STUDYING THE CONTAMINATION STATUS AND THE SOURCES OF NITROGEN COMPOUNDS IN GROUNDWATER IN HOCHIMINH CITY AREA USING THE ISOTOPE HYDROLOGY TECHNIQUES

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ABSTRACT: The obtained data on nitrate, ammonium and total nitrogen concentration of 100 groundwater samples collected from 3 main aquifers show that although the nitrate concentration is still lower than the authorized limit of this compound in groundwater but the concentration and, specially the distribution of nitrate in shallow aquifer (Pleistocene) shows the increasing tendency in pollution level while ammonium and also total nitrogen content exceeded the authorized limit of these compounds in groundwater. For deeper aquifers (Upper and Lower Pliocene) groundwater is less polluted by nitrogen compounds. Analysis data on isotopic composition $\delta^{15}N$ and $\delta^{18}O$ of nitrate of the collected groundwater samples in compiling with other environmental isotopes data as $\delta^{2}H$, $\delta^{18}O$ of water and natural radioactive isotopes in groundwater (^{3}H and ^{14}C) show that nitrate in Pleistocene groundwater is derived from both sources, geogenic source such as organic matter buried in aquifer soil layers and anthropogenic source like fertilizers, manure and septic wastes with the dominance of anthropogenic source. At the same time, obtained isotopic data proved the geogenic source of nitrate in water of the deeper aquifers. Study results on infiltration rate and infiltration depth of fertilizers and water using tracer techniques in the zone specializing in legume cultivation of the study area show the possible infiltration into shallow groundwater of water and also fertilizers. The obtained results prove the need of better management of the use of fertilizers for cultivation activities in the study area and to apply the advanced cultural manners for minimizing amount of fertilizers used. At the same time to strengthen wastes management and treatment in whole study area, especially in the zones which intake rain water as a recharge source to shallow groundwater such as Cu Chi, Hoc Mon and also inner city districts.

INTRODUCTION

Groundwater contaminated by nitrogen has been recorded in Hochiminh city. Over exploitation of groundwater in this area bring about not only the declining of water table in existing aquifers but also the migration availability of contaminants into groundwater aquifers. Due to the toxicity of nitrate for man health, defining the source of nitrate in groundwater is very important beside the assessment of contaminated groundwater by nitrate to prevent or/and to reduce the migration of nitrate into groundwater. Use of the environmental isotope techniques to define the source of nitrate in groundwater aquifers which are being exploited for water supply in Hochiminh City is the aim of this study.

I. EXPERIMENTS

Suitable analysis techniques have been applied to analyze nitrate concentration and environmental isotopic composition (^{2}H, ^{18}O, ^{3}H, ^{14}C, ^{15}N and ^{18}O of nitrate) in groundwater. Nitrate as well as ammonium and total nitrogen concentration of collected groundwater samples have been use to assess the status of groundwater contaminated by nitrogen compounds while

isotopic composition $\delta^{15}N_{NO3}$ (^{15}N concentration in NO_3) and $\delta^{18}O_{NO3}$ (^{18}O concentration in NO_3) of water samples in compiling with δ^2H, $\delta^{18}O$ of water, natural radioactive isotopes (^3H and ^{14}C) and nitrate concentration will be used to define the source of nitrate in groundwater based on the fact that each source of nitrate has isotopic specific indices ($\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$).

Tracer technique using suitable tracers (^{15}N for nitrogen fertilizer and ^{131}I for water) has been applied to trace the movement of water and ^{15}N fertilizer in unsaturated zone. This field experiment has been carried out in the area where shallow groundwater could be recharged directly by local rain water. The obtained results on infiltration rate and infiltration depth of water and fertilizer have been used to assess the contaminating availability of nitrogen fertilizer to shallow groundwater.

II. PROCEDURES

A sampling network of 100 sampling wells points with the consideration of regions as well as the aquifers which need to be pay more attention has been set up based on the hydro-geological setting, the existing boreholes of study area and the study aims.

Groundwater has been sampled in sampling campaign. A total of 100 groundwater samples including 44 from the Pleistocene aquifer, 29 from the Upper Pliocene and 21 from the Lower Pliocene aquifer have been collected for chemicals and environmental isotopic analysis.

All collected water samples have been analyzed for environmental isotopes (^2H, ^{18}O, $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$), major ions and nitrogen compound concentration. Some of them have been also analyzed for ^3H, ^{14}C.

At the same time, a tracing experiment using ^{131}I and ^{15}N fertilizer as suitable tracers has been conducted at a place in the region which is specializing in legume cultivation of the study area.

III. RESULTS AND DISCUSSION

1. Status of groundwater polluted by nitrogen compounds in the study area

Based on the analysis data on NO_3, NH_4 and total N concentration of groundwater samples collected and in comparing with the pollution grades (concentrations) for these compounds for groundwater, the ratio of polluted groundwater samples to the total of collected samples of each study groundwater aquifer is listed in the Table 1. And the distribution of these compounds in aquifers in the study area has been mapped.

Table 1: Data of groundwater contaminated by nitrogen compounds in study area.

