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# GROUNDWATER TREATMENT TECHNOLOGIES FOR THE NATIONAL PROGRAM “CLEAN WATER AND ENVIRONMENTAL SANITARY” OF HOCHIMINH CITY AND SOUTHERN PROVINCES

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## ABSTRACT

This report explains some major problems concerning the groundwater in Hochiminh City (HCMC) and southern provinces, including its reserve and quality; ability for water supply; real exploitation, use and management of this resource; existing groundwater treatment technologies; proposal and suggestion for the next studies. Initial observed results show that groundwater exploitation and use in HCMC suburb and southern provinces have some large advantages, but there are also some certain limitations of natural water quality and worse change of groundwater dynamic (dropping of groundwater table). The shown studies have given many models for clean water supply and suitable groundwater treatment technologies, allowing widespread application in many southern rural areas.

## OVERVIEW OF GROUNDWATER IN HCMC AND SOUTHERN PROVINCES

Because surface water quality does not reach for water supply standards, together with bad environmental sanitary and water pollution in many places, the groundwater in HCMC particularly and Southern provinces generally have important significance for living of rural people, especially for alum or salty water areas. For sensible exploitation and effective use of this resource, firstly to have examine two main factors, including reserve and quality. The correct and complete estimation of groundwater potentiality is very complicated problem, and until now there are many different opinions because there is not reunification of estimate methodologies. However, could show below some general number representative for two Southern areas:

- In Mekong delta, follow the estimation of professional organizations, groundwater has natural mobile reserve of 60 millions  $m^3$  per day, but the exploitable quantity is only 420,000  $m^3$  per day (it is less than 1%). However, these are very important water source for the alum or salty areas in dry season. Likely surface water, groundwater quality in Mekong delta also has big change by space and depth. Groundwater of upper Pleistocene layer is brackish in Long Xuyen quadrangle, a part of Dong Thap Muoi and a small part laying between Tien river and Hau river, from Sa Dec to Eastern sea. For lower Pleistocene layer, groundwater is also brackish in some areas belong to Long Xuyen quadrangle, Dong Thap Muoi and a small part laying between Tien river and Hau river, from Can Tho to Eastern sea. Some areas are saline, including nearly all Vinh Long province, a part of Tra Vinh, Ben Tre provinces and Dong Thap Muoi.
- In Eastern provinces, the total groundwater potential reserve is estimated about 51.9 millions  $m^3$  per day. The exploitable quantity is 24.6 millions  $m^3$  per day, while the existing exploitative quantity in this area is about 0.65 millions  $m^3$  per day. Generally, groundwater used coefficient is still in low level (average is about 2.2 %). Particularly, in HCMC and Binh Thuan province, the groundwater used coefficient is 24.6 % and 10.7 % respectively; it is relatively high compared with another provinces (Table 1).

Follow former studies <sup>[1]</sup>, the groundwater reserve of exhausted month in Eastern provinces (except for Ninh Thuan and Binh Thuan) was reached near 15 millions  $m^3$  per day, among which water with total mineralisation  $M \leq 1,0$  g/L had occupied 92,48%, that means 13,8 millions  $m^3$  per day; water with total mineralisation  $M = 1,0 \div 1,5$  g/L had occupied 0,94%;  $M = 1,5 \div 4,0$  g/L had occupied 1,65% and water with total mineralisation  $M > 4,0$  g/L had occupied 4,92%.

Table 1. Some characteristics of Groundwater in Eastern provinces and surrounding

Province/City	Potential reserve (m <sup>3</sup> )	Exploitable reserve (m <sup>3</sup> /day)	Exploitative quantity (m <sup>3</sup> /day)	Used coefficient
Tay Ninh	6,287,807	3,772,684	52,567	0.014
Binh Duong + Binh Phuoc	5,078,042	3,045,625	108,935	0.036
Dak Lak	6,895,097	4,137,058	9,458	0.002
Lam Dong	7,391,228	4,434,737	30,498	0.007
Ninh Thuan	306,828	184,106	19,760	0.107
Binh Thuan	7,934,293	4,780,576	34,305	0.007
Ba Ria - Vung Tau	3,260,289	1,956,161	21,840	0.011
Dong Nai	9,312,207	5,567,324	112,120	0.020
HCMC (1)	3,523,881	845,731	207,998	0.246
Long An (2)	2,772,358	1,081,220	27,446	0.025
Total	61,591,928	29,805,222	644,471	0.022

Source: From document [2].

