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# Radon Concentration Measurement in Water of Dhi - Qar Governorate (in Iraq) Using Emanometer

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## Abstract

The aim of this study is to measure the radon ($^{222}$Rn) concentration in water of rivers and groundwater in Dhi-Qar governorate (Iraq). The measurements were performed by analyzing the water samples collected from 58 location, using Emanometer techniques.

The obtained radon concentrations ranged from 116 Bq/m$^3$ to 601 Bq/m$^3$ in river water and from 355 Bq/m$^3$ to 681 Bq/m$^3$ in the wells water. The results are presented and compared with other studies. The results could be utilised to make distinctive supplementary contributions when contamination event occurs and to implement water quality standards by concerned authorities to maintain radioactive contamination-free drinking water supplies for the people.

**Key wards :**Radon, Water, Emanometer, Dhi-Qar Governorate

## Introduction

Radon is a chemically inert gas, it's a colorless, odorless, tasteless gas that occurs naturally in most soils, rocks, materials building and water **[1]**. Radon historically called radium emanation. There are three isotopes of radon occurring naturally $^{222}$Rn, $^{220}$Rn, $^{219}$Rn. These isotopes are direct product decay of radium. $^{222}$Rn is the important isotope; it's occurring from the radioactive decay of uranium series $^{238}$U and has a half-life (3.82 day). The second isotope is $^{220}$Rn, it's from daughter decay of thorium series $^{232}$Th, it has a half-life (55.6sec). While the third isotope $^{219}$Rn is not important in the evaluation of the health effects which arise from radon inhalation because it is rare in the environment ( $^{219}$Rn is part of the decay chain of $^{235}$U, a relatively no abundant isotope) and has an extremely short half-life (4 seconds)**[2].** Radon decays into a series of short-lived radioisotopes (often called as radon daughters) that can be inhaled **[3].**

Radon and its daughters are the second most important cause of lung cancer **[4]** (after smoking) in many countries. It is estimated to range from 3% to 14% of all lung cancers, depending on the average radon level in the area **[4]**. Radon and its short-lived decay products are the most important contributors to human exposure to alpha particles from natural sources; this

contribution represents 50 % of the average annual dose from natural background **[5].** Radon is soluble in water, and it comes from the radium in the water, surrounding soil and bedrock **[6].** When we use water such as washing clothes, showering and flushing toilets, radon is released from the water and mixes with the indoor air. Thus radon from water contributes to the total inhalation risk associated with radon in indoor air. In recent years, radon monitoring has become a global phenomenon due to its health risks inside dwellings **[7].** The purpose of this study is to investigate the radon levels of sources water being used for drinking as potable water in some areas and to determine the health hazards.

**Sampling Sites**

In the present study, the concentration of radon has been measured in water samples collected from different areas spans across Dhi – Qar Governorate stretching for over (12900) km$^2$**,** southern Iraq **[8]**. The latitude and longitude of Dhi - Qar Governorate are ˉ30.33◦ __32◦ N ˉ45.37◦__ ˉ47.12◦ E **[9]**. The area surveyed in the present investigations is shown in Figure 1 (a and b).

**Experimental procedure**

A total of 58 water samples were collected for this study from different sites in Dhi – Qar Governorate. All these samples were taken from different locations each site is called station. These samples distributed over all cities and townships in Dhi – Qar Governorate, and it consists of 55 water samples from surface water from rivers and small streams, and 3 water samples from groundwater from wells.

