

## ASSESSING METAL POLLUTION IN GROUNDWATER AT PLEISTOCENE AQUIFER IN GO VAP DISTRICT, HO CHI MINH CITY

**Tran Thi Phi Oanh<sup>1,\*</sup>, Mai Hoang Phuc<sup>1</sup>, Nguyen Viet Ky<sup>2</sup>, Dau Van Ngo<sup>2</sup>,  
Ho Chi Thong<sup>2</sup>**

<sup>1</sup>*Faculty of Environment and Natural Resource, Hochiminh City University of Technology,  
268 Ly Thuong Kiet, Ward 14, 10 District, HCM City*

<sup>2</sup>*Faculty of Geology and Petroleum Engineering, Hochiminh City University of Technology,  
268 Ly Thuong Kiet, Ward 14, 10 District, HCM City*

\*Email: [tranthiphioanh@gmail.com](mailto:tranthiphioanh@gmail.com)

Received: 15 August 2016; Accepted for publication: 10 November 2016

### ABSTRACT

The appearance of some metals such as Fe, Al, As and other compounds with artificial origin as Zn, Cu, Pb in groundwater has become issues and being interested to many researchers. In the area of water supply, the problem of metal pollution from some water supply companies and households not only appears in surface water but also in groundwater, which reflected in the metal contamination over permissible standards and seasonal oscillations. In this study, a survey of current pollution was carried out to elucidate the distribution of some metal ions such as total iron,  $\text{Al}^{3+}$ ,  $\text{As}^{5+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Pb}^{2+}$  and  $\text{Zn}^{2+}$  in groundwater in Go Vap District. The results showed that these metals are distributed mainly at mid-upper Pleistocene aquifer (qp<sup>2-3</sup>) from 8 meters to over 40 meters and in strongly to moderately acidic environment, which have pH from 4.2 to 5.0. As results, this study shows that these metals in groundwater related to the origin and sediments composition of permeable and impermeable aquifers. In addition, the metal pollution such as  $\text{Cu}^{2+}$ ,  $\text{Pb}^{2+}$  and  $\text{Zn}^{2+}$  in recent years may be due to the artificial origin.

*Keywords:* pollution in groundwater, ion Fe, Mn, As, Pb, Cu, Zn, Pleistocene aquifer.

### 1. INTRODUCTION

Hochiminh City is one of the biggest economic, cultural, and educational centers of the nation. Currently, in the city, the flow of water supplied for domestic use is approximately 2,600,000 m<sup>3</sup>/day, in which about 30 % of the water used at night is taken from groundwater sources with a flow of about 800,000 m<sup>3</sup>/day. According to the development strategy of the city until 2020, 100 % of the city's population will have clean water to use. Although from 2007 up till now, the measurements to secure the water supply with the financial support from WHO has increasingly supporting effective implementation, it is still difficult target to reach because of

the dwindling in water quality of the city. The appearance of total iron, Mn ion and other compounds tend to growing in exploited wells has become a threat to the water supply system of the city and it has become a subject to be considered. If the appearance of the mentioned metals in groundwater is not handled thoroughly, it will cause the congestion of the pipe, the water turbidity in the water supply system and will have an impact on the human nervous system, especially of the elderly, pregnant women ... and finally, that can cause the symptoms similar to Parkinson's [1].

For all the reasons, water resources exploited at 104 private wells in Go Vap District - Hochiminh City have been taken and analyzed. By combining the inhesion of metals pollution in the previous studies for Mn, Fe, As ... [1] and the analysis results of metal contamination from these wells, we could evaluate the pollution zones of each metal in groundwater and figure out the metal contamination capability in the studied area.

## 2. RESEARCH METHODS

### 2.1. Data base

This research was based on the daily surveys of metal analysis at 104 private exploited wells, in which water samples were taken and analyzed from 15/09/2015 to 30/12/2015 at 10 wards of the Go Vap District, Hochiminh City. All the wells were operated with a flow of 3 m<sup>3</sup>/hours to 15 m<sup>3</sup>/hour, distributed from 8m to 80m deep at mid-upper Pleistocene aquifer (qp<sup>2-3</sup>) and low Pleistocene aquifer (qp<sup>1</sup>). The distribution of sampling wells by wards and location distribution sketch were shown in Figure 1 and Figure 2. The Figure 1 showed the percentage distribution of the sample between the wards of the district, while the Figure 2 showed the regional distribution of spatial sampling.