Note: Exploitable reserve =  $P_w \times 0.6$ , where  $P_w$  is Potential reserve

(1) Exploitable reserve =  $P_w \times 0.6 \times (1 - 0.60)$

(2) Exploitable reserve =  $P_w \times 0.6 \times (1 - 0.35)$

Brackish or saline groundwater causes a big difficulty for the water supply, and until now Vietnam not yet uses these sources. Beside that, groundwater in many Southern provinces is contaminated by many polluted substances such iron, mangan, silica, sulfate, nitrate, disulphur hydrogen, E. Coli, etc... due to the stratigraphy structure characteristics and/or the effects of infiltration of upper polluted water layer. That makes the difficulties for water supply (the recognizable examples are the unutilized or broken down UNICEF wells). The reuse of these wells requires complicated treatment that is not appropriate for rural areas.

The groundwater monitoring in Southern provinces is still limited and dispersed. Almost former investigation programs (General Investigation on Mekong Delta - Program 60B, 1985 – 1990, General Investigation on Eastern provinces, National Program on Clean water and Sanitary for rural areas, etc.) focus only on the estimation of groundwater saline/brackish level, without considering on other parameters. Whereas, the groundwater is contaminated by many parameters as described above.

Based on the preliminary studies <sup>[3,4,5]</sup>, groundwater in HCMC and Long An province has undesired quality for water supply. A great part of wells is contaminated by iron with different level, commonly with iron content from 10 to 35 mg/l, some areas have iron content over 100 mg/L (Nha Be, Binh Chanh).

Groundwater of many places is contaminated by nitrate, ammonia with high content (especially in urban districts of HCMC and some other provinces).

### Clean water demand for rural areas of HCMC and Southern provinces

Until now, clean water problem for rural areas is very pressing and Vietnamese government seriously concerns it. In these areas, the people use untreated and unsanitary water, therefore diseases easily arise and spread.

Through the investigation programs of real clean water demand in some rural areas of HCMC and Southern provinces, we are understanding, identifying and sharing with local inhabitants by a number of difficulties as follow:

- No clean water for living;
- Storm water reserve is limited, not sufficient for living in dry season (not counting the pollution of storm water);

- Surface water is saline or contaminated by organic substances, toxics, and disease microbes. Since could not utilize directly this water source for domestic purposes (the treatment cost is very high);
- Groundwater source is contaminated by iron with the content from average to high or very high, or contaminated by nitrate, ammonia, H<sub>2</sub>S, E. Coli, etc... since it could not utilize for water supply;
- The clean water price provided by private services is too high (average from 20,000 to 50.000 VND/m<sup>3</sup> in dry season, in some peak days up to 70,000 VND/m<sup>3</sup>), exceed financial standing of local people;
- The rural people don't know and approach to water treatment technologies

Especially, there is a great part of inhabitant living in flooded areas or effected by floods. Therefor-clean water for these areas is more pressing than other rural areas.

These difficulties enumerated above reflect real situation of clean water demand in HCMC suburb and rural areas of Vietnam. Once again show that clean water supply for these areas is very imperative, requiring a big effort of Government and local administrations, with large participation of scientists, also with unanimity of local inhabitants.

## APPLICATION OF SUITABLE TECHNOLOGIES FOR GROUNDWATER TREATMENT, SERVING WATER SUPPLY IN RURAL AREAS

### **The National Program "Clean water and Sanitary for rural areas"**

Understanding the pressing of clean water problem, in last years Vietnamese Government and local administrations together with many scientists have interested in this subject and got considered development in solving of clean water demand for rural living. Instruction 200/TTg of Prime Minister dated April/1994 has got very big sense, improving knowledge on clean water and environmental sanitary, and impulsing water supply for rural areas (on quantity and quality). After that, in September/1994 Steering Committee of National Program "Clean Water and Environmental Sanitary for Rural Areas" had been established, targeted at water supply for 80% of rural inhabitants in 2000, with the norm of 20 L/person/day. In 3/December/1998, the Government had approved this program till 2005 as main point program. National strategy on developing water supply and environmental sanitary has been studied since 1997, is submitting to approving of Prime Minister. Together with Water Resource Act, Environmental Protection Act, and other related acts the above national program and national strategy is legal basis to carry on water supply and environmental sanitary for rural areas.