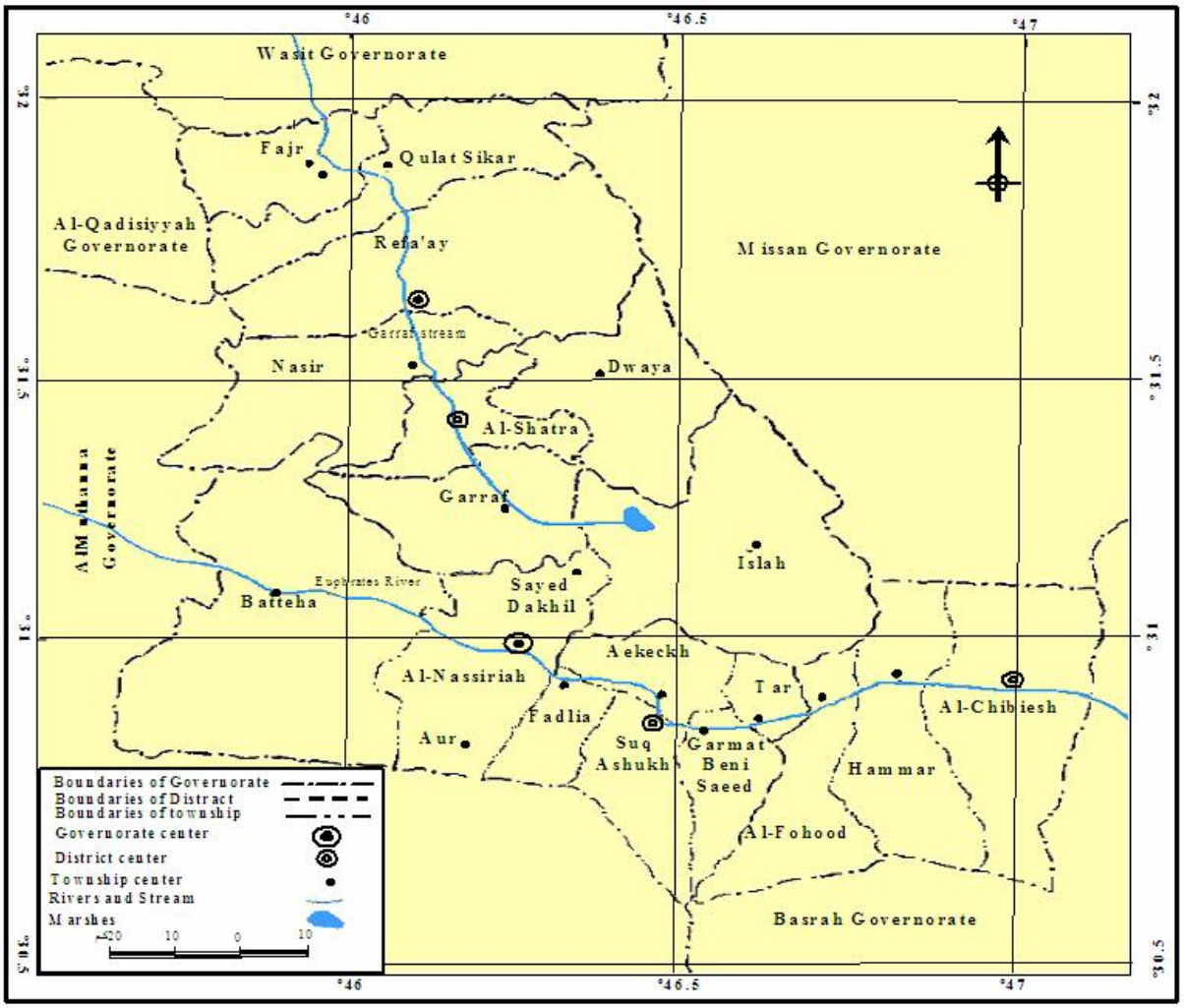



**Figure (1) a- Administrative units in Dhi-Qar Governorate [10]**

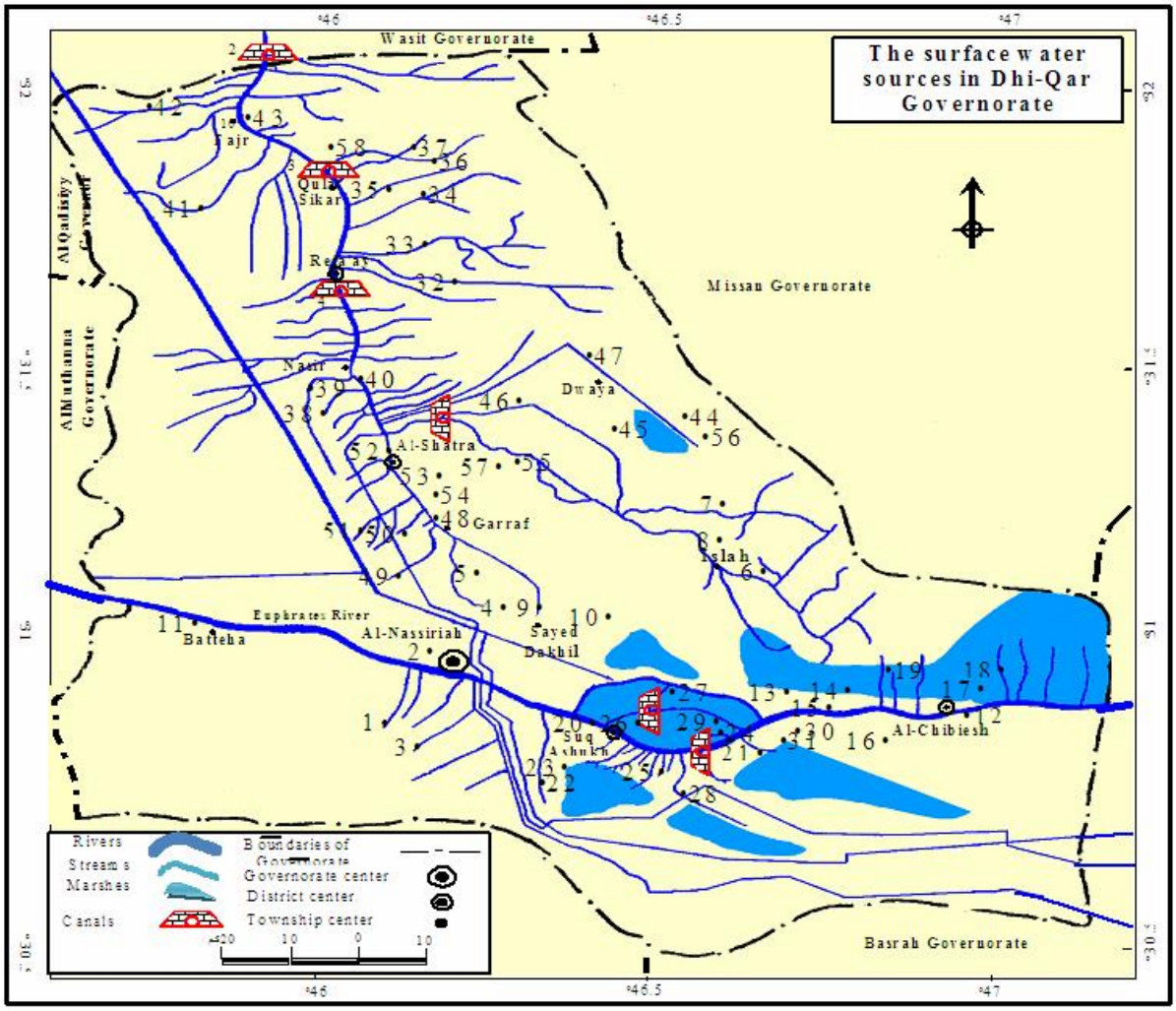



**Figure (1) b- Surface water resources in Dhi-Qar Governorate [8] see table 1 for details different areas**

Scintillometry technique (Emanometer) was used for the determination activity of radon concentration in water; the apparatus represents an active technique of radon measurement. This apparatus is based on the principle of Lucas cell **[2]**.

Figure (2) shows the diagram of Emanometer which is consists of a 1.5 L radon –tight reagent bottle connected in a closed circuit with glass vessel internally coated with silver activated zinc sulphide phosphor, ZnS (Ag), was used as a scintillation material through a hand-operating pump and a glass bulb containing absorbing material, for the moisture a Calcium chloride ($CaCl_2$) was used. The glass vessel is transparent and coupled to a photomultiplier (PMT). it can be any shape depending on the type of (PMT) employed to count the scintillation produced, but used shape is cylindrical (5 cm) in diameter and its height (20 cm).

Water sample of 750 ml is used in the bottle, after that, air was then circulated in the closed circuit for 10 minutes until the radon formed a uniform mixture with the air, and when radon decays alpha particles, this causes scintillations in ZnS (Ag), thereupon the photomultiplier tube detected that and generate an electric pulse, then the scintillation counter recorded accounts. The electronic digital counter records the alpha counts to find radon concentration in water which is converted by using the calibration constant (1 counts/min = 72.43 $Bq/m^3$)**[2].** The counting was done for 10 minutes. The measurement is repeated three times for each sample and hence the errors ± 7%.