### 2.2. Target and analysis methods

For all taken and analyzed samples, sampling and preserving processes were strictly compliant with the current regulations [2].

The analysis targets were pH, total Fe, concentrations of Al<sup>3+</sup>, As, Cu, Pb and Zn.

Sampling methods, experiment procedures and analysis processes were conducted following the 22<sup>nd</sup> Standard for the Examination of Water and Waste Water and the current Vietnam standards [3]. Procedure inspection, quality control and monitoring, management and quality warranty processes were performed in accordance with ISO/IEC 17025 [4] with the methodology and analysis devices as shown in Table 1.

Table 1. Analysis Methods and Target.

No.	Criteria	Unit	Analysis method	Analysis device	Device model	Accuracy
1	pH		ISO 10523 – 1994	pH tester	SenIon 3600	± 0,01
2	Fe total	mg/l	ISO 6333 - 1986	HACH	DR3900	± 0,01

3	Al <sup>3+</sup>	μg/l	ISO 12020:1997	ICP - OES	7000 DV	± 1
4	As <sup>5+</sup>	μg/l	ISO 11969 – 1986	ICP - OES	7000 DV	± 1
5	Cu <sup>2+</sup>	μg/l	ISO 8288 - 1986	ICP - OES	7000 DV	± 1
6	Pb <sup>2+</sup>	μg/l	ISO 8288 - 1986	ICP - OES	7000 DV	± 1
7	Zn <sup>2+</sup>	μg/l	ISO 8288 - 1986	ICP - OES	7000 DV	± 1

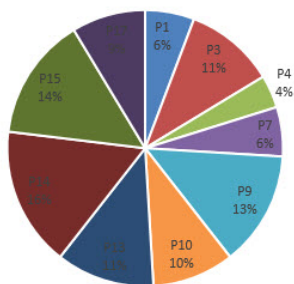


Figure 1. Correlation quantity of wells in wards.

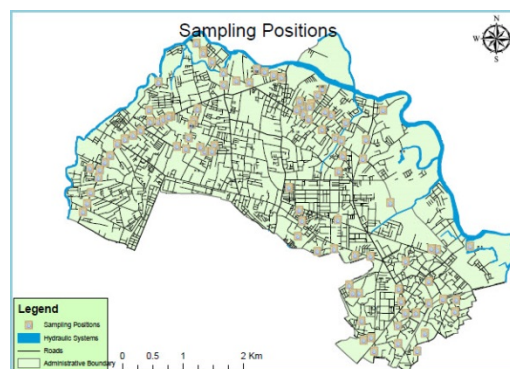


Figure 2. Distribution map for sampling locations.

### 2.3. Evaluation regulation

The evaluation has been conducted using the Vietnam National Technical Regulation for groundwater quality QCVN 09: 2015/BTNMT.

## 3. RESULT AND DISCUSSION

In Hochiminh City, the ions of Fe, Al<sup>3+</sup>, As<sup>5+</sup>, Cu<sup>2+</sup>, Pb<sup>2+</sup> and Zn<sup>2+</sup> were all found in groundwater with various concentrations. To assess the contamination of these metals, we need to have a base value for each metal. The concentrations of the metal ions in the 1990s were selected as base values. The reason is that in the 1990s, the industrial and urban areas of this city was not much developed and the impact of climate change was unclear. Basically, in 1990, the metal contents of Fe, Al<sup>3+</sup>, As<sup>5+</sup>, Cu<sup>2+</sup>, Pb<sup>2+</sup> and Zn<sup>2+</sup> in groundwater in Go Vap district were not high enough to be detected or traced [5].