Program "Clean water for rural areas" supported by UNICEF has got practical contributions on adapting of clean water demand for living in rural areas. However, as mentioned above, due to geolo-hydraulic characteristics and other influences, groundwater in some areas is contaminated with iron content from average (10 - 30mg/l) to high (30 - 80mg/l) or even very high (up to 170 - 220 mg/l). Since UNICEF wells could not display it's effects (exploited water can not use for living purposes). In other areas, groundwater is contaminated by nitrate, inhibiting consumers and influencing to children health. Belong to these areas are HCMC suburb such Nha Be, Binh Chanh and Govap.

### **Performed developing water supply models from groundwater for rural areas**

Studying and performed developing water supply model for rural poor inhabitants is indispensable and has profound socialo-economical meaning. It satisfies immediate demand of clean water in HCMC suburb and other rural areas, also to set up scientific base to widespread these models. Follow this, in 1994 the HCMC Government allowed to develop project "Study and develop performed water supply models for HCMC suburb". This Program had large participation of many local scientific organizations such Center for Environmental Technology (CEFINEA) - Institute for Environment and Resources - National University of HCMC (presided), Environmental Protection Center (EPC), New Technology Center, Institute of Chemical Technology, Sub-Institute of Material, Creative Center of Young City Group, Center of Tropical Technology Vietnam - Russia.

Based on water quality of studied areas, the project was divided into two phases: Phase I from 1995 to 1997, focussed on studying suitable, diversified technologies to treat groundwater with iron content below 35 mg/l. This phase had developed 12 treatment stations in follow districts of HCMC: Nha be, Binh Chanh, Go Vap, Thu Duc. Phase II (1997-1998) had focussed on studying treatment groundwater with higher iron content (over 40 mg/L) and contaminated by nitrate. As results, the project had developed 5 treatment stations in Phuoc Kien - Nha Be, Hung Long - Binh Chanh and sub-district 5 - Go Vap.

From performed models, project result had been widespread in bigger scale for the areas having similar water quality, such Nhon Duc, Phuoc Kien (Nha Be), Hung Long (Binh Chanh), Long Phuoc (Thu Duc), Hoc Mon, etc...with total 30 water supply stations (with average capacity from 3 – 5 m<sup>3</sup>/h). These stations are financed by local people and operate very effectively. Recently, the similar model has spread not only in HCMC suburb, but also in almost Southern provinces (especially in provinces such Long An, Tien Giang, Tay Ninh, An Giang, Ben Tre, Dong Thap, Can Tho, etc...). This also contributes a large movement supported by the Government: socialization of water supply for rural areas.

## SUMMARY OF SOME MAJOR RESULTS

### *a) Scale and general characteristic of the water supply system outline for rural areas*

Some basic parameters and general characteristics suggested as follow:

- Groundwater source (Drilled well – UNICEF)
- Iron content: 10 to 35 mg/L
- Iron content: 40 to 120 mg/L
- Suitable capacity for rural areas:  $Q = 4$  to  $5$  m<sup>3</sup>/hour
- Serving scale: 600 to 1000 inhabitants/ station
- Working times: 8 to 10 hours/day
- Full water supply system: Treatment station, distribution network and public water supply points
- Out put quality: Iron content stables at level  $< 0.3$  mg/L

Reusing some available drilled wells (or makes new one), with serving scale from 600 to 1000 inhabitants/station is suitable to existing situation of many rural areas.

