

# DETERMINATION OF THE EXISTENCE OF POLYCYCLIC AROMATIC HYDROCARBONS IN WELL WATER OF CO NHUE 1 WARD BY GC/MS MASS SPECTRUM CHROMATOGRAPHY

ĐÁNH GIÁ VÀ DỰ ĐOÁN XU HƯỚNG LAN TRUYỀN HYDROCARBON THƠM ĐA VÒNG TRONG NƯỚC NGẦM TẠI CỔ NHUẾ 1, HÀ NỘI

Nguyen Thi Thu<sup>1</sup>, Nguyen Thi Nang<sup>1</sup>, Dang Minh Quang<sup>1</sup>,  
Nguyen Kim Thuy<sup>1</sup>, Nguyen Manh Ha<sup>2,\*</sup>

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## ABSTRACT

PAHs are toxic, mutagenic, and carcinogenic organic pollutants that pose environmental and health hazards. This work uses gas chromatography-mass spectrometry to detect and quantify PAHs in Co Nhue 1 Ward well water samples. GC/MS was used to identify and quantify PAHs chemicals in well water samples from Co Nhue 1 Ward. Data were compared to environmental safety requirements to estimate contamination hazards. GC/MS was used to identify and quantify PAHs chemicals in well water samples from Co Nhue 1 Ward. Data were compared to environmental safety requirements to estimate contamination hazards. The investigation found PAHs chemicals in the water samples, some exceeding limits. PAHs with low- and high-molecular-weight compounds were found, indicating pollution from industrial emissions, vehicle exhaust, and poor waste disposal. PAH-contaminated well water in Co Nhue 1 Ward may harm people. To reduce PAHs pollution and maintain safe drinking water, regular monitoring and water treatment are needed.

**Keywords:** Polycyclic aromatic hydrocarbons (PAHs), GC-MS analysis, groundwater contamination, persistent organic pollutants (POPs).

## TÓM TẮT

PAHs là chất ô nhiễm hữu cơ độc hại, gây đột biến và gây ung thư gây ra mối nguy hại cho môi trường và sức khỏe. Công trình này sử dụng phương pháp sắc ký khí khối phổ để phát hiện và định lượng PAHs trong các mẫu nước giếng của phường Cổ Nhuế 1. GC/MS được sử dụng để xác định và định lượng hóa chất PAHs trong các mẫu nước giếng từ phường Cổ Nhuế 1. Dữ liệu được so sánh với các yêu cầu về an toàn môi trường để ước tính mối nguy hại ô nhiễm. GC/MS được sử dụng để xác định và định lượng hóa chất PAHs trong các mẫu nước giếng từ phường Cổ Nhuế 1. Dữ liệu được so sánh với các yêu cầu về an toàn môi trường để ước tính mối nguy hại ô nhiễm. Cuộc điều tra phát hiện ra hóa chất PAHs trong các mẫu nước, một số vượt quá giới hạn. PAHs có hợp chất có trọng lượng phân tử thấp và cao đã được tìm thấy, cho thấy ô nhiễm từ khí thải công nghiệp, khí thải từ xe cộ và xử lý chất thải kém. Nước giếng bị ô nhiễm PAHs ở phường Cổ Nhuế 1 có thể gây hại cho con người. Để giảm ô nhiễm PAHs và duy trì nguồn nước uống an toàn, cần phải theo dõi và xử lý nước thường xuyên.

**Từ khóa:** Hydrocacbon thơm đa vòng (PAH), phân tích GC-MS, ô nhiễm nước ngầm, chất ô nhiễm hữu cơ khó phân hủy (POP).

<sup>1</sup>Department of Chemistry and Environment, Joint Vietnam-Russia Tropical Science and Technology Research Center, Vietnam

<sup>2</sup>Faculty of Chemical Technology, Hanoi University of Industry, Vietnam

