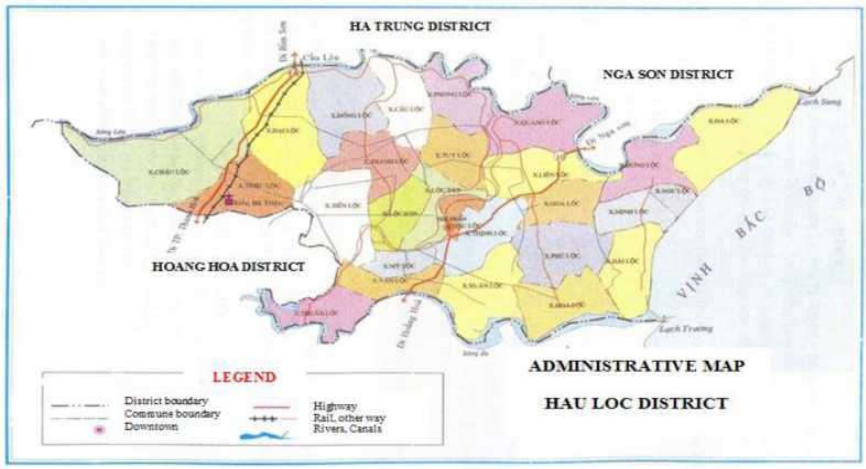

Figure 1. *Administrative map at Hau Loc district*

1.2. Groundwater characteristics

According to data from Thanh Hoa Centre for Hydro-Meteorological Forecasting in February 1998, the coastal land in Hau Loc includes two 2 layers of groundwater. Upper layer (superficial) with a depth of 10 - 15 meters contains relatively abundant water; well-water flow rate reaches 0.7 - 1.7 l/s; and the mineralization below 1g/ l. At the deeper layers (deep vessels) with weak pressure, well-water flow rate reaches 15-17 l/s (Figure 2) [3].

Groundwater salinity occurred in the region, causing water salinity at many wells to exceed permissible standards for drinking [3]. This water source is mainly used for daily activities of residents, therefore, it is crucial to assess the quality of the groundwater in this area.

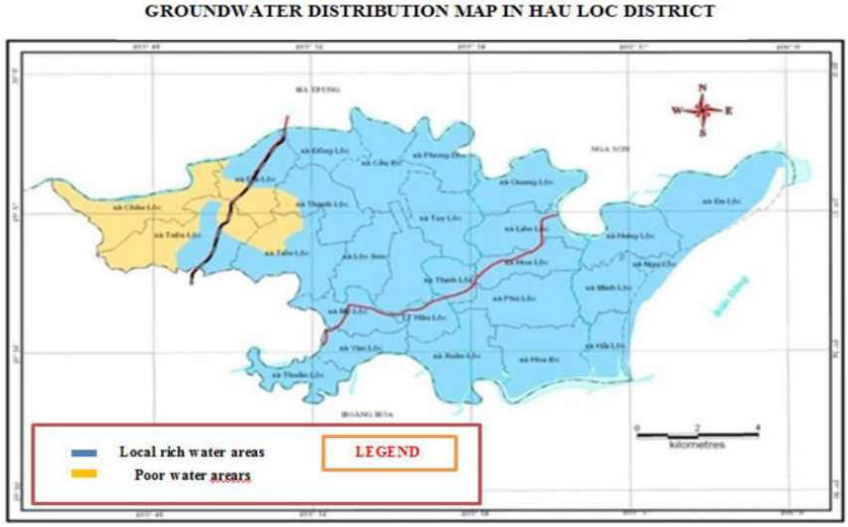

Figure 2. *Groundwater Distribution in Hau Loc district [3]*

2. Methodology

a) Inheritance method

Collect, review documents and inherit the scientific research results, especially the results of the current state of economic, social, environmental and groundwater at Hau Loc district.

b) Analysis, synthesis and data processing methods

The collected data of natural conditions, economic - social condition and environment will be selected, analyzed, synthesized and processed in line with the research objectives.

c) Groundwater sampling method

General regulations:

Groundwater sampling method is based on the following regulations:

TCVN 6663-1:2011 (ISO 5667-1:2006) - Water quality- Part 1: Guidance on the sampling program and sampling techniques.

VN standard 6663-3:2008 (ISO 5667-3:2003) - Water quality - Sampling. Guide to storage and handling of samples.

VN standard 6663:2011 (ISO 5667-11:2009) - Water quality - Sampling. Part 11: Guidance on sampling of groundwater.

