Groundwater Management in Việt Nam

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Abstract: *Groundwater in Việt Nam occurs in many formations such as loose sediments, carbonate rocks, terrigenous sediments and basalt. The natural dynamic reserve is 128,500,000 m^3/day.*

The quality of groundwater in Việt Nam is generally good for the water supply. In some regions, the groundwater is contaminated by arsenic, nitrogen and organic matter.

The problems of the groundwater management in Viet Nam must obey the law of water resource.

I. OVERVIEW OF GROUNDWATER IN VIỆT NAM

1. Hydrogeological regions

The Vietnamese territory can be divided into 6 hydrogeological regions (HGR):

- West Bắc Bộ HGR located in folded mountain structure in West Bắc Bộ. This is a complicated hydrogeological region.

- East Bắc Bộ HGR belonging to formation of mountainous area in East Bắc Bộ.

- Bắc Bộ Delta HGR including the whole delta plain in North Việt Nam, which extends from Việt Trì City to the East Sea. This delta is built up by Red and Thái Bình River systems.

- North Trung Bộ HGR including coastal plain provinces in the north of Central Việt Nam such as Thanh Hóa, Nghệ An, Hà Tĩnh, Quảng Bình and Thừa Thiên – Huế.

- South Trung Bộ HGR including coastal plain provinces in the south of Central Việt Nam such as Tuy Hoà, Bình Thuận and Nha Trang – Khánh Hoà.

- Nam Bộ Delta HGR including the whole delta plain of Mekong and Đồng Nai River systems.

2. Main water-bearing formations

Groundwater on the Vietnamese territory exists in following formations:

a. Groundwater in loose sediments

Groundwater in loose sediments is distributed mainly in two large deltas: the Bắc Bộ delta plain in North Việt Nam and the Nam Bộ delta plain in South Việt Nam, which correspond to two hydrogeological regions. A part of it exists in loose sediments of coastal plains of Central Việt Nam.

In the Bắc Bộ and Trung Bộ plains, groundwater exists mainly in two aquifers, namely the Holocene aquifer in the upper part and the Pleistocene in lower part. In general, these aquifers are rather abundant in reserves, with the water of high quality, therefore they can meet the water demand. In some areas, the water is salted or has pollution manifestation by exogenous factors.

In the Nam Bộ plain of South Việt Nam, groundwater is abundant but the upper part is mainly salted, so that it cannot be used for living activities. The freshwater is distributed in rather great depth part. It has high quality and can satisfy large water demand of the life.

In the coastal plains of Central Việt Nam and loose sediments in piedmont areas, the groundwater has good quality but small reserves. It can meet the demand of medium or small scale, except some areas where it can be supplied with large amount.

b. Groundwater in basalts

Groundwater in basalts is distributed mainly in the Tây Nguyên plateau belonging to the Kon Tum, Gia Lai, Đắc Lắk, Lâm Đồng Provinces and some provinces of South Trung Bộ and East Nam Bộ. Groundwater in basalts has a complicated hydro-dynamic system because it is formed by volcanoes during different geological times. Therefore, water-bearing basalt and dry basalt formations are intercalated, that makes the hydrological characteristics more complicated.

This water source has small discharge with water springs having the discharge of from 0.1 to more than 1 liter/s. The water-bearing property of this formation is inhomogeneous. The change of groundwater level is 2-4 months slower than the change of rain in the area.

Groundwater in basalts has good quality. Normally, it is fresh or ultra-fresh and satisfies the water requirement in many using purposes.