### 3.1. Distribution in depth of metals

The depth distribution of total Fe, Al<sup>3+</sup>, As<sup>5+</sup> were shown in Figure 3 and similarly, Cu<sup>2+</sup>, Pb<sup>2+</sup>, Zn<sup>2+</sup> - in Figure 4. These figures showed the metal pollution mainly in the middle - upper Pleistocene aquifer (qp<sup>2-3</sup>) with the depth from 20m to over 40m. In Figure 5, it could be seen that the appearance of total Fe, Al<sup>3+</sup> and As<sup>5+</sup> increased, as well as the appearance of Cu<sup>2+</sup>, Pb<sup>2+</sup> and Zn<sup>2+</sup> in the depth of 30m to 40m. Compared with the QCVN09/2015/BTNMT, it was proved that most of the metals were under the acceptable limit.

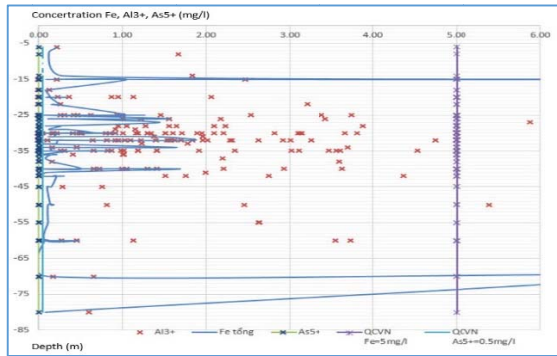


Figure 3. Distribution in depth of metals Fe, Al<sup>3+</sup> and As<sup>5+</sup> in Pleistocene aquifer.

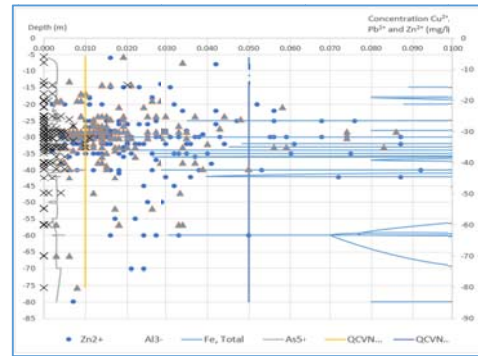


Figure 4. Distribution in depth of Cu<sup>2+</sup>, Pb<sup>2+</sup> and Zn<sup>2+</sup> in Pleistocene aquifer.

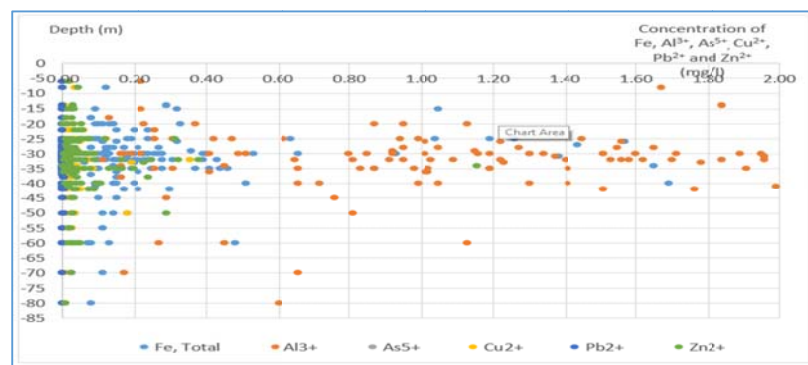


Figure 5. Distribution in depth of metals in Pleistocene aquifer.

### 3.2. Interrelation between pH and metals

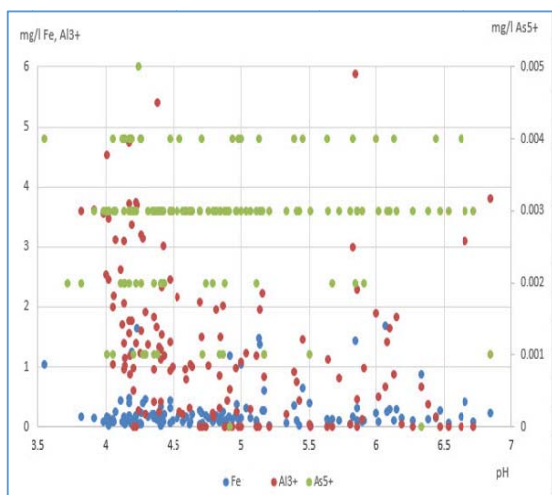


Figure 6. Interrelation between pH and metals Fe, Al<sup>3+</sup>, As<sup>5+</sup> in Pleistocene aquifer.