**Figure (2) The Emanometer apparatus.**

## Results and discussion

Table 1 reports the results for radon concentration in water samples which are collected from some areas in Dhi – Qar Governorate, southern Iraq.

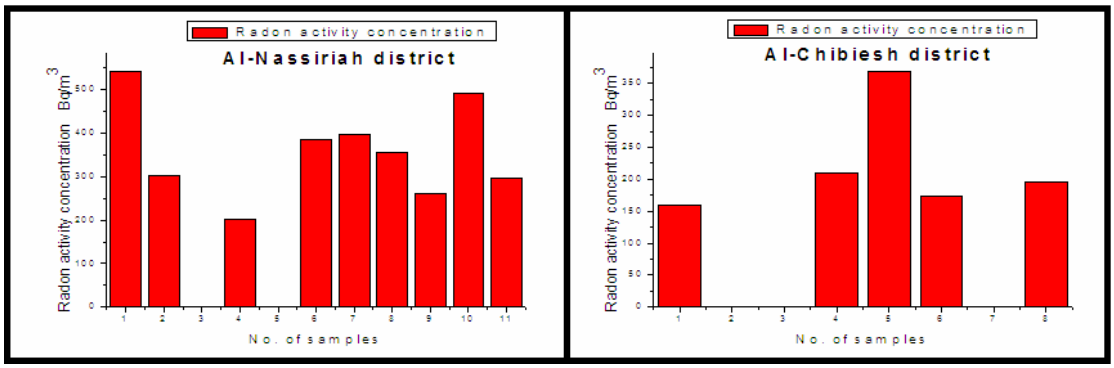
***Table 1 Values of radon concentration in water samples from different areas of Dhi – Qar Governorate.***

| *No.* | *station number* | *The name of station* | $A_c^{222}$ *(cou/min)* | $A_c^{222}$ *(Bq/m$^3$)* |
|---|---|---|---|---|
| **Al-Nassiriah district** | | | | |
| 1 | 1 | Alsaah | 7.5 | 543 |
| 2 | 2 | Almohia | 4.2 | 304 |
| 3 | 3 | Almsaffar | 0 | 0 |
| 4 | 4 | Khumessat | 2.8 | 203 |
| 5 | 5 | Al Boudjemaa | 0 | 0 |
| 6 | 6 | Snah | 5.3 | 384 |
| 7 | 7 | Al-Hsen | 5.5 | 398 |
| 8 | 8 | Gddeer | 4.9 | 355 |
| 9 | 9 | Al-Brahim | 3.6 | 261 |
| 10 | 10 | Al Toman | 6.8 | 493 |
| 11 | 11 | Euphrates (1) | 4.1 | 297 |
| **Al-Chibiesh district** | | | | |
| 1 | 12 | Euphrates (3) | 2.2 | 159 |
| 2 | 13 | Abu Sobat | 0 | 0 |
| 3 | 14 | Abu nersi | 0 | 0 |
| 4 | 15 | Maa Al-Chibiesh | 2.9 | 210 |
| 5 | 16 | Barbid | 5.1 | 369 |

