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ENVIRONMENTAL STUDIES ON TOXIC AND RADIOACTIVE CONTAMINANT ON THE GROUNDWATER OF SOUTH WESTERN SINAI, EGYPT

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ABSTRACT

Six groundwater well samples were collected from wadi El Sieh and wadiNasieb, southwestern Sinai, Egypt. The radioactive and heavy toxic elements were measured on the collected samples using ICP-OES. The result for radioactive measurements show that the level of uranium contamination in five wells was exceeds the maximum acceptable concentration guided by WHO. The pollution indices for heavy toxic elements were calculated. The calculation show that the contamination index in all wells suffers a medium contamination, the ecological risk factor of five groundwater wells suffer a considerable ecological risk contamination by toxic heavy elements and one well only have a moderate risk factors. Geo accumulated index (unpolluted to moderate) for Pb. Cd, Cr and Ni have unpolluted geo accumulated index for all groundwater wells. The effect of pH on radioactive and toxic heavy element solubility on the groundwater was studied. The study shows that R^2 for uranium and thorium concentration on groundwater have a medium relation with pH and there are no relation between toxic heavy elements and groundwater pH.

Keywords – *Environmental, groundwater, radioactive, toxic, contaminant*

1. INTRODUCTION

Water quality has always been a primary concern because it directly affects human health and reflects on our living environment. Groundwater is a valuable water resource for domestic and agricultural use in both rural, urban areas and on the studied area.

The chemical composition of groundwater is a key factor in order to determine its quality. Water quality is very important and is often degraded due to agricultural, industrial and human activities. Pollution of groundwater by toxic and radioelements comes from many sources such as discharge of waste from agriculture, industry and municipalities. These pollutants may enter directly into the groundwater and contaminate it[1]. Pollution indices to assess heavy metal contamination were classified by to three types: (i) contamination indices, (ii) ecological risk factor, and (iii) geo accumulation index[2].

1.1 Contamination index (C_f^i)

The contamination index (C_f^i) is used to describe the contamination of a given toxic element in the groundwater and its relation is suggested by Håkanson[3]:

$$C_f^i = \frac{\bar{C}_i}{C_S} \text{ ……..(1)}$$

Where $\bar{C}_i$ the mean concentration of the toxic element and C_S is the standard for maximum permissible concentration of the toxic element according to WHO[4] and given in table 1. The value scale of contamination index consists of three ranges: C_f^i<1, low contamination factor; 1≤C_f^i<3, moderate contamination factors; C_f^i>3, high contamination factors [5].

1.2 Ecological risk factor

An ecological risk factor (Er^i) to quantitatively express the potential ecological risk of a given toxic element and also suggested by Håkanson[3] is

$$Er^i = Tr^i \cdot C_f^i \text{ …….(2)}$$

Where Tr^i is the toxic-response factor for a given heavy toxic element by Håkanson[3] and showed in table 1, C_f^i is the contamination index.The following classifications are used to describe the ecological risk factor: Er^i<40, low potential ecological risk; 40≤Er^i<80, moderate potential ecological risk; 80≤Er^i<160, considerable potential ecological risk; 160≤Er^i<320, high potential ecological risk; and Er^i≥320, very high ecological risk.

Table 1: Håkanson[3] toxic response and WHO maximum acceptable concentration for heavy metal elements

Element	Cd	As	Cu	Pb	Cr
Toxic response factor	30	10	5	5	2
WHO [4]	5	10	2000	15	50

1.3 Geo accumulation index

The geo accumulation index is defined originally by Müller[6] to allow estimation of contamination comparing pre-industrial and recent element concentrations. The geo accumulation index is computed from Eq modified by Loska et al.[7]:

$$I_{geo} = \log_2 (C_i / 1.5C_s) \text{……..(3)}$$

According to Müller [6] and Buccolieri et al.[8], the geo-accumulation index (I_{geo}) is divided into seven classes by: I_{geo}≤0, class 0, unpolluted; 0<I_{geo}≤1, class 1, from unpolluted to moderately polluted; 1<I_{geo}≤2, class 2, moderately polluted; 2<I_{geo}≤3, class 3, from moderately to strongly polluted; 3<I_{geo}≤4, class 4, strongly polluted; 4<I_{geo}≤5, class 5, from strongly to extremely polluted; and I_{geo}>5, class 6, extremely polluted.