\*Email: nmhacnh@gmail.com

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## 1. INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are a class of persistent organic pollutants (POPs) that present

considerable environmental and human health hazards owing to their toxicity, carcinogenic potential, and bioaccumulative characteristics [1-3]. These chemicals

predominantly originate from the incomplete combustion of organic sources, including coal, oil, wood, and petroleum products. Polycyclic aromatic hydrocarbons (PAHs) can infiltrate aquatic ecosystems by atmospheric deposition, industrial discharges, urban runoff, and inadequate waste management. Upon release into the environment, PAHs can permeate the subsoil and pollute groundwater, an essential resource for potable water and agricultural use [4-6]. Groundwater pollution by PAHs is an escalating issue, especially in urban and industrial areas where human activities facilitate their accumulation [7, 8]. The presence of PAHs in groundwater can lead to prolonged ecological harm and health risks if inadequately controlled [9-11]. Evaluating and forecasting the dispersion patterns of PAHs in groundwater is essential for efficient pollution management, risk evaluation, and remedial approaches. A thorough comprehension of PAHs transit and fate in subsurface ecosystems can assist policymakers, environmental managers, and scientists in formulating sustainable groundwater protection strategies [12, 13].

Hanoi, the capital of Vietnam, has seen swift urbanization and industry, resulting in heightened environmental challenges. Co Nhue, a suburban locality of Hanoi, has been recognized as an area with considerable contamination hazards owing to its closeness to industrial zones and elevated population density. The detection of PAHs in groundwater in this region raises concerns about water quality and potential health risks for local inhabitants. Examining the diffusion patterns of PAHs in groundwater in Co Nhue is crucial for comprehending the degree of contamination and enacting suitable remediation strategies. Multiple factors affect the transport and diffusion of PAHs in groundwater, including the physicochemical properties of PAHs (molecular weight, solubility, and hydrophobicity), hydrogeological characteristics of the subsurface, and environmental conditions such as pH, temperature, and microbial activity [13-16]. Low-molecular-weight PAHs are generally more soluble and mobile in groundwater, while high-molecular-weight PAHs have greater adsorption to soil particles, resulting in localized pollution [17-19]. The intricate interplay among these parameters requires the implementation of predictive models to evaluate PAHs movement patterns and associated dangers. Water pollution by organic contaminants is an escalating environmental and public health issue, especially in metropolitan regions where industrial and domestic activities substantially increase

the presence of toxic substances. Polycyclic aromatic hydrocarbons (PAHs) are particularly noteworthy among these contaminants because of their poisonous, carcinogenic, and persistent characteristics. Polycyclic aromatic hydrocarbons (PAHs) are a category of chemical molecules consisting of many fused benzene rings, predominantly resulting from the incomplete combustion of organic substances including coal, oil, wood, and other hydrocarbons. These chemicals may infiltrate water sources by air deposition, industrial effluents, petroleum spills, and leaching from polluted soils. Groundwater, encompassing well water, is an essential potable water supply for millions globally. Nonetheless, its susceptibility to contamination from both human and natural sources requires ongoing monitoring and study.

In Vietnam, swift urbanization and industrialization have raised significant worries about water quality, especially in suburban and peri-urban regions such as Co Nhue 1 Ward, Hanoi. The existence of PAHs in well water presents significant health hazards, including chronic illnesses and carcinogenic consequences, necessitating the evaluation of their prevalence and concentration levels. Gas chromatography-mass spectrometry (GC/MS) is a highly effective analytical method for the detection and quantification of polycyclic aromatic hydrocarbons (PAHs) in environmental samples. This technique provides elevated sensitivity, specificity, and the capacity to differentiate among various PAHs molecules. Although the determination of 16 priority polycyclic aromatic hydrocarbons (PAHs) using gas chromatography-mass spectrometry (GC/MS) has been standardized under TCVN 10496:2015 (ISO 28540:2011), the present study focuses on applying and optimizing this method for the analysis of well water in Co Nhue 1 Ward, an urban area with potential PAHs contamination from nearby industrial and residential sources. The novelty of this research lies in the refinement of sample preparation techniques - including extraction and purification steps - and the adaptation of analytical parameters to suit the characteristics of groundwater samples and local laboratory conditions. Furthermore, the study establishes key performance indicators such as detection limits, recovery efficiencies, and repeatability through method validation on real samples. Importantly, this work provides the first dataset on PAHs contamination in well water from Co Nhue 1 Ward, offering valuable insights for environmental quality assessment and public health risk evaluation.

