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THE VARIATION OF QUALITY AND CURRENT SITUATION OF ARSENIC IN THE PLEISTOCENE AQUIFER - MEKONG DELTA

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Abstract

The variation of groundwater quality is very complicated and can be easily changed with time and space, especially in Mekong Delta. In general, groundwater quality depends on many factors such as ions, colloids, etc... among of which TDS factor is the most important one, since it can show an overview about the groundwater quality. Moreover arsenic pollution in groundwater in Mekong Delta has been attended in recent years. The paper presents the latest analytical results of the variation of TDS (1995-2004) and the current analytical results of arsenic of over 60 samples collected by Division of Hydrogeology and Engineering of the South in Pleistocene aquifer in Mekong Delta - Vietnam.

Keywords: Arsenic, content, Pleistocene Aquifer, pollution, Quality, TDS.

1. Introduction

The aquifer distributes almost in Mekong Delta and covered by younger sediments except several small areas in Long Xuyen, Ha Tien where mountain can be seen. It looks like a hollow with the deepness increases from outside (0-20m) to the center (100-120m) and the thickness also increases from outside (40-80m) to the center.

2. Methods

The quality of this aquifer is evaluated by TDS. The limit values which are used to evaluate presented in Table 1, there are seven levels show the variation of quality.

Table 1: Limit values of levels to evaluate the variation of quality

Indicator	Limit values						
	Increase			Steady	Decrease		
	Strong	Medium	Weak		Strong	Medium	Weak
TDS (g/l)	>1	0,5 ÷ 1	0,1 ÷ 0,5	-0,1 ÷ 0,1	-0,5 ÷ -0,1	-0,5 ÷ -1	<-1

WHO standard and TCVN 5944-1995 are used to evaluate the current situation of arsenic pollution.

3. Results and discussion

Variation of quality

TDS values are collected from 26 monitoring stations (distribute all over Mekong Delta). After comparing monitoring data series of the aquifer (1995-2004) to the limit in Table 1, the variation of quality as follow:

- Steady level: dominant, observed at 17/26 monitoring stations.
- Weak increasing: observed at 4/26 monitoring stations.
- Medium increasing: observed at 3/26 monitoring stations.
- Strong increasing: only observed at 1/26 monitoring stations (at Soc Trang).
- Weak decreasing: only observed at 1/26 monitoring stations (at Lai Vung).

These variations are showed in Figure 1.

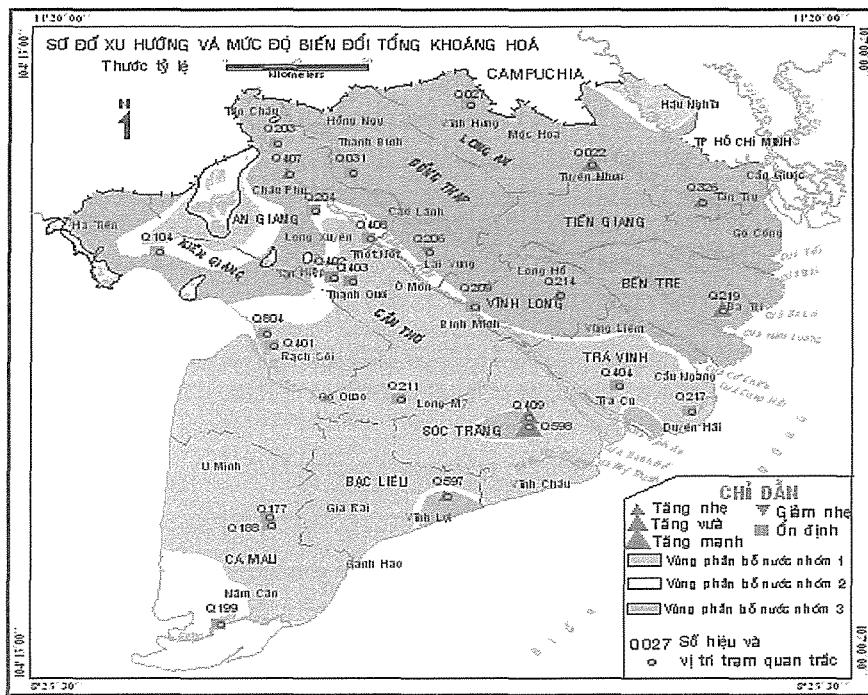


Figure 1: Monitoring stations and variation of quality

Increasing tendency

This tendency can be observed along the coastline (from Soc Trang to Bac Lieu), at the center of Mekong Delta (from Tuyen Nhon to Long Ho) and some small areas in An Giang. In Figure 1, this tendency showed as red triangle points.

