AN OVERVIEW OF GROUNDWATER QUALITY IN HANOI, VIETNAM

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I.INTRODUCTION

Groundwater, since the earliest recorded history has been regarded as very good source of clean drink water. In its natural state, it is generally of excellent quality and an essential natural resource. However, the natural quality of groundwater in aquifers is continually being modified by the influence of man. This occurs due to groundwater abstraction and the consequent change in groundwater flow, artificial recharge and direct inputs of anthropogenic substances. A thorough knowledge of the quantity and quality of groundwater in aquifers is therefore essential for effective management of this valuable resource.

Almost water supply in Hanoi, Vietnam is provided by groundwater resources. Rapid growth of population and urbanization in Hanoi has put more pressures on water supply. Hence sustainable management of groundwater resources is one of the essential objectives for the future of this area, especially when the rising demand for clean drinking water is considered (Bui et al., 2011). This means that it is essential to understand the quality of groundwater to enable the necessary protection, management and restoration measures for groundwater to be adopted.

II. STUDY AREA

Hanoi is the capital of Vietnam with a total area of about 3,344 km^2 in the northern part of Vietnam (Fig.1.). The population was about 6.5 million in 2009, occupying 7.5% of the Vietnam's population. The Hanoi belongs to the tropical monsoonal region with two distinctive seasons. The rainy season is from May to October and the dry season lasts from November till April. The annual rainfall is about 1,600 mm of which rainfall in the rainy season occupies about 75%. The annual average humidity is about 90% and the average temperature is around 24^oC. Evaporation is quite high with an annual average of 900 mm . The river network is quite dense with the density of about 0.7km/km^2. There are also more than 100 lakes with a total surface area of more than 2,180 hectares. However, the water of the Red River has a high concentration of suspended alluvials at any one time. Due to poor infrastructure and management of dumping waste, surface water in Hanoi has been seriously polluted. Therefore, groundwater is a main source of water supply. (Bui et al. 2011b).

III. GROUNDWATER RESOURCES IN HANOI

Most of the groundwater under the Hanoi plain is contained in quaternary sediments, in two main aquifers: Holocene unconfined aquifer (HUA) and Pleistocene confined aquifer (PCA). HUA is mainly composed of silty clay and various kinds of sands mixed with gravels. Thickness of this layer varies greatly, up to more than 35m with an average of about 15m. The transmissivity for HUA is form 20 to 1,788 m^2/day. The specific yield is between 0.01-0.17. The water level is 3-4m below the surface however in the south of the Red River the water level is lower due to the groundwater pumping. HUA is sufficient for small-scale water supply. (Bui et al., 2011).

PCA or lower aquifer is situated lower in the stratigraphic sequence. The depth is only less than 10m in the North of the Soc Son District, but around 20m in Dong Anh district, and up to 40m in the south of the Red River. The PCA is made up of sand mixed with cobbles and pebbles. The thickness of the PCA also fluctuates over a large range, up to 50m with the average of about 35m and has an increasing tendency from the North to the South. The transmissivity ranging from 700 to 2,900 m^2/day indicate a very high potential of groundwater resources. The specific storativity ranges from 0.00004 to 0.066. The specific capacity in the all tested wells in most cases is over 1L/sm. The aquifer has a significant potential for the supply of groundwater.

IV. GROUNDWATER QUALITY IN HANOI

The groundwater quality depends on many physicochemical parameters and their concentrations, which are derived from laboratory tests on water samples. (Jamshidzadeh and Mirbagheri, 2010). To determine the suitability of groundwater for different uses such as agricultural, industrial and domestic uses, the data obtained from 189 sampling wells monitored in HUA and 203 sampling wells monitored in PCA and publishes during April 2007 by the Ministry of Resources and Environment were analyzed in this study to find their physicochemical characteristic such