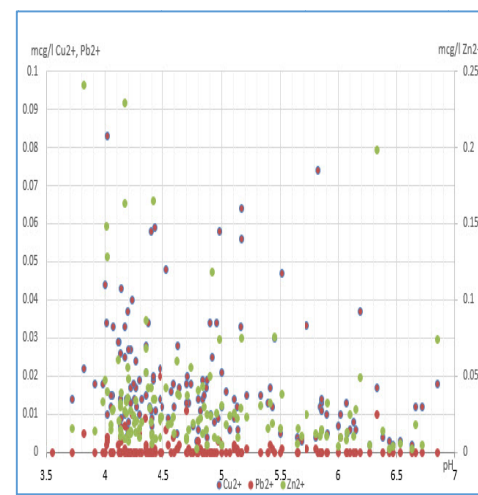


Figure 7. Interrelation between pH and metals Cu<sup>2+</sup>, Pb<sup>2+</sup> and Zn<sup>2+</sup> in Pleistocene aquifer.

The pH of water plays an important role for the stability of metals in groundwater. In Figure 7 and Figure 8, interrelation between pH and metals was presented. It indicated that these ions mainly distributed in between strong acidic environment and moderate one. These metals were mainly distributed in the pH range from 4.1 to 4.9 with 74 among 104 samples, constituting 73 %. This was also consistent with the fact that the solubility of metals increases in acidic environments.

### 3.3. Map for distribution of pH and metals in groundwater in Pleistocene aquifer

The metals in the groundwater were mainly from natural origin as scientists all agreed. However, in some cases, if their concentrations increased suddenly, comparing to the base value, it could be thought of an artificial origin. From the analysis results mentioned above, we used ArcGIS software to build up a distribution region for metal pollution. Figure 8 showed that the areas with low pH (less than 5) covered most of the studied area, except the southern part of Go Vap District (including the 1,3,4,5 wards). Figures 9, 10, 11 showed that the composition of total Fe,  $Al^{3+}$ ,  $As^{5+}$  in the areas below the regulation standards mostly distributed in low pH ranges while in some areas with high concentrations of metals, they distributed locally but still below the standard. On the other hand, as we know, the chemical types of groundwater in Hochiminh City are mainly  $HCO_3^-Na$ ,  $HCO_3^-Cl-Na$  or  $Cl-HCO_3^-Na$  [5] and the characteristics of sediments with aluvi-marine origin often contain significant amounts of supplied mineral groups such as pyrite, chalcopryrite ... In filtrative form, they are major minerals provided groundwater, surface water with a significant concentrations of  $Fe^{2+}$ ,  $Al^{3+}$  ions.

Alike, the distribution of metals  $Cu^{2+}$ ,  $Pb^{2+}$  and  $Zn^{2+}$  was given in Figures from 12 to 14. We could see that metals pollution occurs primarily in the areas where samples collected from the production company or the business households as cafeses or bars in the locality. From the appearance of these metals in the groundwater at the present time compared with the base value of the area, it could also temporarily concluded that the metals pollution of  $Cu^{2+}$ ,  $Pb^{2+}$  and  $Zn^{2+}$  was caused by human activities. So that, we could temporarily agree that the contamination of these metals was of the artificial origin.

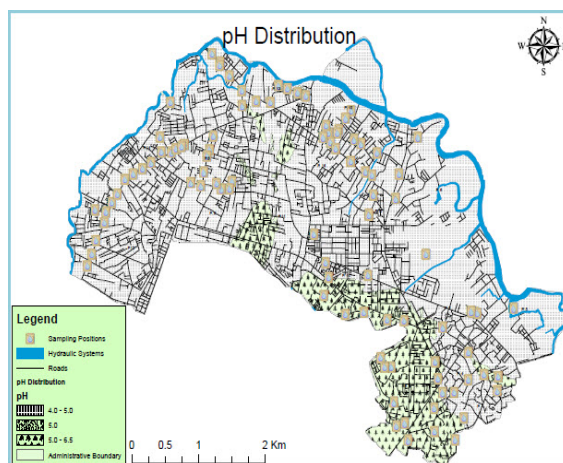


Figure 8. pH distribution map in Pleistocene aquifer in Go Vap.