## 2. EXPERIMENTS

### 2.1. Research sample

The research area is Co Nhue 1 Ward, situated in the eastern part of Bac Tu Liem District. The east adjoins Xuan Tao Ward and Cau Giay District; the west adjoins Phu Dien Ward; the south adjoins Cau Giay District; the north adjoins Co Nhue 2 and Xuan Dinh Wards. The size is 2.22km<sup>2</sup>, the population is 45.274 individuals (2020), and the density is 20.394 people/km<sup>2</sup>.

Well water samples were obtained at eight locations throughout the ward's aquatic environment; further details are available in Table 1. Water samples were obtained using a pre-cleaned container. All samples were preserved at -20°C until extraction.

Table 1. Sample Location and Coordinates

| Location | Coordinates |              |
|----------|-------------|--------------|
|          | N           | E            |
| L1       | 21°03'24.5" | 105°47'04.6" |
| L2       | 21°02'43.1" | 105°46'54.8" |
| L3       | 21°03'49.7" | 105°47'04.9" |
| L4       | 21°03'18.4" | 105°46'44.4" |
| L5       | 21°03'04.0" | 105°46'16.0" |
| L6       | 21°02'56.8" | 105°46'32.9" |
| L7       | 21°02'59.6" | 105°46'49.4" |
| L8       | 21°03'01.4" | 105°47'41.3" |

Groundwater samples were collected from active drilled wells in Co Nhue 1 Ward, Bac Tu Liem District, Hanoi. Prior to sampling, the wells were purged by pumping for 5 - 10 minutes to remove stagnant water and ensure representative sampling. Samples were collected directly into 1-liter amber glass bottles with Teflon-lined caps, which had been pre-cleaned with dilute nitric acid, rinsed with deionized water, and baked at 400°C to eliminate organic residues. After collection, the bottles were stored in ice boxes at a temperature of 4 ± 2°C, protected from light, and transported to the laboratory within 6 hours. All samples were analyzed within 48 hours of collection to minimize potential degradation or volatilization of PAH compounds.

### 2.2. Chemicals

All solvents and chemicals must be of analytical purity, by Merck or Fisher including: n-hexane, cyclohexane, dichloromethane, toluene, acetone, pentane, nonane, sodium sulfate granules, glass wool, silica gel 60-130 Mesh (Merck), Standards: analytical standard (Native STD)

for PAHs (EPA-PAH-STK) PAHS Native Standard Mixture 5µg/mL includes 16 components; companion standard (EPA-PAH-LCS) PAHS Surrogate Standard Mixture 5µg/mL, internal standard/recovery standard (EPA-EU-PAH-ISS) p-Terphenyl-d14 5µg/mL.

### 2.3. Analysis of PAH

Adjust water samples to pH < 2 using a 1:1 (v/v) H<sub>2</sub>SO<sub>4</sub> solution. Transfer 1.0L of the sample into a separatory funnel and add 25 µL of a 1000 pg/µL companion standard. Add 60 mL dichloromethane, shake for 1 - 2 minutes while venting, and allow phase separation for 10 minutes. Extract the solvent layer, repeat twice with fresh solvent, and combine all extracts. Using a rotary evaporator at < 40°C, concentrate the extract to 1 - 2mL, rinse with 5mL cyclohexane, and repeat 2 times. Prepare a silica gel column (10g, dried at 130°C for 16h) with Na<sub>2</sub>SO<sub>4</sub>, activate with pentane, and load the extract (< 10mL). Eliminate contaminants with 25mL pentane, then dilute with 25mL dichloromethane/pentane (2:3). Concentrate the sample in a rotary evaporator to ~0.5mL, rinse with n-hexane, and transfer to a test tube. Further concentrate with N<sub>2</sub> gas to < 1mL, transfer to a 500µL-marked vial, and add 25µL recovery standard. Seal with a PTFE septum, and vortex, and inject the sample into the GC/MS for analysis.