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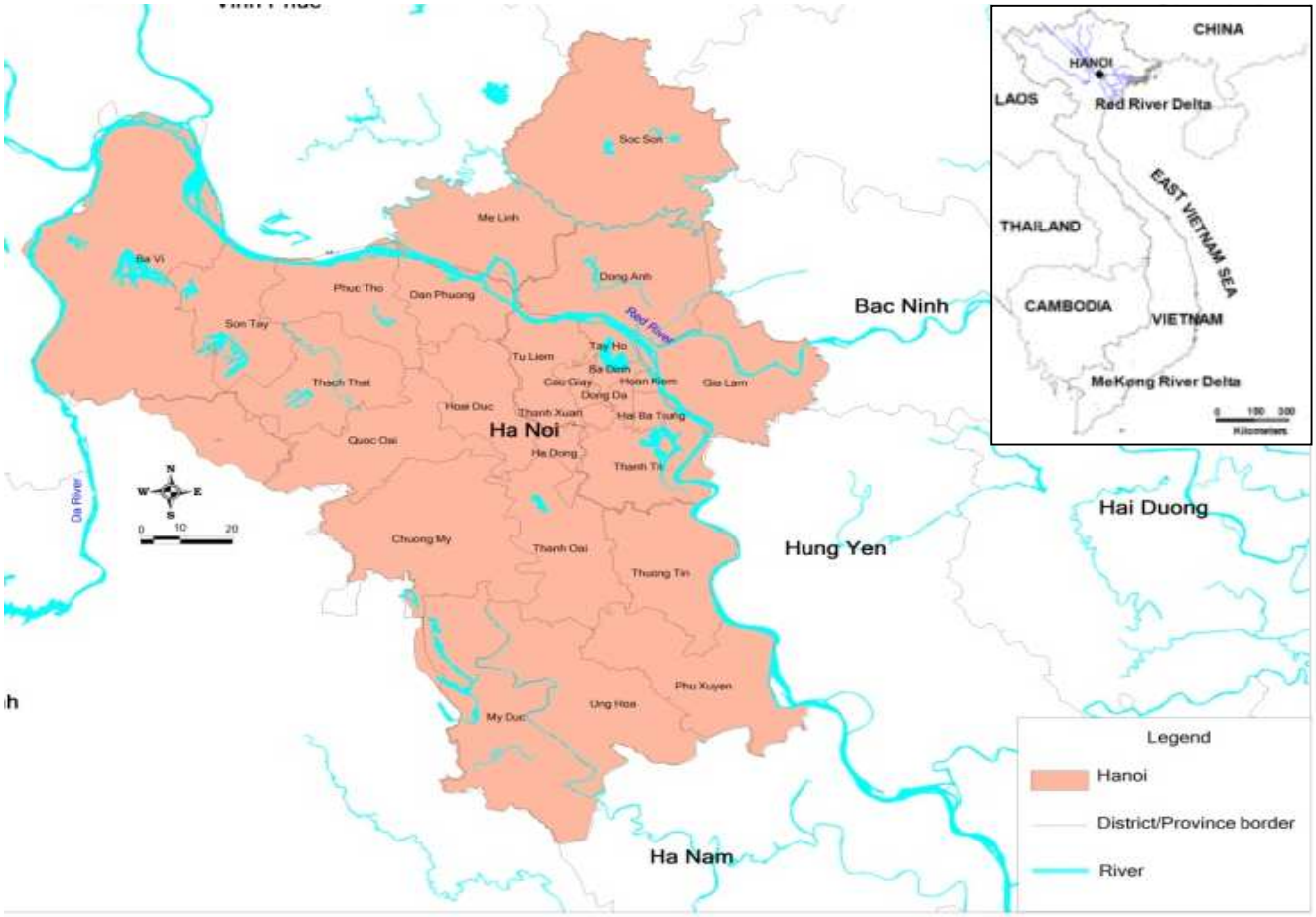

Figure 1: Study area

as Nitrogen compounds, Arsenic and E.coli in both aquifers (Table 1, 2). The experimental values were compared with Vietnam technical regulation on underground water quality (QCVN 09:2008/BTNMT).