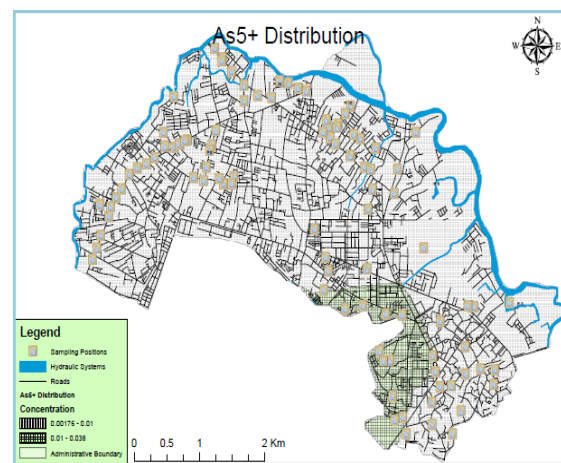


Figure 9.  $As^{5+}$  distribution map in Pleistocene aquifer in Go Vap.

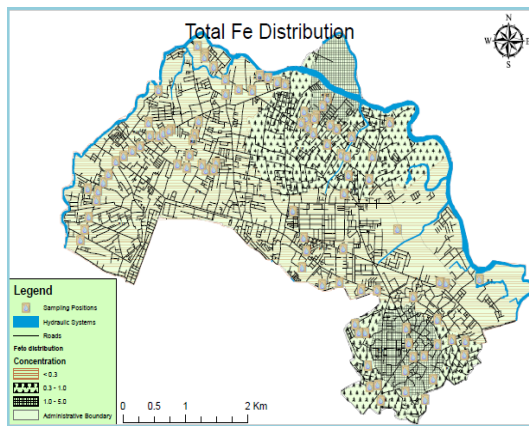


Figure 10.  $\text{Fe}^{\text{tc}}$  distribution map in Pleistocene aquifer in Go Vap.

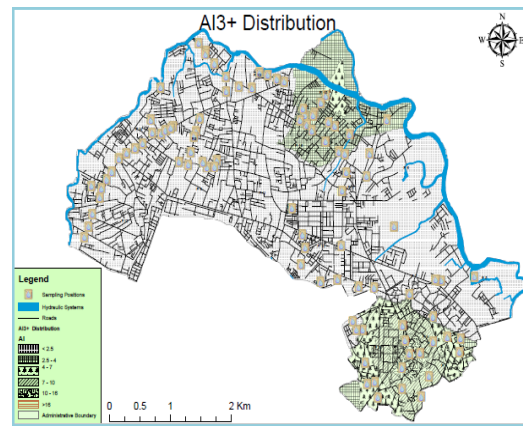


Figure 11:  $\text{Al}^{3+}$  distribution map in Pleistocene aquifer in Go Vap.

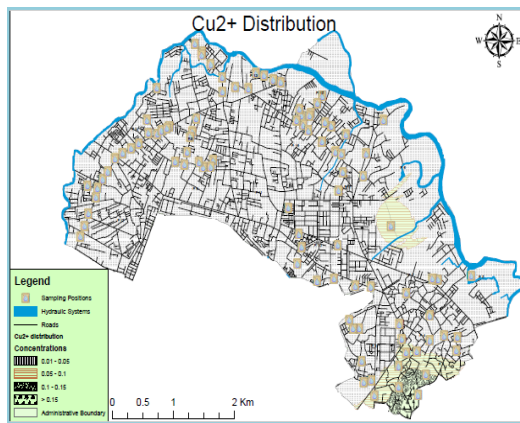


Figure 12.  $\text{Cu}^{2+}$  distribution map in Pleistocene aquifer in Go Vap.

