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DETECTION OF ORGANIC AROMATIC POLYCYCLIC HYDROCARBONS IN UNDERGROUND WATER OF AL-QASSIM REGION, CENTRAL OF SAUDI ARABIA

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ABSTRACT

Polycyclic aromatic hydrocarbons were detected in groundwater of Al-Qassim region of central Saudi Arabia. Water samples from sixteen wells of different depths located at varied site were analyzed spectrophotometrically. The three fundamental bands characteristic of aromatic hydrocarbons nuclei at 240 – 250 nm were recorded. However, the very slight difference in absorption is due to solvent interaction as the medium analyzed is an aqueous solution. Wavelength shifts towards longer wavelength due to fusion of aromatic nuclei in polycyclic systems around 280 nm were also observed. The data were discussed in relation to the possibility of contamination by direct mixing of sewage water with underground water and/or leaching of agricultural chemical fertilizers and pesticides with rainfall or irrigation water down through sandy soil particles to reach the underground water bed.

INTRODUCTION

Characterization as well as quantitative determination of chemicals dissolved in water have received a considerable attention during the last two decades. This particular attention is obviously due to the dramatic relation of water to public health, plant and animal existence and to the environmental hazards that might arise from harmful or even toxic chemical constituents of water (Abdel-Magid, 1997; Garawi and Alhendi, 1993; Wallin and Bassett, 1990 and Hashim, 1990). Thus, drinking water, natural or processed, and irrigation water were the inevitable targets for investigation an research (Rees and Bassett,1990; Rees, 1989; Eychaner and Stollenwerk, 1985 and Eychaner, Rehman and Brown, 1989).

Chemical analysis of underground water of Al-Qassim region received very little attention indeed except for Garawi and Alhendi (1993) who determined some metal ions as constituents of groundwater. However, polycyclic aromatic hydrocarbons (PAHs) have never been investigated previously. Many of PAHs have pleasant odour hence the name of aromatics. Some of the PAHs are generally quite toxic and even can induce cancer or cause mutations at very low concentrations level such as Benzo (a) pyrene (Bales, 1994). These compounds are less dense than water and highly insoluble. PAHs are slightly more active than other organic compounds as the carbone-hydrogen bonds are not all equal in strength. The delocalized nature of the electrons in these aromatics compounds make their structure more stable (Fessenden and Fessenden, 1982).

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Al-Qassim region is the central semi-desert part of the Kingdom of Saudi Arabia. The main source of both drinking and irrigation water is the underground water of Al-Sag famous aquifer. The water in this bed varies considerably in its depth (50 to >1000 m).

The main objective of this research study is to survey and screen underground water in this region for possible contamination with aromatic polycyclic aromatic hydrocarbons. In order to accomplish this task, sixteen underground water samples from wells of different depths and locations, were analyzed spectrophotometrically.

MATERIALS AND METHODS

Sixteen underground water samples were carefully collected from different locations in Al-Qassim region of Saudi Arabia. The depth of the wells, pH, electrical conductivity (EC) and absorption regions together with absorption shifts of the studied samples are shown in Table (1). The pH was measured potentiometrically using an Orion pH meter. A spectrophotometer were employed to determine the absorption characteristics of PAHs compounds. Measurements were recorded at the region of absorption of 200 – 300 nm in order to include characteristic absorption of aromatic nuclei (240 – 250 nm).The spectrophotometer employed in this investigation is Computerized Varian Carry 50, UV - Visible connected with HP DeskJet 610 printer.

RESULTS AND DISCUSSION

Contamination of groundwater by various types of chemicals may be due to one of the following mechanisms:

a) The presence of harmful chemicals present in the neighboring soils such as lead, cadmium, mercury, arsenic and others.

b) Direct mixing of contaminated water such as sewage, mines and factory's residue water with groundwater (Rees and Bassett, 1990).

c) Chemicals utilized in agriculture such as fertilizers, pesticides, herbicides etc, which find their way through sandy soil particles to reach the underground water bed by the aid of rain or irrigation water.

d) Decomposing organic matter of plant, animal or microorganisms that get leached down to the aquifer in the same way as mentioned above.

In addition, chemical reaction may occur between these different compounds initiating chemical transformations leading to the formation of new compounds, which were not originally present in the matrix. Absorption bands characteristic of unsubstituted aromatic hydrocarbons appeared exactly at the expected region (Figs 1, 2 and 3). However, absorption shifts towards higher wavelength around 280 nm were also recorded indicating the presence of fused aromatic nuclei (polycyclic systems), as contaminants of underground water (Wingrove and Carel, 1981).

Figure 1. Absorption bands characteristic of unsubstituted aromatic polycyclic hydrocarbons of sample 4.