GC-MS analysis was performed using an Agilent GC7890A coupled with an MSD5975 (USA). The system utilized an HP-5MS chromatographic column (30 m × 0.25mm ID, 0.25µm film thickness) with a splitless injection mode (2µL sample volume) and helium as the carrier gas at a flow rate of 1.0mL/min. The column temperature program started at 80°C (1 min hold), increased at 20°C/min to 160°C (no hold), then at 2°C/min to 190°C, followed by 5°C/min to 270°C, and finally at 10°C/min to 320°C with a 3-minute hold. The auxiliary heater was set to 300°C. Mass spectrometry was conducted in Selected Ion Monitoring (SIM) mode with Electron Impact (EI) ionization at 70eV, an ion source temperature of 230°C, and a quadrupole temperature of 150°C, using a Delta EMV detector configuration. The system was controlled via ChemStation software.

### 2.4. Health risk assessment

The incremental lifetime cancer risk (ILCR) is estimated using the following formula for ingestion exposure:

$$ILCR = CDI \times CSF$$

Where:

CDI: Chronic Daily Intake (mg/kg/day);

CSF: Cancer Slope Factor (mg/kg/day)<sup>-1</sup>.

CDI is calculated as:

$$CDI = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

C: PAHs concentration (mg/L);

IR: Ingestion rate (2.0L/day);

EF: Exposure frequency (350 days/year);

ED: Exposure duration (30 years);

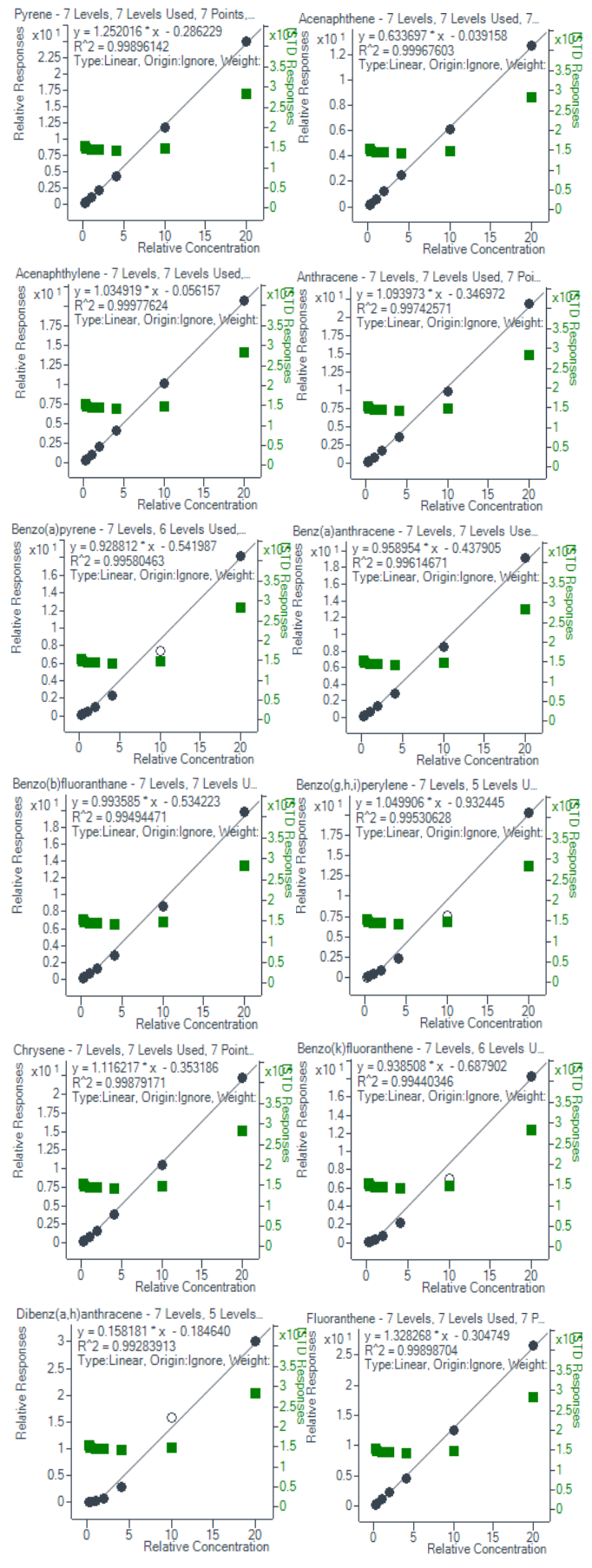
BW: Body weight (70kg);