The present work aims to determine the quality of southwestern Sinai groundwater through calculation of groundwater pollution indices.

2. METHODOLOGY

2.1 Sampling and analytical methods

Groundwater samples were collected from two wadies on southwestern Sinai,Egypt. Two wells (B.H.1 and B.H.2) were located on Wadi El Sieh and four wells (NS.2, NS.3, NS.4 and Ag.1) were located on WadiNasieb. pH of the samples were measured by (3510 PH Meter), then the samples were placed in plastic bottles and acidified by 5 mL/ L nitric acid conc. The heavy toxic element such as As, Pb, Cd and

Cr were measured using inductively coupling plasma optical emission spectroscopy (ICP-OES prism, Teledyne technologies) under the operating condition tabulated in table 2.

Table 2: The operating parameters of ICP-OES

Parameter	The best results
RF power current	1000-1100 Watt
Coolant gas	18-19 L/min
Nebulizer gas	32-35 psi
Sample uptake time	20 sec
Replicates	3

3. RESULT AND DISCUSSION

3.1 The radioactive contamination

The two groundwater wells (BH.1 and BH.2) of wadi El Sieh are located on Sarabit El Kadim formation. It is non-conformably overlying the basement rocks (granites), the basal conglomerate is present in some localities and non-deposited in others as in wadiNaseib. This formation is consists mainly of sandstone (fine, medium to coarse grained), contains interlayers of conglomerate quartz with different size. The groundwater radioactivity of BH.1 is low and of BH.2 is moderate as in table 3 and this is due to the total radioactivity of surrounding rocks are very low (5-10 ppm) expect some black leness are moderate radioactivity (50-60 ppm).

The average concentrations of heavy toxic elements of the two wells are tabulated in tables 3. The trace element contamination for B.H.2 well is higher than B.H.1 well expects the arsenic contamination on B.H.1 is higher than B.H.2.

Table 3: Chemical analysis of radioactive and toxic contents on the groundwater.

Sample	Concentration (ppb)						
	U	Th	As	Pb	Cd	Cr	Ni
BH.1	<10	28.13±0.23	28.24±0.42	94.61±0.20	7.64±0.02	2.12±0.05	7.53±0.08
BH.2	97.01±0.15	30.66±0.56	<5	171.55±0.40	7.60±0.07	1.61±0.04	7.76±0.06
NS.2	279.5±0.39	27.21±0.12	17.10±0.07	102.9±0.30	7.84±0.04	3.30±0.04	19.11±0.69
NS.3	94.05±0.22	27.12±0.13	<5	104.28±0.28	7.48±0.05	5.99±0.11	8.30±0.1
NS.4	281.47±0.48	31.90±0.17	11.98±0.17	68.02±0.09	7.42±0.10	2.74±0.08	5.90±0.07
Ag.1	475.41±0.46	37.20±0.20	25.99±0.18	103.91±0.14	7.65±0.08	2.70±0.07	7.60±0.04

The four groundwater wells (NS.2, NS.3, NS.4 and Ag.1) of wadiNaseib are located on um Bogma formation. It's represent as radioactive anomaly and it is subdivided into three members as the following : Lower shale ore member which is oldest rocks of carboniferous and it's consisted of black shale with thin sandy dolomite[9]. The rock unites is highly radioactive when it is karstified and lateritized to reach 1000 – 2000 ppm total radioactivity. Middle marlydolostone-siltstone members is also karstified and lateritized which cover the soil profile. Its thickness (6-8 m) and its radioactivity moderate between (100 and 250 ppm). Upper dolostone member is overlying the karstified and lateritized soil profil. Its thickness (3-4m) and its radioactivity are low with range between (60- 100 ppm).