Especially, the increasing tendency is observed clearly at Soc Trang (Figure 2). In 1995, TDS value is only 9.7g/l and it increases rapidly to 25.9g/l in 2002 and still high in 2003 and 2004.

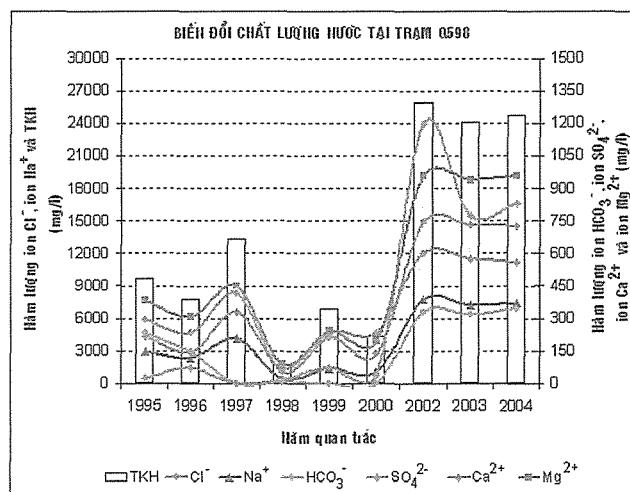


Figure 2: The variation of groundwater quality at Soc Trang

Therefore, the agent that caused this variation must be a strong one. At Soc Trang, there is an exploiting station, the amount of groundwater exploited from this aquifer is too big, so water level has drawdown rapidly and strongly in recent years (figure 3). This phenomenon leads to salt water boundary from Eastern reach to exploiting station.

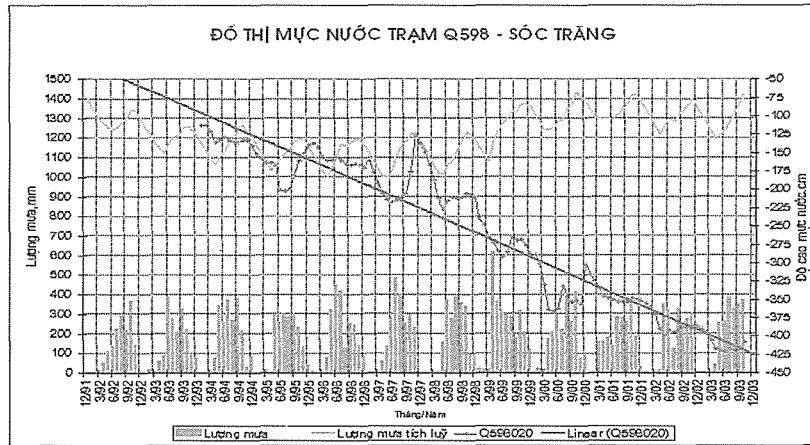


Figure 3: Monitoring groundwater level at Soc Trang

Similarly to Northern of Tien River, TDS also increase. The salinity in groundwater is so high in this area, groundwater not be exploited here but TDS increase due to the groundwater exploiting effect in neighbor areas (HCMC).

Steady tendency

This tendency is very popular in Mekong Delta. It distributes as a long narrow zone from Long An, Dong Thap to Can Tho and Ca Mau. In Figure 1, this tendency showed as pink four-square points. This tendency occurs in two ways:

- TDS and main ion contents are steady: observed at Tra Vinh and Ca Mau (Figure 4). As previous researches, the origin of groundwater here is from ancient rain water, it separated from outside and there is no recharge for it. However, groundwater exploited from this aquifer is not large enough to change its quality.