AT: Averaging time for carcinogens (70 × 365 = 25,550 days).

### 3. RESULTS AND DISCUSSION

#### 3.1. Establishment of standard curve of 16 PAHs

Figure 1 displays standard calibration curves for polycyclic aromatic hydrocarbons (PAHs), illustrating the correlation between relative concentration and response. Each graph displays a linear regression fit, accompanied with equations and correlation coefficients (R<sup>2</sup>), substantiating the robust linearity of the calibration models. Most PAHs display R<sup>2</sup> values approaching 1, indicating good accuracy and dependability in quantification. The majority of curves exhibit a linear trend, confirming the uniformity of detector response over the evaluated concentration ranges. Nevertheless, tiny discrepancies are seen in certain graphs, perhaps attributable to instrument variability, matrix effects, or modest non-linearity at elevated doses. The regression equations demonstrate variability in sensitivity among PAHs, as evidenced by the differences in slopes. Elevated slopes imply more robust detector responses, whereas diminished slopes may signify weaker signals or decreased ionization efficiency. The standard curves validate the method's reliability for PAHs analysis with GC-MS. The elevated R<sup>2</sup> values and continuous linearity across various levels signify precise and reproducible quantification, affirming the method's dependability for environmental and analytical purposes.



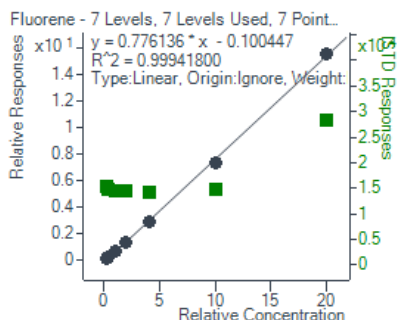


Figure 1. Standard curve for PAHS analysis

Table 2 displays the standard curve equations and correlation coefficients ( $R^2$ ) for 16 polycyclic aromatic hydrocarbons (PAHs), evaluating their linearity in calibration. The standard curves demonstrate remarkable linearity, with  $R^2$  values between 0.9910 and 0.9998, signifying a robust connection between concentration and detector response. Naphthalene (Naph) and acenaphthylene (Acy) exhibit the greatest  $R^2$  values (0.9998) among the PAHs, indicating exceptionally reliable measurement. The majority of substances exhibit  $R^2$  values exceeding 0.995, indicating exceptional linearity. Indeno[1,2,3-cd]pyrene (IcdP) demonstrates the lowest  $R^2$  value (0.9910), indicating a little lower correlation, however still within an acceptable range for precise quantification. The slope of the standard curve signifies sensitivity; chemicals such as fluoranthene (Flt, 1.3283) and pyrene (Pyr, 1.2520) have elevated slopes, reflecting more robust detector responses. In contrast, dibenzo[a,h]anthracene (DA) exhibits the lowest slope (0.1582), indicating a diminished signal response per unit concentration. Negative intercepts in certain equations, such as benzo[b]fluoranthene (BbF, -0.5342) and benzo[k]fluoranthene (BkF, -0.6879), may suggest modest matrix effects or shifts in the instrument baseline. The robust linearity confirms the calibration approach for precise PAHS measurement via GC-MS. Table 2 presents a correlation coefficient of  $R^2 > 0.991$ . This demonstrates that the standard curve for quantifying PAHs within the concentration range of 10 to 1000ppb is appropriate for this purpose.