### *b) Some performed technologies for groundwater treatment having iron content below 35 mg/L (Phase I)*

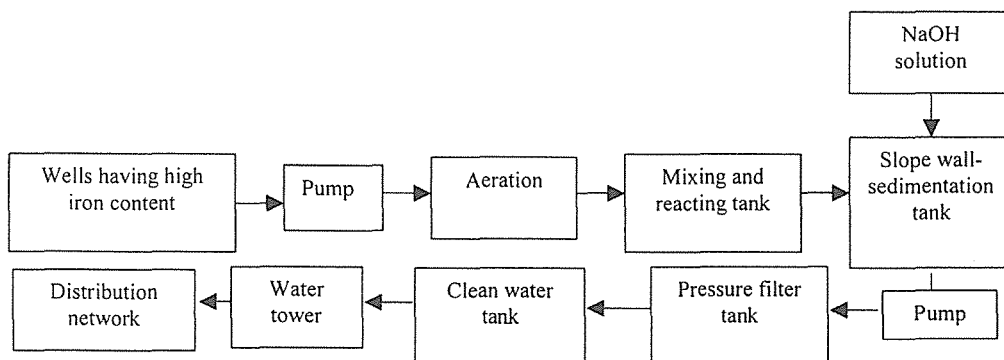
- CEFINEA technology (Carried out by CEFINEA), having capacity: 4 to 5 m<sup>3</sup>/hour; serving scale: 600 to 1000 inhabitants/station; mainly use slow filter tank, easy management, very suitable for the rural situation. The flexible and abundant characteristics of this technology was shown in following aspects:
  - With the iron content below 10mg/L, the selected technology is simple aeration and slow filtration. And with iron content from 10 to 35 mg/L, the technology is deep aeration, contacting filtration and slow filtration;
  - About the materials and arrangement : could utilize various materials such brick, concrete, composite, etc...depending upon the budget and the geological conditions;
  - Beside that, to manage and operate easily and comfortably, the developed technology had design automatic pump controller, backwash system... and water supply network to every family.
- KATAWA technology (Carried out by Institute of Chemical Technology) can be summarized as follows: AIRWA equipment supplies oxygen by Ejector principle, upper oxidation tower on KATAWA catalyses “1”(made based on Japanese Patents) for increasing reaction rate, tower support on KATAWA “2” for trapping precipitate and lightening loading in the filter tower, which can keep 90%

iron precipitate, and finally pass through the two component filter tower (active coal and sand) to increase the effectiveness of the treatment.

- ALUWAT technology (Carried out by The Department Institute of Material Science) can be summarized as follow: Mechanical aeration, pass through filter catalyzed with ALUWAT material to increase the iron oxidation, and then final filtration.
- Technology carried out by The Young City Group: Natural aeration, contacting filtration, pressure filtration (2 step filter column), clean water tank and distribution network...

c) Some performed technologies for groundwater having iron content over 40 mg/L (Phase II)

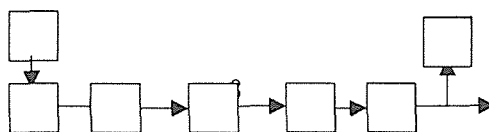
- CEFINEA performed technology is the combination of aeration and using alkaline agent (NaOH, lime or Javel) to rise water pH and oxidize iron (II) to iron (III); sedimentation (in slope-wall sedimentation tank); fast filtration and distribution network. This technology can be applied flexibly for groundwater having iron content from 50 to 100 mg/L or more, but treated water quality still reaches The Standard For Drinking Water (iron content less than 0.3 mg/L)



This technology was applied in Phuoc Kien (Nha Be district) with iron content varied from 57 to 65 mg/L, and in Hung Long (Binh Chanh district) with iron content varied from 85 to 105 mg/L. Both has very good treatment effect and stable operating till now (near two years).

- EPC performed technology is using natural oxidizing agent (Oxygen taken from Air Compressor) to oxidize Fe(II) to Fe(III) in contacting material layer. The Fe(OH)<sub>3</sub> precipitate is removed by sedimentation and filtration. The treated water quality reaches the Standard for Drinking Water. The limitation of this technology is iron content below 80 mg/L.

EPC technology for groudwater having high iron content

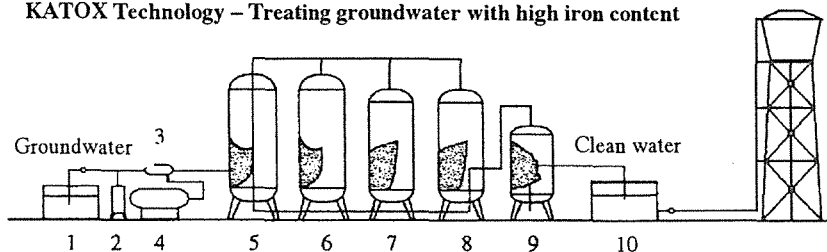


- Notes:
- |                             |                 |
|-----------------------------|-----------------|
| 1. Air compressor           | 5. Filter tank  |
| 2. Drilled well             | 6. Storage tank |
| 3. Contacting reaction tank | 7. Water tower  |
| 4. Sedimentation tank       | 8. Consumption  |