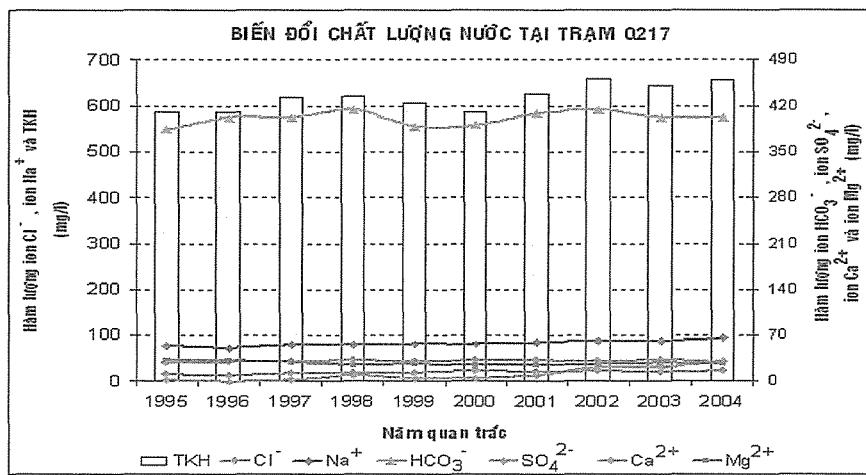


Figure 4: Variation of quality at Tra Vinh

- TDS steady but main ion contents varies regularly: observed at Northern of Can Tho and An Giang (Figure 5). Groundwater quality in this area is good enough for human. As Figure 6, water level drawdown is not significant to others. Bicarbonate and sulphate content (Figure 5) increase. In addition, Figure 7 shows the Hau River structure relative to the aquifer, so that, may be groundwater at this area is recharged by Hau River.