Water sample analysis was carried out in 3 days from 7/5 to 9/5/2012 at the laboratory of Department of Environmental Engineering Environmental Sciences University of Natural Sciences, National University of Hanoi.

Sampling Method: Sampling by pump and sampling in depth

Analysis Method: According to ISO 6194-1996, Water quality - Determination of chloride - Silver nitrate titration with chromate indicator (Mohr's method)

Method of evaluating results: Based on VN National Standard 09:2008/ MONRE on National technical regulation on underground water quality, which stipulates the chloride limit value is 250 mg/l (Cl^- standard is not changed compared to VN National Standard 09: 2015/ MONRE).

Method of mapping by interpolation: Based on chlorine concentration results in the area and Arc GIS software for establishing the zoning map of salinity

3. Results and discussion

3.1. Results

The analytical results of chloride concentrations in water samples are presented in Table 1.

Table 1. *The concentration of Cl^- in the groundwater*

No	Sampling locations		Wells	Depth (m)	Concentration of Cl^- (mg/l)
	Latitude	Longitude			
1	19.9117	105.86208	Drilling machine	40	158.12
2	19.908336	105.87723	Drilling machine	30	1074.935

3	19.906951	105.88565	Manual drill	8	1639.347
4	19.915657	105.89049	Drilling machine	32	1134.496
5	19.919812	105.89512	Drilling machine	30	1758.469
6	19.929705	105.89028	Drilling machine	28	783.52
7	19.926737	105.8505	Manual drill	7	38.998
8	19.939598	105.84124	Manual drill	6	146.066
9	19.921988	105.88607	Drilling machine	45	53.18
10	19.920405	105.87555	Deep-well	10	198.537
11	19.938213	105.88144	Drilling machine	20	316.95
12	19.940983	105.87113	Manual drill	8	301.351
13	19.92555	105.86545	Manual drill	9	768.621
14	19.902598	105.89618	Manual drill	6	737.422
15	19.916844	105.90501	Manual drill	7	1352.886
16	19.889342	105.90102	Manual drill	5	2188.632
17	19.930298	10.91385	Manual drill	7	54.598
18	19.932673	105.92817	Drilling machine	20	248.171
19	19.922384	105.92396	Manual drill	8	150.321
20	19.912689	105.9248	Drilling machine	18	42.544
21	19.904775	105.92522	Drilling machine	15	195.701
22	19.904775	105.92375	Manual drill	10	3935.283
23	19.947908	105.95784	Drilling machine	30	524.704
24	19.935443	105.94711	Drilling machine	25	124.086
25	19.942566	105.97152	Manual drill	7	51.052
26	19.95879	105.98604	Manual drill	8	36.871
27	19.927528	105.93995	Drilling machine	7	131.176
28	19.91724	105.95153	Manual drill	5	211.3
29	19.91724	105.93785	Drilling machine	12	160.957
30	19.93109	105.96352	Manual drill	6.5	250.302
31	19.926143	105.95826	Manual drill	5	243.208
32	19.893892	105.94627	Drilling machine	70	1396.848
33	19.908732	105.94753	Drilling machine	68	1045.812
34	19.942763	105.92396	Drilling machine	15	561.576
35	19.944148	105.90796	Drilling machine	20	155.993
36	19.945533	105.89302	Drilling machine	43	972.638
37	19.956416	105.91722	Drilling machine	50	791.569
38	19.891914	105.85156	Drilling machine	25	439.617
39	19.890529	105.83914	Drilling machine	38	150.321
40	19.902994	105.86019	Drilling machine	25	269.443
41	19.897454	105.86797	Drilling machine	20	1437.974
42	19.902994	105.89554	Drilling machine	45	379.612

The chloride concentration in the region generally fluctuates in a wide range. There are many high values of chloride concentration. Based on location of sampling sites and the chloride concentration it shows the dependence of salinity level on the sampling locations adjacent to the coastline and salinity river shoreline.

Many places located close to each other in the same area, but the Cl^- concentration showed a large difference. For example, the sample 1 taken in Tran Phu, My Loc showed the Cl- concentration of 158.120 mg/l, while the sample 2 is taken in Dai Huu, My Loc showed Cl- concentration of up to 1074.935 mg/ l.

Some water samples were taken in shallow layer, from 7m to 9m, especially in coastal areas such as the Ngu Loc, Xuan Loc, Minh Loc, Da Loc, etc. Because of the characteristic of sandy soil, water was found even in a very shallow layer. However, at this depth, the groundwater was influenced by a lot of surface water causing seasonal and unstable salinity variation.