Figure 2. Absorption bands characteristic of unsubstituted aromatic polycyclic hydrocarbons of sample 9.

Figure 3. Absorption bands characteristic of unsubstituted aromatic polycyclic hydrocarbons of sample 14.

All sixteen underground water samples investigated in this work were found to be contaminated with aromatic hydrocarbons as is evidenced by the presence of absorption bands at the very region characteristic of such compounds (240 – 250 nm). However, the very slight difference in absorption is due to solvent interaction as the medium analyzed is an aqueous solution. Moreover, shift of absorption towards longer wavelength (280 nm) was also observed indicating the presence of polycyclic aromatic hydrocarbons. These findings are in full concord with observations of Wallin and Bassett (1990), Rees and Bassett (1990) and Rees (1989) who reported contamination of underground water by polycyclic aromatic hydrocarbons in an area very rich in mining and or processing activities in Arizona.

It is most probable that contamination of underground water in Al-Qassim region by such compounds is attributed to organic chemicals used in agriculture and/or sewage water direct mixing. It is generally an ordinary practice that farmers in this heavily cultivated region utilize organic and mineral fertilizers in order to increase sandy soil fertility and to improve soil physical condition. Thus the leaching downwards of such chemicals is not far remote.

Table 1. The depth, pH, absorbance and shifted absorbance for the sixteen underground water samples.

Well No.	Depth (M)	pH	EC mmhos cm^{-1}	Fundamental absorption bands (nm)	Shifted absorption Bands (nm)
1	70	6.4	10.64	205 – 240	250 – 278
2	300	6.88	1.017	200 – 238	250 – 278
3	90	6.34	7.75	200 – 235	250 – 278
4	80	6.44	6.03	200 – 235	250 – 278
5	40	6.42	7.86	210 – 258	260 – 278
6	70	6.3	7.94	200 – 238	250 – 278
7	80	6.4	7.75	200 – 238	247 - 278
8	25	6.87	11.86	200 – 235	250 – 278
9	23	6.4	16.66	200 – 235	250 – 278
10	140	6.87	1.34	200 – 238	250 – 278
11	750	6.77	3.66	200 – 240	250 – 278
12	500	6.46	1.13	200 – 238	250 – 278
13	500	7.0	1.15	200 – 240	250 – 278
14	45	6.43	3.17	200 – 238	250 – 278
15	50	7.22	2.68	220 – 238	250 – 285
16	150	7.26	2.64	210 – 245	260 - 285

A striking feature of the data included in Table (1) is that the observed fundamental absorption bands as well as shifted absorption bands corresponding to aromatic polycyclic hydrocarbons are nearly identical with no significant differences. As regards to pH, thirteen samples are very slightly acidic, one being neutral and the remaining two are very slightly alkaline. Most of the investigated wells are located in well infiltrated sandy soils type. Some of the found organic contaminates may it be driven directly form a mixing sewage water due to the leakage in the wells case or an infiltrated fertilizers or pesticides along with sewage and rain water throughout the soil profile. This screening project needs to be extended to include quantitative determination of the actual organic polycyclic aromatic contaminants before declaring any environmental hazards that might originate from the presence of these chemicals in underground water.

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تقدير المركبات العضوية العطرية الهيدروكربونية متعددة الحلقة في ستة عشر عينة مياه جوفية بمنطقة القصيم بالمملكة العربية السعودية

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شمل هذا البحث تحليل ١٦ عينة مياه جوفية بمنطقة القصيم (المنطقة الوسطى للمملكة العربية السعودية) بغرض التعرف على وجود مركبات هيدروكربونية عطرية متعددة الحلقات وذلك بواسطة استخدام جهاز الامتصاص المرئي – فوق البنفسجي. ووجدت الثلاث حزم ضوئية المميزة للمركبات العطرية في موقعها المعروف بين طول موجات منحصرة بين ٢٤٠-٢٥٠ نانومتر. كما وجد أيضًا الموجات الناتجة عن امتداد الامتصاص الطيفي في الموقع المحدد ٢٨٠ نانومتر. على الرغم من وجود أملاح غير عضوية ذائبة في الأملاح تسببت في وجود قيم عالية في التوصيل الكهربي إلا أن ذلك لم يحول دون ظهور جميع الحزم الضوئية في موقعها المحدد للامتصاص. أوضحت النتائج أن جميع هذه المياه الجوفية تحتوي على المركبات الهيدروكربونية المذكورة. وقد تمت مناقشة النتائج على ضوء احتمالية تلوث مياه الآبار بمياه الصرف الصحي أو غسل المخصبات والمضادات الحشرية والعشبية التي تستخدم في الزراعة ثم وصولها للمياه الجوفية.