The Nitrogen compounds values

Nitrogen compounds are major inorganic components deteriorating the quality of groundwater for drinking purposes (Jeong 2001). Groundwater affected by urban wastewater and agricultureal activities are generally high in NO_3^-. In addition, NO_3^- in groundwater may originate from oxidation of ammonium in the unsaturated zone. In urban areas, the sources of ammonium are mostly sewages generated from domestic and industrial activities and septic tanks, whereas ammonium prevails over other N compounds (Jacks et al. 1999). Therefore, the studied nitrogen components are $NH4^+$, NO_2^-, NO_3^- with the maximum permissible considerations of 0.1 mg/l, 1 mg/l and 15 mg/l, respectively. Nitrate is probably the most widespread contaminant in groundwater (Pacheco and Cabrera 1997). Nitrate can cause health problems in infants and animals, as well as the eutrophication of water bodies (Mohsen Jalali, 2011). From the table 1, the $NH4^+$ values, the NO_2^- value, the NO_3^- value of water samples in HUA were in the range of 0-17.5 mg/l, 0-35.2 mg/l and 0-400 mg/l respectively. About 43% ammonium component, 15% Nitrogen Dioxide component and 12% Nitrate component of water samples are not permissible for drinking water. The Nitrogen compound in HUA is higher than in PCA indicating that the pollutants migrate downward (Table 1,2). Areas having high average ammonium concentration in the both aquifers were Chuong My, Thanh Xuan, Thanh Tri (more than 60% of sample are higher than the standard values prescribed by Ministry of Resources and Environment). The sampling area which has maximum nitrate value in HUA is Me Linh with 400mg/l and in PCA is Chuong My with 28 mg/l.

The arsenic values

Arsenic is a persistent contaminant in groundwater and drinking water in the Red River Delta of Vietnam (Berg et al., 2001). Long-term exposure to arsenic can affect human health and is a significant cause of skin pigmentation, hyperkeratosis, cancer, cardiovascular disease and may affect the mental development of children, among other possible adverse effects (Smith et al., 2000; Wasserman et al., 2004; Kapaj et al., 2006). A guideline value of 0.01mg/l for Arsenic in Vietnam

Table 1. Groundwater quality in HUA

No	Sampling area	No of samples	NH4+	NO2-	NO3-	As	Coliform	E. Coli
1	Cau Giay	2	0-1.7	0	0	0.001	0-1	0
2	Dong Anh	2	0	0	2.32-2.48		0-1	0
3	Dong Da	1	4.9	0	0		0	0
4	Gia Lam	4	0-6.75	0	0-0.4	0.0082	0-1	0
5	Hoang Mai	6	0-12	0-0.18	0-5.6	0-0.0114	0-1	0
6	Thanh Xuan	1	5.75	0	0	0.0114	0	0
7	Thanh Tri	8	0-30	0-5.4	0-16	0.0053-0.0269	0-1	0
8	Tu Liem	10	0-5	0-0.06	0-1.64	0.0012-0.0248	0-1	0
9	Me Linh	11	0-1,28	0-35,2	0-400	0,0018- 0,00411	0-5	0
10	Dan Phuong	12	0-0,4	0-6,8	0-24	0,00105- 0,08349	0-12000	0-5600
11	Hoai Duc	13	0-26	0-35,2	0-32	0,00137- 0,13902	0-8	0
12	Thuong Tin	14	0-12	0-24	0-20	0- 0,07816	0-12	0
13	Chuong My	3	0,56-	0-0,1	0	0,00105- 0,00786	0	0
14	Thanh Oai	13	0-14	0-20	0-72	0,00439- 0,2482	0-34	0
15	Thach That	7	0-10	0-22,4	0-16	0,0008- 0,0088	0-8	0-1
16	Quoc Oai	9	0-0,48	0-0,52	0-8,4	0,00082- 0,00346	0	0
17	Phuc Tho	12	0-9,8	0-2,8	0-16,8	0,0012- 0,08003	0-5	0
18	Ha Dong	8	0-7,5	0-6	0-25,6	0,00273- 0,0308	0-8	0
19	Phu Xuyen	13	0-17,5	0-17,6	0-40	0,00374- 0,04149	0-14	0
20	Ung Hoa	14	0-32	0-24	0-30,4	0,00217- 0,2335	0-7	0-5
21	My Duc	17	0-12,5	0-0,3	0-60,8	0,0003- 0,04434	0-32	0
22	Ba Vi	2	0	0,04-	10,4-32	0,00107- 0,00348	21-250	1-2
23	Son Tay	6	0	0	1,4-68	0,00059- 0,0026	0	0-25
24	Standard value		0.1	1	15	0.01	3	0