Table 1. **Natural dynamic reserves of groundwater in Việt Nam territory**

Water-bearing formation	Natural dynamic reserve (m^3/s)					
	East Bắc Bộ	West Bắc Bộ	Bắc Bộ Delta	North Trung Bộ	South Trung Bộ	Nam Bộ Delta
Loose sediments	2.25	9.09	88.86	83.17	48.53	158.25
Basalts	-	-	-	13.00	51.30	-
Carbonate	12.55	40.97	-	22.80	-	-
Terrigenous sediments	35.85	27.97	-	120.51	47.53	-

Metamorphic rocks	27.65	86.94	-	69.56	62.84	-
Intrusives	47.12	40.79	-	72.90	108.62	-
Mixed formations	114.16	47.74	-	85.03	-	-
Total	239.40	214.83	88.86	466.96	312.82	158.25

Table 2. **Forecasted water demand until 2010 [1, 3, 4]**

No	Area	2000 (m^3/day)			2010 (m^3/day)		
		Urban area	Rural area	Total	Urban area	Rural area	Total
1	Bắc Bộ Plain	1,004,600	633,170	1,637,770	1,452,860	1,252,700	2,705,560
2	Midland and mountainous area in Bắc Bộ	265,600	345,160	610,760	417,100	726,550	1,143,250
3	North Trung Bộ	204,600	411,710	616,310	372,600	739,600	1,112,200
4	South Trung Bộ	272,800	248,990	521,790	410,900	348,500	750,400
5	Tây Nguyên	77,800	130,400	208,200	108,000	333,730	441,730
6	East Nam Bộ	1,280,600	226,740	1,507,340	1,632,300	425,380	2,057,380
7	Nam Bộ Plain	360,600	520,410	881,100	470,700	608,650	1,079,350
8	Total	3,466,600	2,516,580	5,983,180	4,855,460	4,435,110	9,290,500

c. Groundwater in carbonate (karst water)

Groundwater in carbonate occupies an area of 50,000 km^2. It occurs in many localities such as Quảng Ninh, Bắc Sơn, Cao Bằng, Trùng Khánh, Sơn La, Mộc Châu, Hòa Bình, Ninh Bình, Thanh Hoá and so on. Groundwater in carbonate and carbonate formations themselves play an important role in industry and construction fields.

Groundwater in carbonate has very complicated and inhomogeneous water level fluctuation. It is being exploited for living activities, especially the water used in Bỉm Sơn Townlet reaches 20,000 m^3/day.

d. Groundwater in other crushed formations (terrigenous sediments, effusives, intrusives and metamorphic rocks)

Terrigenous sediments, effusives, intrusives and metamorphic rocks are widespread in Việt Nam, but they have low water-bearing capacity except the places of tectonic faults, crushed zones caused by folds and contact zones.

Groundwater in crushed formations usually has good quality and satisfies the water use demands. However, because of small reserve, its exploitation is scattered with each well of only some cubic meters per day of output.

3. Groundwater potential

Việt Nam has high rainfall so that supplement capacity of rain water to groundwater is rather high. Nevertheless, due to topographic factors and influences of climate and weather the rainy supplement is irregular by time and space. The total dynamic natural reserves of groundwater in Việt Nam territory is 128,500,000 m^3/day.

In North Việt Nam, A, B, C_1, C_2 categories the calculated reserves are 600,503, 554,673, 897,521 and 5,284,951 m^3/day, respectively.

In coastal area of South Việt Nam and Tây Nguyên Plateau, potential exploitation reserve is 29,335,000 m^3/day and supply capacity is 1.76 m^3/day per person.

In the Nam Bộ plain, the total industrial exploitation reserve is 103,000 m^3/day in the 1998 year, the static reserve is 6,000,000 m^3/day.

In the Hà Nội city, at present, the exploitation is approximately 1,000,000 m^3/day. In four years to come, it will be more than 1,400,000 m^3/day.

However, the water distribution is not regular. The reserves of the formations and areas are shown in Table 1, calculated results of water use demand in Việt Nam are shown in Table 2.

II. GROUNDWATER MANAGEMENT IN VIỆT NAM

1. Management of quantity

Although the natural dynamic reserve presented in Table 1 shows great capacity of exploitable water (128,500,000 m^3), the real of economic and suitable exploitation is different from calculation. The groundwater exploitation is based on the use demand, supplementary resources and product cost.

At present, in the whole country, there are many water exploitation works. Fresh water requirement is always a worth problem.

To manage the quantity of groundwater, there are many projects with different solutions, but in general, on the following problems should be concentrated:

- To assess the potential reserve of each area, each region and each locality for advising the management and exploitation, professional software can help in evaluating reserve by time believably and quickly.