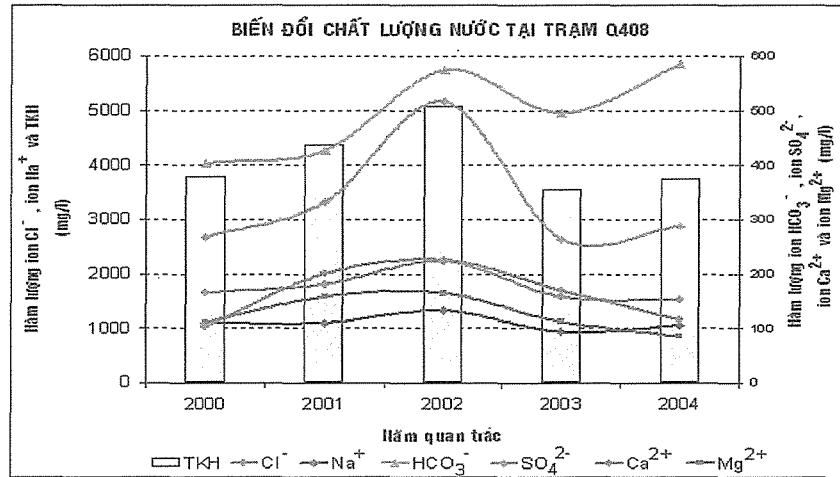


Figure 5: The variation of groundwater quality at Long Xuyen

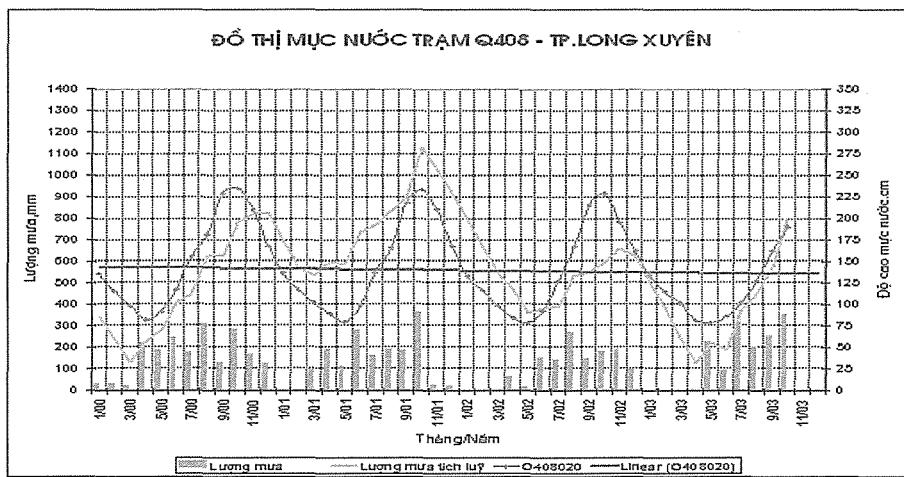


Figure 6: Monitoring groundwater level at Long Xuyen

Decreasing tendency

The decreasing tendency of TDS only observed at Lai Vung (in Figure 1, as green triangle point), it changes from 3.2 g/l in 1991 to 1.16g/l in 2004. This result can be explained as follow: the water level has drawdown over 1m up to now because of groundwater exploiting and water with lower TDS content around ran into and dissolved together in the aquifer.

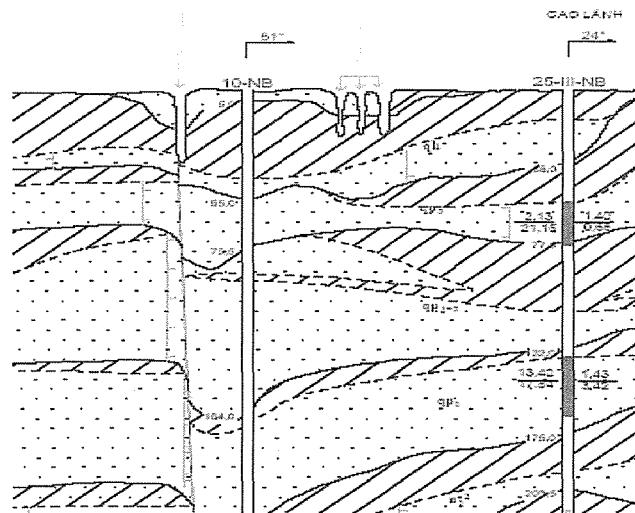


Figure 7: Relative of Hau River and the aquifer structure

Current situation of arsenic pollution

Arsenic pollution in groundwater in Mekong Delta has been attended in recent years. There are several researches about this problem but still separated, not link together. Most of them only present the current total content of As, not paid attention to As^{3+} and As^{5+} in soil and water yet. Methods are used to analyze As not synchronous.

After analyzing over 60 samples were collected by Division of Hydrogeology and Engineering of the South, results of As are showed as follow:

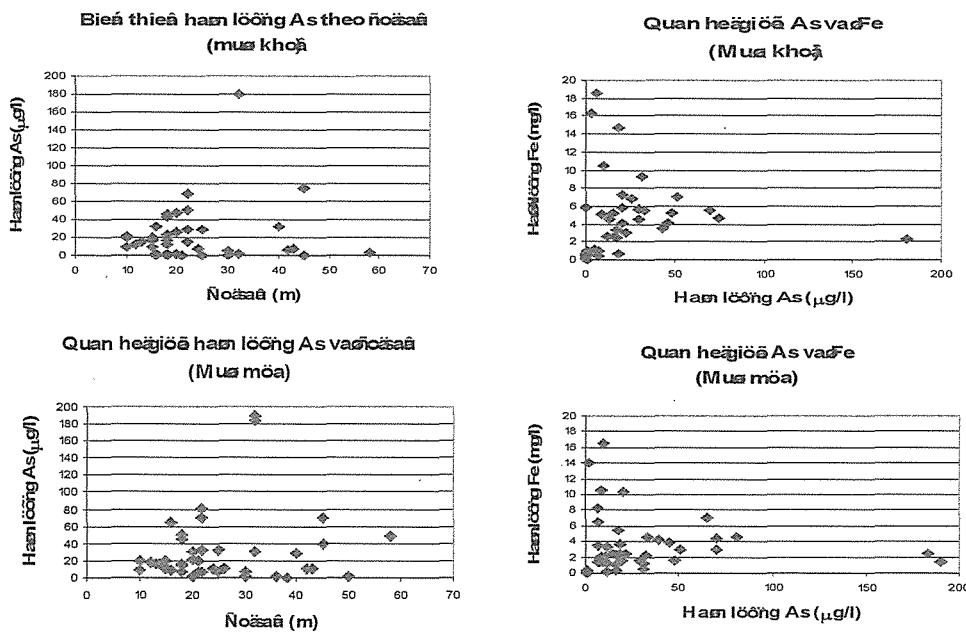


Figure 8: Relatively of arsenic content by depth and iron content

Arsenic content in groundwater distribute mainly at the depth of about 10-50m. It varies from 0.2 $\mu\text{g/l}$ to 180 $\mu\text{g/l}$. To compare these value to WHO Standard (10 $\mu\text{g/l}$), 62.79% of total collected samples have As contents can not be accepted and compare to TCVN 5944-1995 (50 $\mu\text{g/l}$), 9.3% of total collected samples are not accepted.

Arsenic content varies by seasons. After Nguyen Van Lap's research, at the end of dry season (5/2004) As content varies from 0.2 $\mu\text{g/l}$ to 180 $\mu\text{g/l}$ and at the end of rainy season (11/2004) it varies from 0.5 $\mu\text{g/l}$ to 190 $\mu\text{g/l}$. So that, if compare these values to WHO Standard, 69.39% total samples are not accepted and to TCVN 5944-1995, 14.29% total samples are not accepted. It can be said that As content in groundwater increases significantly in rainy season. This may be relevant to flood season (September, October) in this area (Figure 8). The same result is also observed in Ha Noi.

The relative between arsenic and iron content in groundwater is not clear in Mekong Plain while it is very clear in Ha Noi. High arsenic content (183-190 $\mu\text{g/l}$) in low iron content samples (1.4-2.4 $\mu\text{g/l}$). Inversely, in high iron content samples, arsenic content is usually less than 10 $\mu\text{g/l}$. Furthermore, high arsenic content can be found in clay, sandy clay and can not be found in sand layers. Arsenic also does not exist in soil and surface water in some place in Dong Thap. Therefore, arsenic in groundwater may be from fine-grain sediments, pesticide or fertilizer.

There is a general rule of arsenic distribution in the horizons: the depth increase, the arsenic content decrease. In shallow aquifers, arsenic content changes 1.57-1.65 $\mu\text{g/l}$ (Holocene Aquifer); 5.86-6.83 $\mu\text{g/l}$ (Middle-Upper Pleistocene Aquifer); 2.71-19.73 $\mu\text{g/l}$ (Lower Pleistocene Aquifer) and in deeper aquifers it decrease rapidly (see also in Table 2 and Table 3).

Table 2: Some pollutant content in shallow aquifers – Dong Thap Province

Indicator	Limit (mg/l)	Content – (min – max)			
		Unit	Q ₁ ¹	Q ₁ ²⁻³	Q ₂
pH	6,5-8,5	-	7,4-8,6	4,30-8,3	6,6-7,2
As*	0,05	$\mu\text{g/l}$	2,71-19,73	5,86-6,83	1,57-1,65
Sulfate	200-400	mg/l	19,21-48,99	0,15-307,09	13,47-567,2
Nitrate	45,0	mg/l	0,17-1,37	0-20,13	3,1-23,4
Clorur	200-600	mg/l	23,04-88,63	66,65-396,3	85,2-520,6
Total iron	1,0-5,0	mg/l	0,03-1,2	0-40,04	0,03-1,3
F.Coli	None	MPN/100 ml	0	0	0
Coliform	3	MPN/100 ml	0	0	0