| | | | | |
|---|---|---|---|---|
| 6 | 17 | Alla'aiossayyah | 2.4 | 174 |
| 7 | 18 | Tina | 0 | 0 |
| 8 | 19 | Hanbat | 2.7 | 196 |
| **Suq Ashukh district** | | | | |
| 1 | 20 | Euphrates (2) | 0 | 0 |
| 2 | 21 | Al Fadhliyah | 0 | 0 |
| 3 | 22 | Am Hilana | 0 | 0 |
| 4 | 23 | Garmat Bani Sa'aeed | 0 | 0 |
| 5 | 24 | Am nakhala | 4.4 | 319 |
| 6 | 25 | Agarmashiyah | 3.8 | 275 |
| 7 | 26 | Abu Sha'atha | 0 | 0 |
| 8 | 27 | Al rufia'a | 0 | 0 |
| 9 | 28 | Garmat Hassan | 6.4 | 464 |
| 10 | 29 | Kheoah | 3.3 | 239 |
| 11 | 30 | Abu Ouane | 0 | 0 |
| 12 | 31 | Alhaffar | 2.4 | 174 |
| **Refa'ay district** | | | | |
| 1 | 32 | Alsablah alkabir | 0 | 0 |
| 2 | 33 | Zaidiya | 3.3 | 239 |
| 3 | 34 | Alchroah | 2.5 | 181 |
| 4 | 35 | Husseiniya | 0 | 0 |
| 5 | 36 | Almcefna | 7.8 | 565 |
| 6 | 37 | Alhabibia | 0 | 0 |
| 7 | 38 | Al Hatam | 4.9 | 355 |
| 8 | 39 | Alnaumiyah | 2.7 | 196 |
| 9 | 40 | Garraf(2) | 0 | 0 |
| 10 | 41 | Almkhishi | 8.3 | 601 |
| 11 | 42 | Alashtiraki | 2.3 | 167 |
| 12 | 43 | Garraf(1) | 0 | 0 |
| **Al-Shatra district** | | | | |
| 1 | 44 | Al-Fahal | 1.6 | 116 |
| 2 | 45 | Majidiyah | 0 | 0 |
| 3 | 46 | Alchabshiy | 5.1 | 369 |
| 4 | 47 | Maa Dwaya | 0 | 0 |
| 5 | 48 | Shatt al-Shatra | 0 | 0 |
| 6 | 49 | Bahisah | 0 | 0 |
| 7 | 50 | Alrezaqaih | 0 | 0 |
| 8 | 51 | Abu Shabibah | 2.6 | 188 |
| 9 | 52 | Garraf(3) | 2.3 | 167 |
| 10 | 53 | Alimhadiyh | 2.4 | 174 |
| 11 | 54 | Alkhoania | 4.5 | 326 |
| 12 | 55 | Khirbit | 0 | 0 |
| **Wells** | | | | |
| 1 | 56 | Al-Fahal | 4.9 | 355 |
| 2 | 57 | Center for the Health Sayid Tahir | 9.4 | 681 |
| 3 | 58 | Al Abd Al-Hussein | 6.8 | 493 |

From the table one can find that the radon concentration changes from 203 Bq/ $m^3$ in Khumessat Stream (Al-Nassiriah) to 543 Bq /$m^3$ in Alsaah stream (Al-Nassiriah), in Al-Nassiriah district, as shown in figure (3a). While in Al-Chibiesh district is shown in figure (3b), the values of radon concentration are varied from 159 Bq/$m^3$ in Euphrates River (Al-Chibiesh) to 369 Bq/$m^3$ in Barbid stream (Al-Fohood township). In Suq Ashukh district is shown in figure (4a), these values varied from 174 Bq/$m^3$ in Alhaffar stream (Tar township) to 464 Bq/$m^3$ in Garmat Hassan (Aekeckh township). The values of radon concentration, in Refa'ay district are varied from 167 Bq/$m^3$ in Alashtiraki stream (Fajr township) to 601 Bq/$m^3$ in Almkhishi stream (Fajr township), as shown in figure (4b). And in Al-Shatra district range of values are from 116 Bq/$m^3$ in Al-Fahal stream (Dwaya townshep) to 369 Bq/$m^3$ in Alchabshiy stream (Dwaya township), as shown in figure (5a), while in groundwater the values of radon concentration changed from 355 Bq/$m^3$ in Al-Fahal well to 681 Bq/$m^3$ in Center for the Health Sayid Tahir well, as shown in figure (5b).

It can be seen that the radon in the water samples changed from location to other. This variation in radon content in each water sample may be due to different degrees of agitation and change in meteorological parameters. The health and environmental protection agencies had recommended safe limit of radon in drinking water for human beings. The recorded radon concentrations in all the water samples from various areas related to Dhi-Qar governorate were within the international recommended safe limit of 4000 to 40000 Bq/$m^3$ **[11]** and hence safe for drinking purposes. The US Environmental Protection Agency (EPA) proposed that Maximum contaminant level of radon concentration in drinking water is 11000 Bq/$m^3$ and alternative maximum contaminant level is 148000 Bq/$m^3$ **[12].** These levels were set to represent a concentration that does not result in any significant risk to health over the lifetime drinking of water.