Table 2. Linearity range of polycyclic aromatic hydrocarbons standard curves

| No. | PAH  | Standard curve equation | $R^2$  |
|-----|------|-------------------------|--------|
| 1   | Naph | $y = 1.0933x + 0.1582$  | 0.9998 |
| 2   | Acy  | $y = 1.0349x - 0.0562$  | 0.9998 |
| 3   | Ace  | $y = 0.6337x - 0.0392$  | 0.9996 |
| 4   | Flu  | $y = 0.7761x - 0.1004$  | 0.9994 |

|    |       |                        |        |
|----|-------|------------------------|--------|
| 5  | Phe   | $y = 1.1194x - 0.1386$ | 0.9996 |
| 6  | Ant   | $y = 1.0940x - 0.3470$ | 0.9974 |
| 7  | Flt   | $y = 1.3283x - 0.3048$ | 0.9990 |
| 8  | Pyr   | $y = 1.2520x - 0.2862$ | 0.9990 |
| 9  | BaA   | $y = 0.9590x - 0.4379$ | 0.9961 |
| 10 | BaP   | $y = 0.9288x - 0.5420$ | 0.9958 |
| 11 | BbF   | $y = 0.9949x - 0.5342$ | 0.9949 |
| 12 | BkF   | $y = 0.9385x - 0.6879$ | 0.9944 |
| 13 | BghiP | $y = 1.0499x - 0.9324$ | 0.9953 |
| 14 | Chr   | $y = 1.1162x - 0.3532$ | 0.9988 |
| 15 | IcdP  | $y = 0.8014x - 0.9031$ | 0.9910 |
| 16 | DA    | $y = 0.1582x - 0.1846$ | 0.9928 |

### 3.2. Diffusion trend of polycyclic aromatic hydrocarbons in groundwater

Table 3 displays the quantities of several polycyclic aromatic hydrocarbons (PAHs) at distinct places in Co Nhue 1, specified by their latitude and longitude coordinates. The concentrations of most PAHs are reasonably steady between locations, indicating that diffusion is occurring but not significantly differing in intensity among the sites. Low molecular weight polycyclic aromatic hydrocarbons (LMW-PAHs) such as naphthalene (Naph), acenaphthylene (Acy), and acenaphthene (Ace) exhibit minor variations yet consistently retain similar concentrations across all locations. HMW-PAHs, including benzo[a]pyrene (BaP), Indeno[1,2,3-cd]pyrene (IcdP), and benzo[ghi]perylene (BghiP), demonstrate small fluctuations, while certain locations display marginally increased levels. Certain chemicals, such as benzo[b]fluoranthene (BbF) and BghiP, exhibit significant concentration fluctuations at particular sites, potentially signifying localized contamination sources or variations in adsorption and degradation processes. A continuous decrease in PAHS contents in one direction would indicate unidirectional diffusion driven by groundwater movement. The generally steady concentration values across locations indicate a gradual diffusion process, potentially accompanied by localized buildup via adsorption onto soil particles or organic materials in groundwater. Groundwater mobility is sluggish; diffusion may be restricted, resulting in localized buildup. Clay-rich regions may adsorb greater quantities of PAHs, influencing their movement. Industrial or urban sources in proximity to specific places may influence differing concentrations.

The dispersion of PAHs in Co Nhue 1 groundwater seems very steady, exhibiting minor variations across several places. No discernible directional pattern is readily seen, suggesting that local adsorption and potential secondary contamination sources may affect the distribution.