Table 3: Some Pollutant content in deeper aquifers – Dong Thap Province

Indicator	Limit (mg/l)	Content - (min - max)						
		Unit	N ₁ ³		N ₂ ¹		N ₂ ²	
			Rain	Dry	Rain	Dry	Rain	Dry
pH	6,5-8,5	-	8,5	8,15-8,31	7,38-8,5	7,27-8,56	7,6-8,5	
As	0,05	$\mu\text{g/l}$	<1	2,9-12,97	0,23-29,03	0,95-10,11	1,1-7,81	
Cd	0,01	$\mu\text{g/l}$	<10	1,25-5,69	0,36-0,76	9,61-9,61	0,53-0,53	
Cr	0,05	$\mu\text{g/l}$	<10	1,35-1,71	0,79-4,85	0,79-2,71	0,10-0,71	
Cu	1,0	$\mu\text{g/l}$	<10	0,87-15,95	0,9-8,99	2,63-13,08	3,92-14,04	

Indicator	Limit (mg/l)	Unit	Content - (min - max)					
			N ₁ ³		N ₂ ¹		N ₂ ²	
			Rain	Rain	Dry	Rain	Dry	
Pb	0,05	µmg/l	3	0,15-2,15	0,15-2,71	1,2-14,72	1,38-3,41	
Mn	0,1-0,5	µmg/l	0,02	0,02-0,51	0,005-1,03	0,06-12,34	0,006-0,08	
Zn	5,0	µmg/l	<10	0,34-0,91	1,64-45,95	4,45-538,65	1,76-20,68	
Hg	0,001	µmg/l	<1	0,61-0,65	0,4-0,87	0,41-0,41	0,02-0,02	
F	1,0	µmg/l	-	0,21-0,58	0,26-0,63	0,21-2,12	0,18-0,23	
CN	0,01	µmg/l	<10	1,13-1,13	0,2-0,2	-	-	
Sulfate	200-400	mg/l	21,4-60,1	33,62-67,24	36,02-86,45	33,62-33,62	70,6-70,6	
Nitrate	45,0	mg/l	1,97	0,17-0,35	0,21-0,74	0,35-0,35	0,77-0,77	
Clorur	200-600	mg/l	67,4-292,8	90,4-372,23	92,17-215,7	77,99-77,99	109,9-209,9	
Iron	1,0-5,0	mg/l	0,02-0,09	-	0,02-0,73	-	0,01-0,25	
F.Coli	None	MPN/100ml	0	0	0	0	0	
Coliform	3		0	0	0	0	0	

After Nguyen Van Ai and Mai Trong Nhuan, it can be divided into 3 zones of arsenic pollution in Vietnam: mountain zone, coastal zone and delta plain. In some sections in delta plain zone, arsenic content exceeds TCVN 5944-1995 due to natural processes (oxidization of sulphurous minerals, arsenic minerals, deoxidization iron hydride that contains arsenic...). Abnormal arsenic contents usually exist in sediment layers which have high clay-sand ratio. Moreover, in historical time, Mekong Plain has experienced progressions and regressions of sea level, especially in Holocene most of the plain was covered by salt water, during this time lots of sediments that contain sulphurous or arsenic minerals formed.

Therefore, arsenic usually be found in freshwater of this aquifer that locate near these sediments (Hong Ngu, Cao Lanh) or mountain standout (An Giang, Kien Giang). Some diseases due to using arsenic groundwater such as black nails, skin becomes horn... are also popular in these regions. Arsenic also exists in groundwater at Soc Trang, Can Tho, Tra Vinh, Ben Tre... but its content does not exceed TCVN yet.

Arsenic pollution is really threat to the living environment and health in Mekong Delta, so that more researches about those problems are needed.

4. Conclusions

There are three tendency of groundwater quality variation in Mekong Delta: increasing, steady and decreasing. The steady level is predominant and distributes in areas where groundwater good enough for exploiting. The increasing tendency distributes along the coastline and strongly exploiting. At Lai Vung, there is a sign shows that Hau River recharge into the aquifer. The main reason that causes variation of quality in this research area is over groundwater exploiting.

The variation of quality and arsenic pollution are urgent problems in Mekong Delta. Therefore, more detail researches about this aquifer are needed to find the best way to manage and to reserve this resource more effectively.

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