According to Vietnam National Standard 09:2008/MONRE, the allowable concentration of Cl^- is 250mg/l. The analytical results showed a lot of water samples beyond the standard. For example: the sample 16 (Huu Nghia, Xuan Loc) is 2188.632 mg/l (more than 8.7 times the regulations) and the sample 32 (Truong Nam, Hai Loc) is 1396.848 mg/l (more than 5.5 times the regulations), the sample 41 (My Dien, Van Loc) is 1437.974 mg/l (6 times regulation), the sample 22 (Hoa Ngu, Hoa Loc) showed the largest concentration of chloride of 3935.283 mg/l (more than 15 times the regulations).

The analytical results of the concentration Cl^- were mapped on the Figure 3 below:

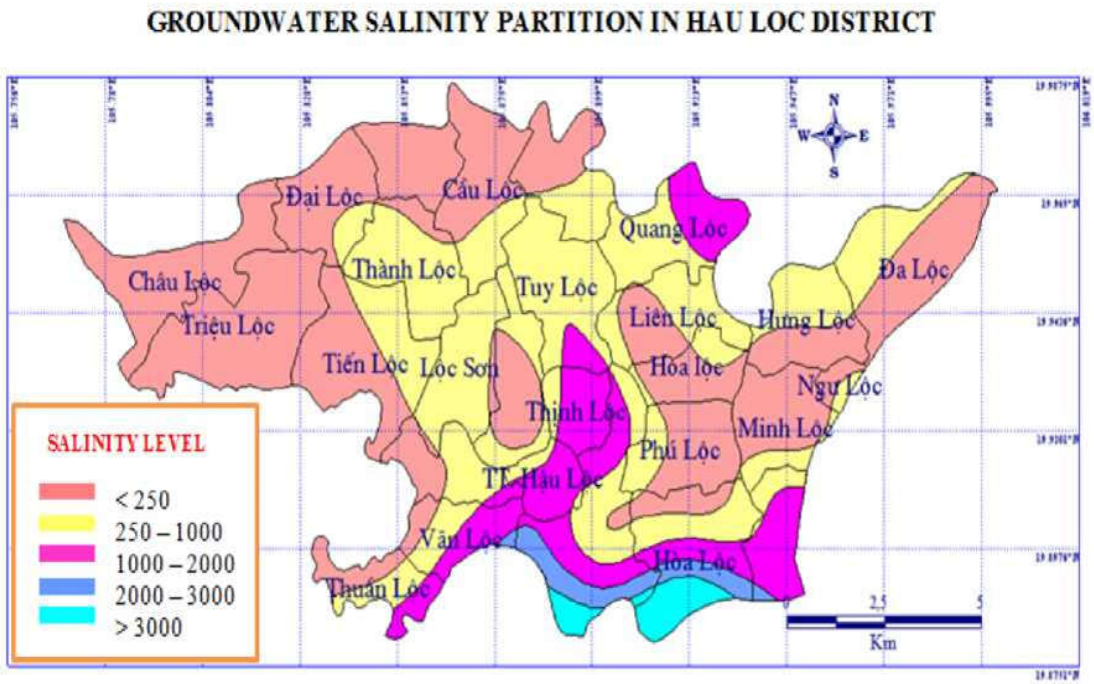

Figure 3. *Groundwater Salinity Partition in Hau Loc district*

3.2. Assessing groundwater situation in Hau Loc district

3.2.1. Causes of groundwater salinity

Due to the seawater intrusion when the hydraulic pressure of the ground water is below sea level. This phenomenon occurs when there is a change in equilibrium conditions of natural groundwater or overexploitation of this water source caused lower groundwater level, leading to the displacement of saline toward land. Specifically, Hau Loc district with 12 km of sea dikes along the diverse hydrological system including four rivers: Len river, Kenh De, Lach Truong, Tra Giang and two large estuaries Lach Sung, Lach Truong, which has a big impact on the groundwater. In the dry season the rivers often have low flow water level, usually lower than sea level. The tide therefore can cause salt water intrusion into the river and saline groundwater at many areas, for example at the coastal communes: Ngu Loc, Hoa Loc and estuaries: Xuan Loc, My Dien - Van Loc, with very high level of salinity. However, salinity at Da Loc - a commune located in the coastal region was under 250mg/l, which is explained by the circulation and abundant flow of the Len river restricting the saltwater intrusion from the sea.

Discrete stratum structure is also a cause of groundwater salinization. In coastal areas, the discrete structure makes evaporation phenomenon occur strongly and saltwater easily penetrate into the soil, rivers, groundwater.

The production activities of people are also a cause of increased water salinity. For example, salt production or the sea water using for aquaculture (shrimp farms) at Hai Loc and Hoa Loc.