The total concentrations of uranium wadiNaseib wells are varied between 94µg/L (well NS.3) and 475.41 µg/L (well Ag.1). It is found that uranium levels in wadiNaseib wells exceeded 15 µg/L which recommended by WHO[4]. Thorium concentration was varied between 27.12 µg/L (well NS.3) and 37.2 µg/L (well Ag.1). The variation in Th concentration was very small between all the groundwater wells samples which reflect the low solubility and migration during water flow than U.

The concentrations of U, Th and Pb are plotted on triangular diagram as shown in fig. 1. As shown in triangular diagram the wells Ag.1, NS.2 and NS.3 are characterized mainly by U, BH.2 well is mainly lead, the samples BH.1 and NS.4 intermediate between uranium and lead. The diagram shows also that no well in the studied area characterized by thorium due to its low solubility on the groundwater.

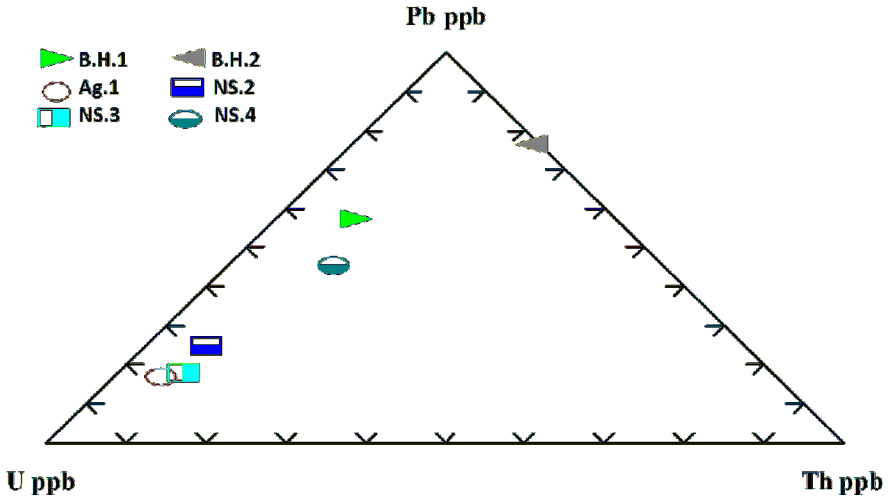

Fig. 1: Triangular diagram for U, Th and Pb concentrations on the studied groundwater wells

The arsenic concentration ranges between 2.87 and 25.99 µg/L with average. It is found that the arsenic level in most wells exceeds 10 µg/l which recommended by WHO[4]. The cadmium concentration ranges between7.42 and 7.84 µg/L, while the maximum permissible limit by the WHO guidelines is 3µg/L. The chromium concentration varied between 1.61 and 5.99 µg/L, While the maximum permissible limit recommended by WHO is 50 µg/L. The chromium concentration in groundwater is very low due to its low solubility in groundwater.

3.2 Toxic elements pollution indices

3.2.1 Contamination index

The groundwater wells of wadi El Seih and wadiNaseib suffer a medium contamination by toxic heavy metals according to data tabulated in table 4.

Table 4: The heavy element contamination index for the groundwater samples

Sample	Contamination index C_f^i					C_d	Contamination classification
	As	Pb	Cd	Cr	Ni		
B.H.1	2.82	6.30	1.52	0.04	0.05	2.14	Medium
B.H.2	-	11.43	1.52	0.03	0.11	2.61	Medium
Ag.1	2.59	6.92	1.53	0.05	0.10	2.23	Medium
N.S.4	1.19	4.53	1.48	0.05	0.08	1.46	Medium
N.S.2	1.71	6.86	1.56	0.06	0.27	2.09	Medium
N.S.3	0.27	6.95	1.49	0.11	0.11	1.78	Medium

The obtained data of contamination index are plotted for each well as in fig 2, the data showed that for wadi El Seih the contamination increase in the east direction and for wadiNaseib increase in north direction.