Table 2. Groundwater quality in PCA

No	Sampling area	No of samples	NH4+	NO2-	NO3-	As	Coliform	E. Coli
1	Ba Dinh	1	2.6	0	0	0.0295	0	0
2	Cau Giay	5	0-4.5	0	0-4	0.0014-0.0315	0-1	0
3	Dong Anh	32	0-1.9	0-1.25	0-15.8	0.001-0.0185	0-1	0
4	Dong Da	1	12.5	0	0	0.0239	0	0
5	Gia Lam	23	0-4.75	0-0.13	0-5.5	0.0006-0.0206	0-1	0
6	Hoang Mai	18	0-34	0-0.9	0-6.16	0.0061-0.0288	0-1	0
7	Soc Son	4	0	0-0.64	0-6	0.0013-0.0018	0-1	0
8	Thanh Xuan	13	0-23.5	0-4.8	0-0.8	0.0142-0.0244	0-1	0
9	Thanh Tri	23	0-20	0-10.8	0-6	0.0086-0.0286	0-1	0
10	Tu Liem	41	0-22	0-2	0-4	0.0011-0.0341	0-1	0
11	Me Linh	9	0	0-0.24	0.4-27.2	0.0009-0.003	0-1	0
12	Chuong My	11	0-8.5	0-6	0-28	0.001-0.019	0-8	0
13	Thach That	3	0	0-0.1	1.8-24	0.0006-0.001	0-11	0
14	Quoc Oai	1	0	0	0	0.00312	0	0
15	Ba Vi	11	0-10.5	0-9.6	0-11.2	0.005-0.036	0-290	0-3
16	Son Tay	7	0	0-4	0-16	0	0	0
17	Standard value		0.1	1	15	0.01	3	0

technical regulation on underground water quality was established by Ministry of Resources and Environment. Arsenic concentration ranged between 0 -0.2482 mg/l in HUA and 0-0.0341 mg/l in PCA are shown as Table 1,2. About 40% of the groundwater samples in HUA and 43% in PCA exceeded the Vietnam guideline of 0.01 mg/l. Average arsenic concentrations in groundwater were higher in the centre of Hanoi (Ba Dinh, Cau Giay, Dong Da, Ha Ba Trung, Thanh Xuan, Hoang Mai, Tay Ho) than other areas. The sampling area had the maximum Arsenic value in HUA is Thanh Oai with 0.248 mg/l and in PCA is Tu Liem with 0.0341 mg/l.

The Microbes values

Coliforms are a broad class of bacteria found in our environment, including the feces of man and other warm-blooded animals. The presence of coliform bacteria in drinking water may indicate a possible presence of harmful, disease-causing organisms. E Coli is present in large numbers in the normal intestinal flora of humans and animals, where it generally causes no harm. However, in other parts of the body, E. Coli can cause serious disease, such as urinary tract infections, bacteriaemia and meningitis (WHO, 2008). The standard value of E.Coli and Coliform recommended by MRM are 3/100ml and 0, respectively. Table 1, 2 show that E Coli was almost not found in both aquifers except Ba Vi area. However, more than 22% of samples in both aquifers have coliform values higher than the standard limit. Especially, there was a HUA groundwater sample in Dan Phuong having very high Coliform and E.Coli with 12000 and 5600 MNP/100 ml respectively.

V. CONCLUSION

Groundwater in Hanoi has been assessed for its quality for use of drinking purposes. The analysis of the data suggests that groundwater in the study area has been polluted and it is necessary to be treated before using for drinking purposes. The main reasons leading to groundwater pollution are extensive pumping, agricultural activities and domestic waste discharge in the study area. Informed and effective approaches are needed, thus further research may be performed based on observed groundwater quality data.

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