a b

**Figure (3) radon concentration in (a) Al-Nassiriah district and (b) Al-Chibiesh district.**

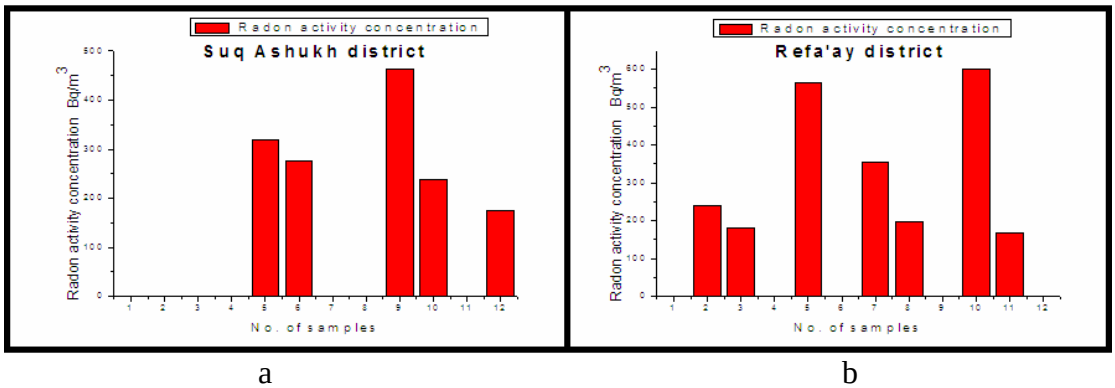



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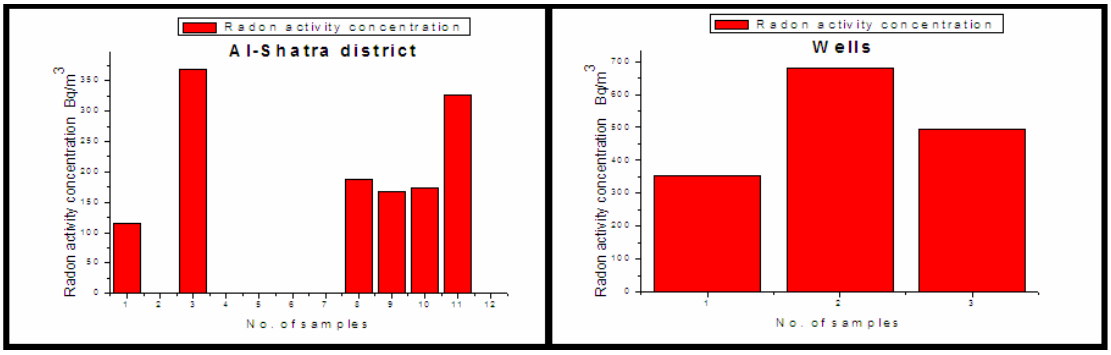
**Figure (4) radon concentration in (a) Suq Ashukh district and (b) Al-Refa'ay district.**




a b

**Figure (5) radon concentration in (a) Al-Shatra district and (b) Wells.**

## Conclusions

This study is the first radon concentration measurement in water sources that is performed in the area of Dhi-Qar Governorate (Iraq). The results can be helpful in finding background levels of radon in drinking water and river water, as well as to understand the effects that geomorphology, lithology and hydrology have on radon concentration in groundwater. The average value of radon concentration in rivers water is 172 Bq/m$^3$, while in groundwater is 510 Bq/m$^3$ both are in acceptable limits of UNSCEAR.

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**الخلاصة**

تهدف هذه الدراسة الى قياس تركيز غاز الرادون ($^{222}Rn$) في مياه انهار محافظة ذي قار جنوب العراق وآبارها. تمت القياسات بتحليل عينات الماء التي جمعت من 58 موقع. باستخدام تقنية الايمانوميتر.

قيم تراكيز الرادون التي حصلنا عليها من $116\ Bq.m^{-3}$ إلى $601\ Bq/m^3$ في مياه الانهار ومن $355\ Bq/m^3$ الى $681\ Bq/m^3$ في مياه الابار. تمت مقارنة النتائج التي حصلنا عليها بالدراسات الاخرى وبالتوصيات من وكالة حماية البيئة الامريكية (EPA) ولجنة الامم المتحدة (UNSCEAR). ان هذه النتائج تمثل مساهمة للكشف عن وجود أي تلوث وكذلك لمساعدة السلطات المعنية لتطبيق معايير النوعية للمياه الخالية من التلوث والمجهزة للمواطنين.