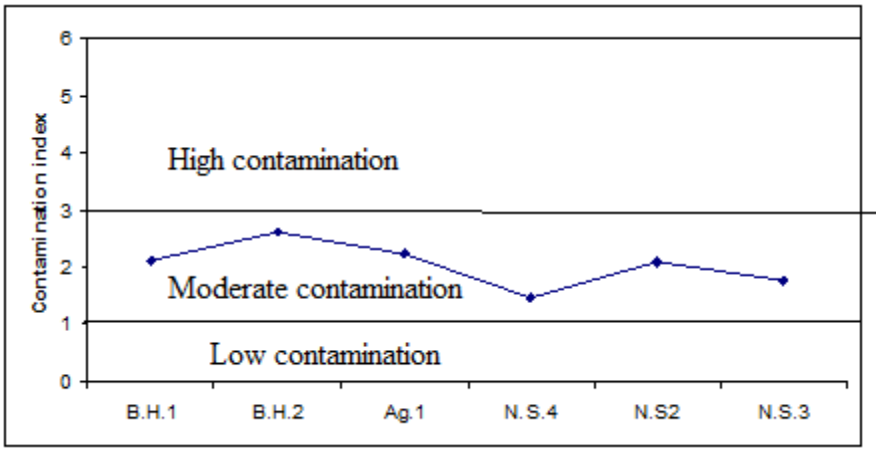

Fig 2: The toxic element contamination index on the groundwater wells

3.2.2 Ecological risk factor

The calculation of ecological risk factor is tabulated in table 5 and show that all the groundwater wells suffer a considerable ecological risk contamination by toxic heavy elements expect NS.4 have a moderate risk factors.

Table 5 : The toxic heavy metals ecological risk factor

sample	Ecological risk factor					Contamination classification
	As	Pb	Cd	Cr	∑	
BH.1	28.2	31.5	45.6	0.08	105	considerable
BH.2	-	57.15	45.6	0.06	103.35	considerable
Ag.1	25.9	34.6	45.9	0.1	106.5	considerable
NS.4	11.9	22.65	44.4	0.1	79.05	Moderate
NS.2	17.1	34.3	46.80	0.12	98.32	considerable
NS.3	2.7	34.75	44.7	0.22	82.37	considerable

3.2.3 Geo accumulation index

The calculation of geo accumulation index for the groundwater wells is tabulated in table 6. It is clear that from fig.3, all the groundwater wells have geo accumulated index $0 < I_{geo} < 1$ (unpolluted to moderate) for Pb. Arsenic has also unpolluted to moderate geo accumulated index for wells BH.1, Ag1, NS.2 and for the other wells. Cd, Cr and Ni have unpolluted geo accumulated index for all groundwater wells.

Table 6: The toxic heavy metals geo accumulation index

sample	Geo accumulation index I_{geo}				
	As	Pb	Cd	Cr	Ni
BH.1	0.274	0.623	0.008	-1.52	-1.99
BH.2	-	0.882	0.005	-1.66	-1.13
Ag.1	0.238	0.664	0.008	-1.44	-1.14
NS.4	-0.009	0.480	-0.004	-1.43	-1.25
NS.2	0.056	0.660	0.019	-1.35	-0.73
NS.3	-0.730	0.666	-0.001	-1.09	-1.10