3.2.2. The ability of the water supply and salinity tendency at Hau Loc district

The increasing groundwater exploitation for living and production activities would decline groundwater reserves.

Groundwater reserves in Hau Loc district was abundant in the past [1]. However, because of growing population and economic development, the demand for water (surface and groundwater) is gradually increasing, leading to groundwater shortage recently. This increases the potential for saltwater intrusion into the groundwater.

Impact of climate change and sea level rise on the groundwater source.

Under the influence of climate change, sea level rise and increasing temperature in the region. The change of these factors have reduced the additional surface water into groundwater especially in the dry season leading to an increase in the penetration of saltwater into groundwater both in terms of scale and concentration.

For the wells in the coastal region, water quality will be affected by saltwater intrusion, causing salinity to increase and decrease of groundwater reserves.

4. Mitigation measures for groundwater salinity

4.1. Saving water

In the area where water is used mostly in agriculture, it should be focused on securing water resources for crops in conditions of climate change by specific measures:

Complete irrigation systems to reduce water losses and leaks by concrete solutions and solidifying canals. These measures are priorities in the strategic management and use of water for agricultural production, in order to reduce the pressure of local groundwater resources.

Look at the scientific irrigation technology applied to save water while improving crop yields: drip irrigation on crop farming area in the water scarcity, or saline areas, etc. in order to save irrigation water and adapt to harsh climate change.

Dig ponds to store water during the rainy season in order to irrigate crop areas at the high hills. Develop and apply agriculture combine aquaculture models: dig a pond to store water, use waterproof materials, combine fishing with farming.

4.2. Construction of the station, centralized water supply plant

With the increasing groundwater salinity and the demand for sanitary water, it's necessary to construct water stations/plants for residential and other welfare needs; especially under the impact of climate change today. The specific directions are as follows:

Construction of water stations/plants to provide water for expected focus areas/industrial complex and large population centers from the Ma river surface water source. For example, the clean water plant construction at Chau Loc commune to provide clean water for the Chau Loc industrial parks and towns from Van Loc to Thinh Loc.

Construction of water mining station to exploit clean water with no salinity to provide for coastal areas such as Da Loc, Ngu Loc, Xuan Loc...

4.3. Protection and management of water resources

The management of groundwater resources now requires the participation of all levels in a systematic manner.

Problem of management, protection of natural resources is now being concerned by the Government. Therefore, management and protection of water resources must comply with the document No.22-LCT/HDNN dated August 7, 1989 on natural resources, minerals and other by laws.

Continue to implement the projects of planning, exploitation, using and protecting underground water resources. Besides, define restricted areas, the limited groundwater extraction and cataloging, the partition map.

Promotes helping people deal with the saltwater intrusion, be active in production and life activities consistent with the characteristics of each ecological region. Research, provide salinity water treatment methods for people or promote the planning and construction of clean water plants to provide drinking water for the population in areas severely affected by salinity.

5. Conclusion

Results of water sample analysis and the partition mapping of groundwater salinity level at Hau Loc district has shown the current status and forecast salinity tendency of each

area in the district. Salinity level at many areas in the district still meets allowable standards, such as at Tan Loc and Loc Son, Tien Loc, Hoa Loc, Phu Loc, etc. However, 50% water-well samples have high level of salinity, which exceeded 15 times the standards. The highest salinity is determined in the coastal communities and the estuary areas such as Ngu Loc, Hai Loc, Hoa Loc, Xuan Loc and Phu Loc, Van Loc, Tuy Loc, Quang Loc. The salinity is caused by seawater intrusion into the aquifer.

Salt water intrusion is an important issue and has a great influence on the production and daily activities of local people at Hau Loc district. The groundwater salinity situation is increasing both in terms of scale and concentration and need to be addressed to ensure sustainable development of Hau Loc district.

References

[1] Nguyen Van Dan, Vo Cong Nghiep, Dang Huu On (1996), *The groundwater of the North Central Coast of Vietnam*, Department of Geology published and copyrighted.

[2] Le Duc, Tran Khac Hiep, Nguyen Xuan Cu, Pham Van Khang, Nguyen Ngoc Minh City (2004), *Some methods of environmental analysis*, of Hanoi National University Publishing House.

[3] Luu Duc Hai and his team (2007), *Research on environmental planning at district level, applications for specific districts (Thuong Xuan, Tho Xuan, Hau Loc) in Thanh Hoa Province*, Report synthetic VNUlevel key themes - QGTD.06- 10.

[4] Hau Loc District People's Committee, *The Economic and Social report 2006, 2007, 2008, 2009, 2010, 2011.*