- To investigate and assess the current status of exploitation and use of groundwater in the whole country as well as its influence to the hydrosphere for finding the solution of management and planning and exploiting reasonably in time and space.

- To plan the exploitation area on the basis of equilibratory and sustainable development. For example, in Hà Nội city, the well fields are disposed along the Red and Đuống Rivers to ensure the supplementary source of the Pleistocene aquifer.

2. Management of quality

The quality of water is the most important factor in water supply. At present, all water sources have been polluted by human activities, so the quality of water declined and that's why, can not be used. Factors leading to the pollution of groundwater are shown in Table 3.

Table 3. **Factors leading to the pollution of groundwater in Việt Nam**

No	Hydrogeological region	Factors leading to the pollution
1	West Bắc Bộ	Garbage, waste, fertilizer
2	East Bắc Bộ	Garbage, industrial waste, fertilizer, waste-water, mining
3	Bắc Bộ Plain	Garbage, waste, fertilizer, insecticide, organic substance, Fe, Mn, nitrogen compound, As, Hg, heavy metals, cyanide, cemetery, dump, trade village
4	North Trung Bộ	Garbage, waste, fertilizer, insecticide, chemical substances, ecological and chemical toxicants, organic matter
5	South Trung Bộ	Garbage, industrial waste, chemical substances, fertilizer, chemical toxicants, fluorite, metal elements...
6	Nam Bộ Plain	Garbage, industrial waste, fertilizer, insecticide, Fe, Al, heavy metals, chemical toxicants, organic matter...

Issue of quality management is an urgent problem not only at present but also in the future. To manage and control the quality of water sources, we need to perform the following works:

- Obeying strictly protective requirements for water sources during the time of exploitation and use;

- Establishing protective areas and belts to protect aquifers;

- Managing successfully and controlling strictly waste and pollutant sources that lead to the degradation of water quality.

- Building monitoring systems for the fluctuation of groundwater;

- Assessing the environmental impact to factors causing pollution and exhaustion of water sources, such as annulation of natural recharge sources (forests, rivers, streams…), exploitation of water with large output and in long time, mineral exploitation causing serious influence to groundwater quality and reserves.

3. Solutions for managing and protecting groundwater resource

To well perform the task of management and protection of precious groundwater resource, we need to realize the following works:

- Seriously designing a law for water resource protection;

- Strictly realizing guides, decretes and under-law documents. Managing successfully the works of drilling for groundwater exploitation. Listing water exploitation works to establish database for different works;

- Propagandizing broadly to people the ways to exploit and use water effectively and economically. By late years of this decade, all people should have good sense in the protection of water resource;

- Building protecting zones for water sources, especially in present exploiting areas of Hà Nội, Hồ Chi Minh Cities and other urban areas…

- Modernizing water management work. It is necessary to have immediately courses on water management for individual, community and organizations related to the exploitation and protection of groundwater;

- Processing pollutant and toxic waste sources which there influence on water sources;

- Planning and building water exploiting centres to manage and supply with water more effectively to minimize catastrophes during exploiting process.

IV. CONCLUSIONS

1. Việt Nam includes six hydrogeological regions, which have different water distribution and storage characteristics and different quantity and quality values. The Bắc Bộ and Nam Bộ Plains are two hydrogeological regions of highest groundwater potential.

2. The total natural dynamic reserves of 7 water-bearing formations in Việt Nam is 1,481,168 m^3/s, among which formations of loose sediments, intrusives, metamorphic

rocks, terrigenous sediments and mixed formation are the richest water-bearing formations.

3. In general, the quality of groundwater in Việt Nam territory sufficiently satisfies the requirements of living activities. The groundwater quality management should be strengthened to limit the pollution by garbage, waste-water, fertilizer, toxic chemicals, insecticides, nitrogen compounds, some heavy metals...

4. The law of water resource and water resource protecting measures is needed to perform identically in the whole country. The Government must have concrete measures in groundwater management, such as regulations on groundwater investigation, sustainable water exploitation, not to cause pollution and exhaustion of water resource during the development process.

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