- KATOX technology is carried out by Center of Tropical technology Vietnam – Russia. This technology includes the following procedures: Primary alkalizing by lime to rise pH, contacting oxidizing Fe(II) on KAT1 catalyses, destroying Fe(OH)<sub>3</sub> colloids by KAT2 catalyses to favour next filtration, filtration and

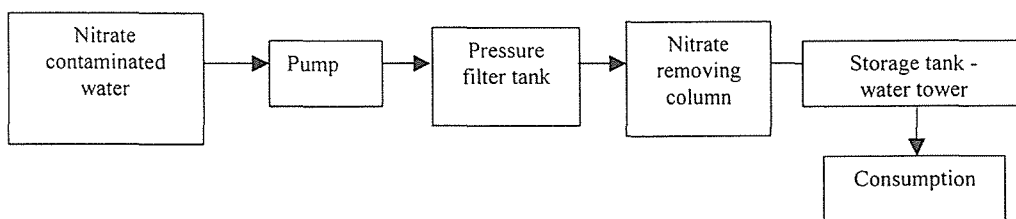
adsorption by active coal. Treated water reaches The Standard for Drinking Water. This technology can be applied for groundwater sources having iron content up to 100 mg/L.

**KATOX Technology – Treating groundwater with high iron content**



- Notes:
- |                              |                             |
|------------------------------|-----------------------------|
| 1. Intermediary storage tank | 6. Secondary reaction tank  |
| 2. Neutralizing equipment.   | 7. Filter tank              |
| 3. Gas mixing tank           | 8. Filter tank              |
| 4. Air compressor            | 9. Chemical adsorption tank |
| 5. Primary reaction tank     | 10. Clean water tank        |

- Technology for nitrate contaminated groundwater carried out by CEFINEA is based on the ion exchange method. This technology can be outlined as follow:



Generally, applied technologies are not so complicated. Local inhabitants can easily understand and operate by themselves. All performed water supply stations (phase I: 12, phase II: 05) are stably operating until now; treated water always reaches standard quality with good management of local administrations; and supply clean water for about 10,000 inhabitants within many passing years.

**Assess the operating of performed models**

By real developing, controlling and monitoring the effectiveness of 17 performed models since 1995 till now (local inhabitants manage and operate by themselves), show that these stations work very effectively and stably. The treated water quality is excellent, reached Standard for Drinking Water. From high input iron content (18 to 35 mg/L - phase I and 54 to 110 mg/L - phase II), after treatment it is stable at less than 0.3 mg/L or not detectable (Vietnamese Standard defined 0.5 mg/L iron for domestic water in the countryside). All other parameters reach Standard for drinking water. People can drink directly with safety for passing years.

Of course, sometimes there were problems (by broken-down pump or dropping of groundwater table in the dry season...), but local inhabitants could solve these difficulties themselves.

Based on observed results together with controlling and monitoring the operating of 17 performed models, can conclude that: The suggested technologies have resolved the pressing need on clean water for areas having groundwater with high iron content at average or high level and the nitrate contaminated underground water.

## CONCLUSION AND SUGGESTION

1. Groundwater in the Southern area has a very important meaning for domestic water supply in countryside. The potential reserve in this area was estimated about 112 million cubic meter per day, but the exploiting ability is limited due to salinity, contaminated by iron or/and nitrate, ammonia, H<sub>2</sub>S, E. Coli ...;
2. The Program “Clean water for rural areas” has positive and useful contributions, day after day improved and innovated on diversifying treatment technologies adapted with different water input quality;
3. The treatment technology and serving scale (600 to 1000 inhabitants/well as suggested) is very reasonable and practical. After long time operating show that the water treatment stations at Nha Be and Binh Chanh are working very stably; treated water quality totally reach The Standard for drinking water; are comfortable for use; and local people very happy. These technologies can apply largely and in reality there are hundred of similar model with very good result;
4. Together with oversea support and investment of the Government to resolve the clean water problem for rural areas, the local administrations can reuse initiatively different budgets to develop the Program “Clean water for rural areas” in own regions

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