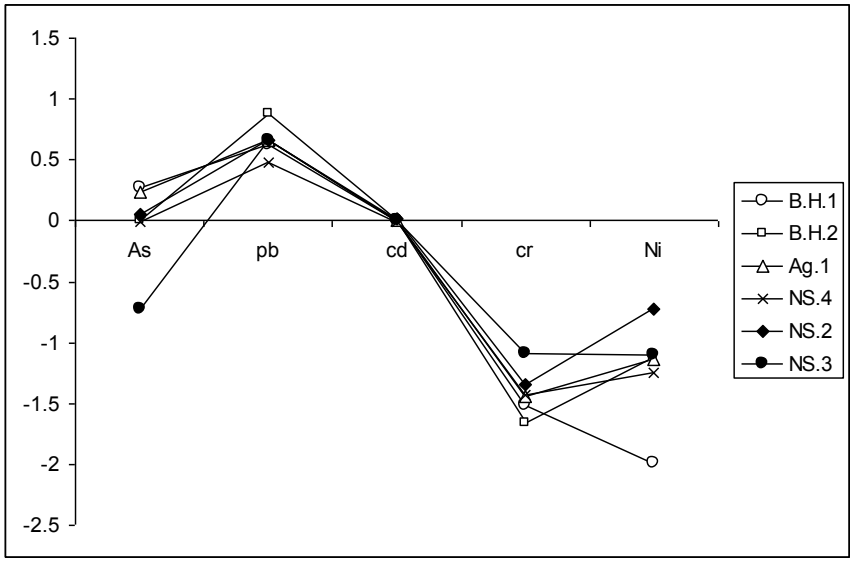

Fig. 3: The toxic element geo accumulation index on the groundwater wells

3.2.4 Effect of groundwater pH on contaminant element concentrations

Uranium has two oxidation states tetravalent and hexavalent. Under the reduction condition, uranium may occur as U^{4+} ions, which are soluble in water of low pH, but high level of pH, the uranium may acts as an anion and present as uranate. In the present work as in fig 4, the relation indicates that uranium concentration increases with increasing pH. This seems to be in agreement with results obtained from uranium solubility experiments, which show an increase in uranium solubility for pH > 6, because of the formation of very stable carbonate complexes (e.g. $UO_2(CO_3)n^{(2n\ L\ 2)L}$) [10]. This seems to be in contradiction with results obtained that, the decreasing pH results in the dissolution of soil minerals[11], and because uranium is adsorbed or forms solid solution with the soil mineral particles enters the aqueous phase upon mineral dissolution.

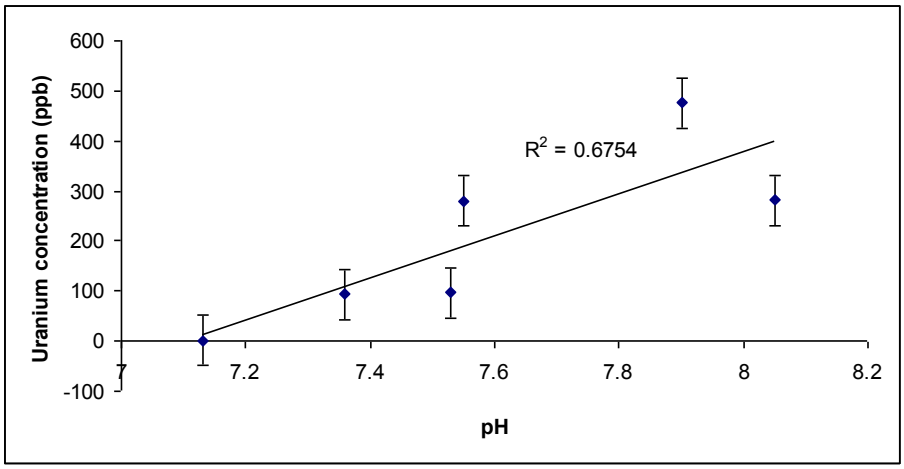

Fig 4: The effect of pH on uranium concentration

Thorium concentration was also affected by groundwater pH. The relation in fig.5 show that as the pH increases the conentration of thorium in groundwater increase.

Uranium and thorium concentrations have a medium R^2 relation with the pH of aquifer, but the toxic heavy metal elements concentrations of the collected samples have no relationship with aquifer pH.