Pollutant	Pollution grade & Concentration (mg/L)	Pleistocene		Upper Pliocene		Lower Pliocene	
		No. of samples	*Ratio (%)*	*No. of samples*	*Ratio (%)*	*No. of samples*	*Ratio (%)*
NO_3	Heavy (> 45)	0	0	0/29	0	0/21	0
	Medium (30-45)	6/66	9	0/29	0	0/21	0
	Light (10-30)	23/66	35	3/29	10	1/21	5
	Non (< 10)	37/66	56	26/29	90	20/21	95
NH_4	Heavy (> 10)	3/50	6	1/29	3	0/21	0
	Medium (3-10)	4/50	8	3/29	10	0/21	0
	Light (1.5-3)	3/50	6	2/29	7	3/21	14
	Non (< 1.5)	40/50	80	23/29	80	18/21	86
Total N	Heavy (> 20)	5/50	10	0/29	0	0/21	0

	Medium (7-20)	3/50	6	2/29	7	1/21	5
	Light (2-7)	18/50	36	7/29	24	2/21	10
	Non (< 2)	24/50	48	20/29	69	18/21	85

The statistical data show that although the nitrate concentration is still lower than the authorized limit of this compound in groundwater but the concentration and, specially the distribution of nitrate in shallow aquifer (Pleistocene) shows the increasing tendency in pollution level while ammonium and also total N concentration exceeded the authorized limit of these compounds in groundwater. For deeper aquifers (Upper and Lower Pliocene) groundwater is less polluted by nitrogen compounds.

2. Source of nitrate in groundwater

In this study, the source of nitrate in collected groundwater samples is defined qualitatively by the isotopic indices ($\delta^{15}N$ and $\delta^{18}O$ of NO_3) which characterize for different sources as shown in the Figure 1.

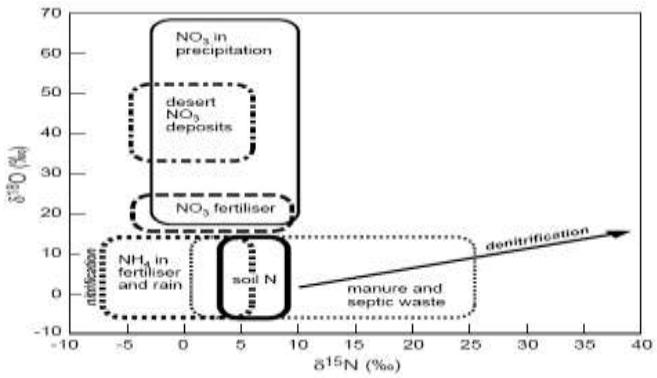

Figure 1: Sources of NO_3 in groundwater and their isotopic characteristics.

Analysis data on $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ in water samples which were collected from the Pleistocene aquifer in the study area are plotted in the Figure 2.

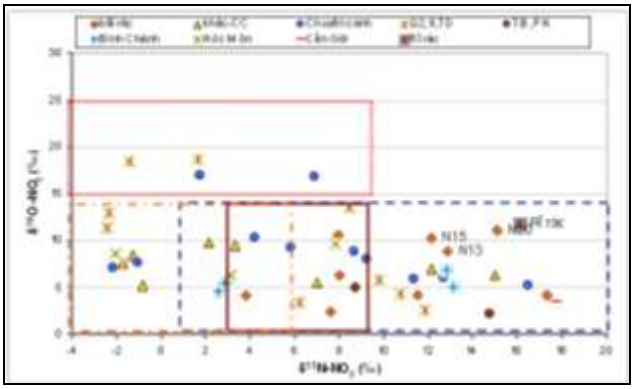

Figure 2: $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ relationship of Pleistocene groundwater samples.

This plot shows anthropogenic and geogenic sources of nitrate in water of this aquifer. The anthropogenic sources include fertilizer (samples locate in the red and orange rectangular), manure and septic waste (samples in the blue rectangular).And the geogenic source deriving from soil nitrogen includes samples in the brown rectangular.

In compiling with NO_3 concentration, $\delta^{15}N_{NO3}$ data prove that nitrate deriving from anthropogenic sources is dominant in nitrate in water of this aquifer.

$\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ relationship of Upper Pliocene groundwater samples is plotted in the Figure 3.

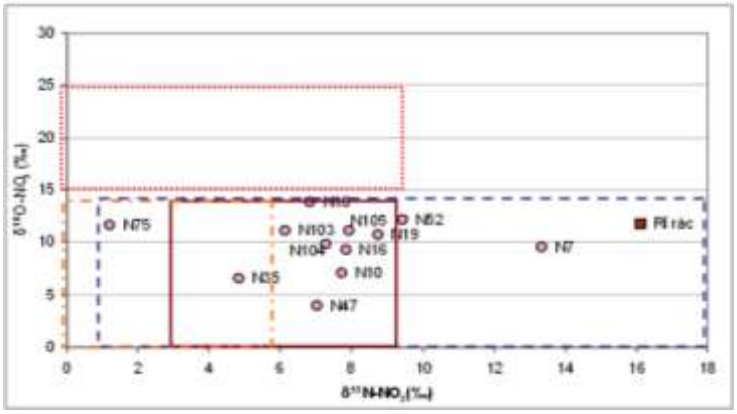

Figure 3: $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ relationship of Upper Pliocene groundwater samples.