The distribution of PAHs across eight groundwater sampling sites in Co Nhue 1 ward shows relatively consistent concentrations, indicating a diffuse and widespread source of contamination rather than a single point source. Compounds like Phenanthrene, Fluoranthene, and Chrysene exhibit minimal variation among locations, suggesting influences from urban runoff, atmospheric deposition, or multiple small-scale sources. Slightly higher concentrations of some PAHs at locations L2 and L8 may reflect groundwater flow or local human activities. The data imply regional-scale PAHs pollution and the need for area-wide monitoring and management strategies.

Table 3. Concentration of of polycyclic aromatic hydrocarbons in groundwater in Co Nhue 1

| Location         | L1                   | L2    | L3    | L4    | L5    | L6    | L7    | L8    |
|------------------|----------------------|-------|-------|-------|-------|-------|-------|-------|
| <b>Compounds</b> | Concentration (µg/L) |       |       |       |       |       |       |       |
| Naph             | 0.100                | 0.109 | 0.105 | 0.105 | 0.102 | 0.107 | 0.101 | 0.108 |
| Acy              | 0.104                | 0.109 | 0.107 | 0.107 | 0.105 | 0.108 | 0.105 | 0.108 |
| Ace              | 0.102                | 0.098 | 0.100 | 0.100 | 0.101 | 0.099 | 0.102 | 0.099 |
| Flu              | 0.103                | 0.089 | 0.096 | 0.096 | 0.100 | 0.093 | 0.101 | 0.091 |
| Phe              | 0.136                | 0.138 | 0.137 | 0.137 | 0.137 | 0.138 | 0.136 | 0.138 |
| Ant              | 0.130                | 0.131 | 0.131 | 0.131 | 0.130 | 0.131 | 0.130 | 0.131 |
| Flt              | 0.132                | 0.134 | 0.133 | 0.133 | 0.133 | 0.134 | 0.132 | 0.134 |
| BaA              | 0.136                | 0.129 | 0.133 | 0.133 | 0.134 | 0.131 | 0.135 | 0.130 |
| Pyr              | 0.146                | 0.143 | 0.145 | 0.145 | 0.145 | 0.144 | 0.146 | 0.143 |
| Chr              | 0.132                | 0.132 | 0.132 | 0.132 | 0.132 | 0.132 | 0.132 | 0.132 |
| BbF              | 0.069                | 0.082 | 0.076 | 0.076 | 0.072 | 0.079 | 0.071 | 0.080 |
| BkF              | 0.070                | 0.068 | 0.069 | 0.069 | 0.070 | 0.069 | 0.070 | 0.068 |
| BaP              | 0.074                | 0.084 | 0.079 | 0.079 | 0.077 | 0.082 | 0.075 | 0.083 |
| IcdP             | 0.048                | 0.052 | 0.050 | 0.050 | 0.049 | 0.051 | 0.049 | 0.052 |
| DA               | 0.046                | 0.041 | 0.044 | 0.044 | 0.045 | 0.042 | 0.045 | 0.042 |
| BghiP            | 0.071                | 0.089 | 0.080 | 0.080 | 0.076 | 0.085 | 0.073 | 0.087 |

Figure 2 depicts the overall concentration of 16 prioritized PAHs in well water at eight sites (L1 to L8) in Co Nhue 1, with each site displaying error bars that presumably indicate standard deviation or variation range. The cumulative concentration of PAHs across all eight locations consistently measures approximately

1.6µg/L. This signifies a pervasive occurrence of PAHs in the groundwater of Co Nhue 1, implying a diffuse and enduring source of contamination rather than a limited discharge. The diversity among places is minimal, with the error bars substantially overlapping. This homogeneity indicates that the pollution is uniformly dispersed, probably as a result of gradual groundwater flow, soil leaching, or extensive human activity (e.g., urban runoff, industrial discharge, or automobile emissions). The US EPA drinking water criterion for benzo[a]pyrene, a highly hazardous PAH, is 0.2µg/L, but the overall PAHS guideline in drinking water varies by country, often remaining below 1µg/L. Consequently, the detected amounts (~1.6µg/L) above standard safety criteria, suggesting a possible health risk if this water is utilized for drinking or domestic applications. The data indicates that the total concentration of PAHs in Co Nhue 1 well water is consistently uniform across locations, averaging approximately 1.6µg/L. This indicates a persistent and widespread contamination problem in the groundwater system, perhaps resulting from continuous environmental pollution. Remediation or source management measures may be necessary, particularly if this water is intended for human consumption.