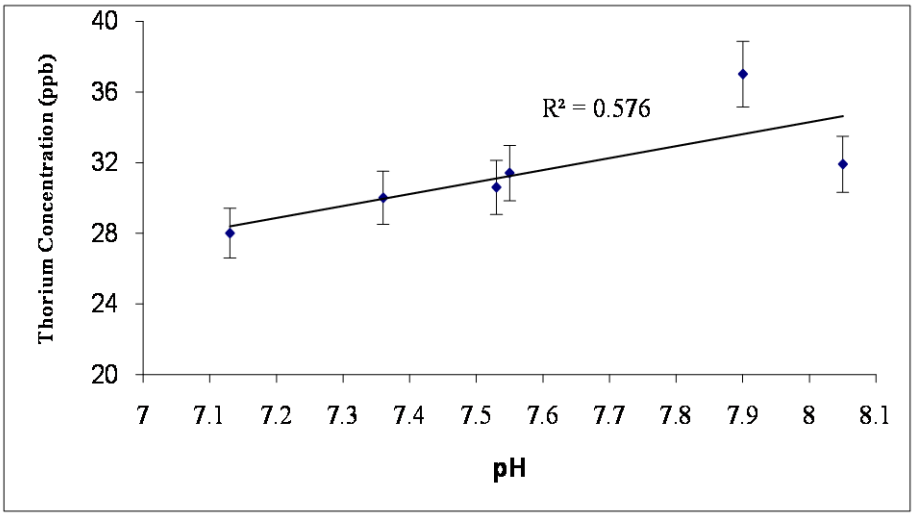

Fig 5: The effect of pH on thorium concentration

4. CONCLUSIONS

The concentrations of radioactive and toxic heavy elements in groundwater of wadi El seih and wadi Naseib southwestern Sinai, Egypt were investigated. The measurements show that the concentration of U, Pb, As and Cd on the studied area groundwater was higher than the maximum permissible guided by WHO. The quality of groundwater wells on the studied area was assessed based on pollution indices. The effect of pH on radioactive and toxic heavy element solubility on groundwater also studied.

5. REFERENCES

1. Hanipha M, M, , Zahir Hussain A . Study of Groundwater Quality at Dindigul Town, Tamilnadu. International Research Journal of Environment Sciences 2013;2(1):68-73. [Google Scholar]

2. Caeiro S, Costa MH, Ramos TB. Assessing Heavy Metal Contamination in Sado Estuary Sediment: An Index Analysis Approach. Ecological Indicators 2005; 5(2):151-169. Available from: http://linkinghub.elsevier.com/retrieve/pii/S1470160X05000051 doi: 10.1016/j.ecolind.2005.02.001.[Google Scholar]

3. Håkanson L. An Ecological Risk Index for Aquatic Pollution Control: A Sedimentological Approach. Water Research 1980;14(8):975-100. Available from: http://linkinghub.elsevier.com/retrieve/pii/0043135480901438 doi: 10.1016/0043-1354(80)90143-8.[Google Scholar]

4. World Health Organisation (WHO, 2011):Guidlines for drinking water quality. Fourth edition. 2011.
5. Akoteyon, I. S. Evaluation of groundwater quality using contamination index in parts of Alimosho, Lagos-Nigeria. American Academic & Scholarly Research Journal, 4(4). 2012, in . parts of Alimosho, Lagos-Nigeria. American Academic & Scholarly Research Journal;4(4). [Google Scholar]
6. Loska K., Wiechula D. and Korus I. Metal contamination of farming soils affected by industry. Environ. Int., 2004, 30: 159–165.

7. Loska K, Wiechula D, Korus I. Metal contamination of farming soils affected by industry. Environ. Int 2004;30(2):159-165. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0160412003001570 PubMed PMID: 14749104. doi: 10.1016/S0160-4120(03)00157-0. [Google Scholar]

8. Buccolieri A, Buccolieri G, Cardellicchio N. Heavy Metals in Marine Sediments of Toranto Gulf. Ionian Sea, Southern Italy. Marine Chemistry 2006;99:227-235. [Google Scholar]

9. El Sharkawi MA, El Aref MM, Abd El Mottelib A . Manganese deposits in caboniferow paleokarts profiles, umbogma region, west central Sinai, Egypt. Mineral deposition. 1989;25:34-43. [Google Scholar]

10. Pashalidis I, Tsertos H. Radiometric determination of uranium in natural waters after enrichment and separation by cation-exchange and extraction techniques. J. Radioanal. Nucl. Chem 2004;260(3):439-442. Available from: http://link.springer.com/10.1023/B:JRNC.0000028200.76234.2f doi: 10.1023/B:JRNC.0000028200.76234.2f. [Google Scholar]

11. Bruno J, Wersin P, Stumm W. On the influence of carbonate in mineral dissolution: II. The solubility of $FeCO_3$(s) at 25oC and 1 atm total pressure. Geochim. et Cosmochim. Acta 1992;56(3):1149-1155. Available from: http://linkinghub.elsevier.com/retrieve/pii/001670379290052K doi: 10.1016/0016-7037(92)90052-K.[Google Scholar]