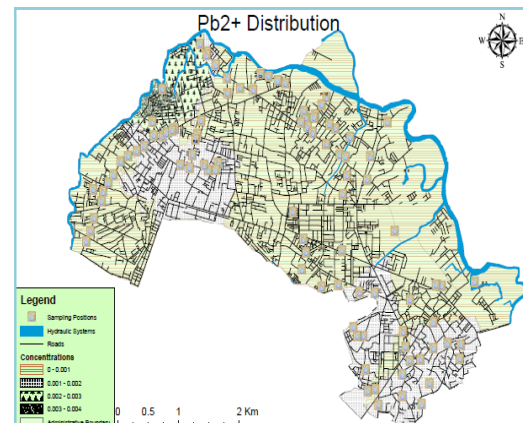


Figure 13.  $\text{Pb}^{2+}$  distribution map in Pleistocene aquifer in Go Vap.

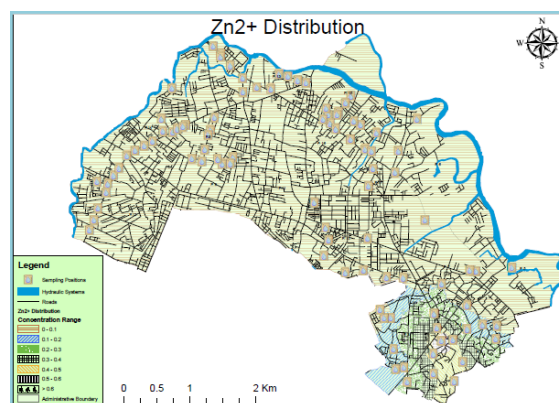


Figure 14.  $\text{Zn}^{2+}$  distribution map in Pleistocene aquifer in Go Vap.

#### 4. CONCLUSIONS

From the research results, it could be clearly clarified that the distributed metals of natural origin were: total iron,  $\text{Al}^{3+}$ ,  $\text{As}^{5+}$  and metals of artificial origin were:  $\text{Cu}^{2+}$ ,  $\text{Pb}^{2+}$  and  $\text{Zn}^{2+}$ . It could be seen that the metal was distributed mainly in the mid - upper Pleistocene aquifer ( $\text{qp}^{2-3}$ ) from 20 meters to over 40 meters in the range of strongly to moderately acidic environment with pH from 4.2 to 5.0. The origin of these metals in groundwater related to the origin and sediments composition of permeable and impermeable aquifers. While the base value of these metals was not detected or detected with trace, the appearance of ions  $\text{Cu}^{2+}$ ,  $\text{Pb}^{2+}$  and  $\text{Zn}^{2+}$  at the research area where human activities increased significantly in recent years lead to a conclusion that the contamination of these metals was due to artificial origin. In addition, we also noticed that the forms of existence of metals in the water depended on the geochemically environmental conditions and were quite consistent with the chemical composition of groundwater in the Hochiminh City.

**Acknowledgment.** The financial support of the Hochiminh City University of Technology to this research under the Project coded T-MTR-2016- 74 is highly appreciated.

#### REFERENCES

1. Nguyen Viet Ky, Le Thi Tuyet Van - Mn pollution in groundwater in Pleistocene aquifer in Ho Chi Minh City, The Scientific Journal of the Earth 1 **35** (2013) 2.
2. Ministry of Science and Technology - TCVN 6663- 11:2011 “Water quality - sampling, groundwater sampling Guidance”, Ha Noi – Viet Nam, 2011.
3. Ministry of Science and Technology - TCVN 5993: 1995 “Water quality - Sampling, Preservation instructions and sample processing”, Ha Noi – Viet Nam, 1995, pp. 9-19.
4. Ministry of Science and Technology - ISO/IEC 17025: 2005 “General requirements for the competence of testing and calibration laboratories”, Ha Noi – Viet Nam, 2007.
5. Nguyen Viet Ky, Chan N.Đ et al. - Exploitation and protection of groundwater resources, Publisher Vietnam National University, Ho Chi Minh City, 2006, pp. 228-273.