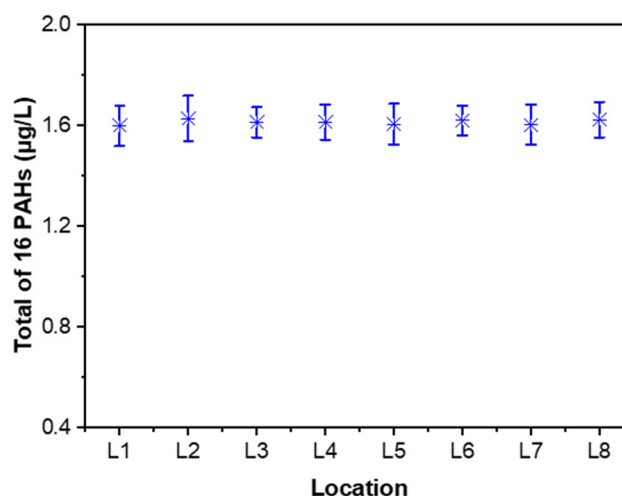


Figure 2. Total concentration of 16 PAHs in well water in Co Nhue 1

Table 4. Health risk assessment results based on PAHs concentrations in groundwater in Co Nhue 1

| Location | BaP <sub>eq</sub> (mg/L) | CDI (mg/kg/day) | ILCR     |
|----------|--------------------------|-----------------|----------|
| L1       | 0.000153                 | 0.000002        | 0.000013 |
| L2       | 0.000159                 | 0.000002        | 0.000014 |
| L3       | 0.000157                 | 0.000002        | 0.000013 |
| L4       | 0.000157                 | 0.000002        | 0.000013 |
| L5       | 0.000156                 | 0.000002        | 0.000013 |

|    |          |          |          |
|----|----------|----------|----------|
| L6 | 0.000158 | 0.000002 | 0.000014 |
| L7 | 0.000154 | 0.000002 | 0.000013 |
| L8 | 0.000159 | 0.000002 | 0.000014 |

All ILCR values range from  $10^{-6}$  to  $10^{-4}$ , indicating a low to acceptable risk level according to USEPA guidelines. These findings suggest that although PAHs are present, the current concentrations pose a relatively low carcinogenic risk to residents consuming the water over a lifetime.

**4. CONCLUSION**

This research effectively identified polycyclic aromatic hydrocarbons (PAHs) in well water samples from Co Nhue 1 Ward utilizing gas chromatography-mass spectrometry (GC/MS). The findings reveal that many PAHs chemicals were identified at different quantities, with some beyond the allowable thresholds established by environmental and health regulations. The investigation indicated that the contamination is probably attributable to anthropogenic activity, including industrial emissions, vehicular exhaust, and inappropriate waste disposal. The existence of high-molecular-weight PAHs indicates possible prolonged environmental durability and health hazards, encompassing carcinogenic and mutagenic consequences. These findings underscore the necessity for consistent surveillance of PAHs in groundwater sources and the execution of suitable water treatment protocols to safeguard human health. Subsequent research should concentrate on pinpointing the principal sources of PAHs contamination and assessing the efficacy of remediation techniques.

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#### THÔNG TIN TÁC GIẢ

**Nguyễn Thị Thu<sup>1</sup>, Nguyễn Thị Năng<sup>1</sup>, Đặng Minh Quang<sup>1</sup>,  
Nguyễn Kim Thùy<sup>1</sup>, Nguyễn Mạnh Hà<sup>2</sup>**

<sup>1</sup>Phân viện Hóa - Môi trường, Trung tâm Nhiệt đới Việt - Nga

<sup>2</sup>Khoa Công nghệ Hóa, Trường Đại học Công nghiệp Hà Nội