Distribution of groundwater sample points shows the anthropogenic and geogenic source of nitrate in this aquifer. But, differing with the above aquifer (Pleistocene), nitrate in water of Upper Pliocene aquifer is mainly derived from organic materials in soil. It means the main source of nitrate in water of this aquifer is geogenic.

Figure 4 is the relationship plot of $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ of water samples collected from the Lower Pliocene aquifer.

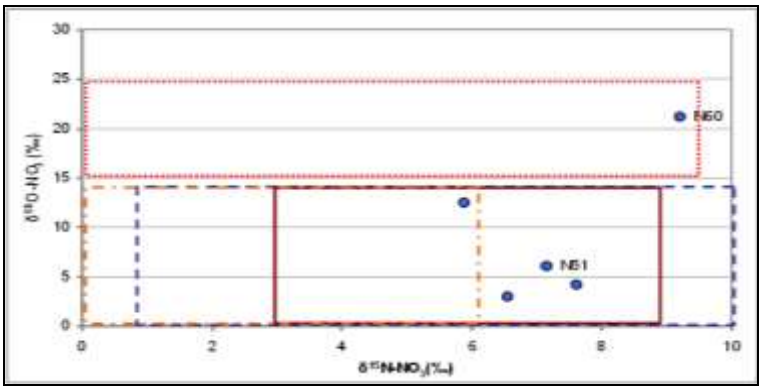

Figure 4: $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ relationship of Upper Pliocene groundwater samples.

Positions of sample points in this graph show clearly that nitrate in water of this aquifer is only derived from geogenic source.

3. Contaminating availability of nitrogen fertilizer used in agricultural activities to shallow groundwater

Tracer technique using suitable tracers (^{15}N for nitrogen fertilizer and ^{131}I for water) has been applied to trace the movement of water and ^{15}N fertilizer in unsaturated zone.

The experiment site locates in a region where is specializing in legume cultivation of the study area and the experiment time is 409 days for ^{15}N fertilizer and 222 days for water.

The infiltration depth of water and fertilizer has been plotted in the Figure 5.

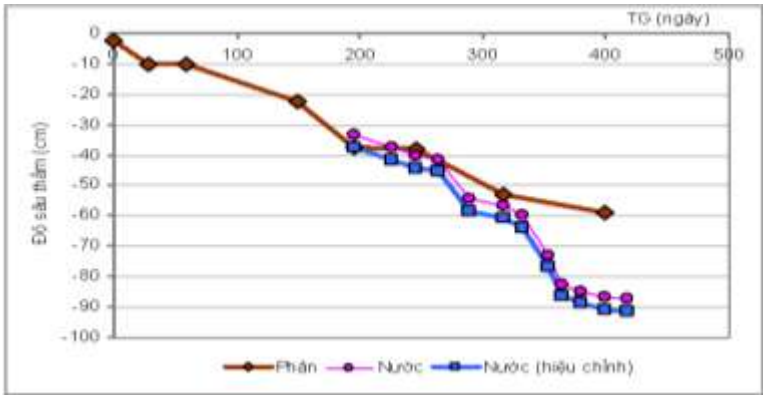

Figure 5: Infiltration of water and fertilizer on experiment time.

This graph shows the down infiltration tendency of water and fertilizer. In comparing with water, infiltration rate of fertilizer is slower due to the interaction of fertilizer and soil materials.

At experiment site, the mean down infiltration rate is 0.2 cm/day for water and 0.14 cm/day for fertilizer.

IV. CONCLUSIONS

1. Although the nitrate concentration is still lower than the authorized limit of this compound in groundwater but the concentration and, specially the distribution of nitrate in shallow aquifer (Pleistocene) shows the increasing tendency in pollution level while ammonium and also total nitrogen content exceeded the authorized limit of these compounds in groundwater. This means that better management of wastes, fertilizers used and also shallow groundwater exploitation needs to be applied to decrease the bad influence on water quality of N compounds. For deeper aquifers (Upper and Lower Pliocene) groundwater is less polluted by nitrogen compounds.

2. The source of nitrate in studied groundwater has been defined qualitatively based on $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ data compiling with other environmental isotope compositions ($\delta^{2}H$, $\delta^{18}O$, ^{3}H, ^{14}C), major ions and nitrate concentration data of 100 water samples. There are two sources of nitrate which are anthropogenic and geogenic. For the Pleistocene aquifer nitrate in water is derived mainly from anthropogenic sources while it is less dominant in the Upper Pliocene aquifer. For the deepest aquifer, Lower Pliocene, nitrate in water is only derived from geogenic sources.

3. Mean infiltration rate which is 0.2 cm/day for water and 0.14 cm/day for fertilizer has been recorded at the field experiment site using tracer technique. With the water table of about 120cm below ground surface and down infiltrating tendency of fertilizer, shallow groundwater at that site should be contaminated by nitrogen fertilizer used for agricultural purposes.

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