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EVALUATION OF TRACE ELEMENT AND RADIOLOGICAL CONTENT IN SOME ENVIRONMENTAL SAMPLES COLLECTED FROM AL LEITH CITY, RED SEA COST, SAUDI ARABIA

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Abstract— **This work aims to evaluate the trace element and radiological content in some environmental samples (4 sediment, 3 plant, 3 surface water and 2 ground water samples) collected from Al Leith City, Red Sea Coast, Saudi Arabia. The concentrations of As, Cd, Ni, Pb and Zn elements were analyzed using Inductively Coupled Plasma Mass-Spectrophotometer, and the concentrations of ^{238}U series, ^{232}Th series, ^{40}K radionuclides were measured using Hyper-Pure Germanium detector. The activity concentrations (in Bq kg^{-1}) of the measured radionuclides were within the world average values, and the concentrations of trace elements in all samples were within the international limits recommended by WHO. The obtained chemical and radionuclide results showed that there is no risk on the public health.**

Keywords— **Natural radioactivity, Trace Elements, Coastal samples, Al-Leith Saudi Arabia.**

I. INTRODUCTION

Natural radioactivity are prevalent in the earth's crust and they found in different geological components like water, soil, plant, rock, sand, and air with various concentrations depending on their geographical states and geological composition (UNSCEAR, 2000; Tzortzis et al., 2004; Abbady et al., 2006; Abd El-mageed et al., 2011; Malain et al., 2010, 2012; Ramasamy et al., 2013; Agbalagba et al., 2014; Bala et al., 2014; Saleh and Shayeb, 2014). The knowing of concentration and distribution of natural radionuclides is of benefit since it provides a tool up useful information in the control of environmental radioactivity and the estimation of radiation exposure. Human exposition to ionizing radiation is most important scientific topic that attract public attention, because radiation of natural origin is accountable for most of the total radiation exposure of the human population. The inorganic silicon-rich rough materials (beach sands) are weathering-resistant remainders of geological components, which may be come to their place after transport by rivers, winds and glaciers to the coast, and are deposited on the beaches by the action of

and waves (De Meijer et al., 2001; Seddeek et al., 2005). The beauty of the coastal systems beside the high accessibility and many services presented by these systems makes coasts an attention for the world's population. People settle on the coasts do a lot of recreational activities and tourism (Ramasamy et al., 2013). Therefore, it is necessary to determine the natural radioactivity level of beach sand in coastal areas for radiation protection.

In recent years, a lot of researches on natural radioactivity level in beach sand have been done all over the world (Kannan et al., 2002; Freitas and Alencar, 2004; Alencar and Freitas, 2005; Veiga et al., 2006; Orgun et al., 2007; Rao et al., 2009; Malain

et al., 2010, 2012; Al-Trabulsy et al., 2011; Korkulu and Ozkan, 2013; Tari et al., 2013; Ozmen et al., 2014), This work aims to evaluate the trace element and radiological content in some environmental samples collected from Al Leith City, Red Sea Coast, Saudi Arabia. The concentrations of As, Cd, Ni, Pb and Zn elements were analyzed and the concentrations of ^{238}U series, ^{232}Th series, ^{40}K radionuclides were measured

Study area

Al-Leith is represented by area that is described as an integral part of the Arabian shield and extends from the western coast of the Red Sea to high mountains in the east between latitudes 20°N and 21°N, and longitude 40°E and 41°E (Fig. 1). The topography of Al-Leith basin is of high variation. In the

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northern part of Al-Leith basin, It is found that a maximum height of 2600 m (above sea level) is recorded at the highly elevated mountainous area while an elevation of less than 1 m is recorded for the sea-warded coastal plains in the southern part of the area. Due to its surface elevation from the sea level, Al-Leith basin can be divided into three zones (Hussein et al. 2013). A high mountainous upstream zone: the elevation ranges from 500 to 2600 m above the sea level and is characterized by high degrees of slopes and rugged area. It includes a number of tributaries and sub-wadies such as Wadi Birayn, Wadi Salibah and Wadi Maqsa which join the mainstream of Al-Leith. An intermediate zone of small hills and mountains: the elevation of this zone ranges from 10 0 to 50 0 m above sea level. It represents the midstream of the Al-Leith and includes the main tributaries and wadies sloping from upstream. It is characterized by moderate gradient and encounters the major waterways of Al-Leith. The coastal flood plain downstream zone: this zone contains alluvial deposits with an elevation range from 100 m to nearly zero at the shoreline of the Red Sea.

Table – 1 Coordinates and altitude for collected samples

Sample name	National Aquaculture Company (NAQUA)	United Cement Factory	Water Treatment Station	Fishing boat area	Alieth coast	Algadm well	Almegerma well	Alsadia well
Latitude	40.256	39.826	40.274	40.248	40.252	40.46	39.730	40.13
Longitude	20.146	20.711	20.145	20.154	20.149	20.65	20.478	20.81

Fig. (1)

II. EXPERIMENT

A- Measurements of natural radioactivity Gamma-ray spectrometry

A total of 12 samples were collected from the coast line of Al Leith City in Saudi Arabia Five water samples (surface and ground water), four plant samples and four soil samples were collected randomly. The sand samples were collected from the surface layer (0–20 cm). The collected sand and plant samples were stored in polyethylene bags for transport and storage. All samples were weighed, dried for 24h in an oven at 110 ºC, (**Chiecoet al., 1992)** The dried samples were grinded in order to achieve homogenization; they were sieved through a 0.8 mm mesh sieve. The sieved samples were weighed and packed into Marinelli-type beaker (100 ml capacities according to the available sample amounts), to be analyzed using gamma spectrometers hermetically sealed and stored for a minimum of 4 weeks before measurement, to prevent the escape of gaseous ^{222}Rn and ^{220}Rn from the samples and to reach secular equilibrium between 226Ra and its progenies (**Mollahet al., 1986.)** Gamma-ray spectrometric measurements were carried out using a hyper pure germanium (HpGe) detector planner configuration CANBERRA Model GC5019, with a relative efficiency of 50% and resolution of 1.95 keV (FWHM) at 1.33 MeV for 60Co gamma line. The detector was calibrated for the efficiency curve followed by standardization using KCl as a standard solution (**El-Tahawy*et al.*, 1992.)**
The gamma energy transition of 295.2 Kev (19.4%) and 351.9 Kev (37.1%) of 214Pb and 609.3 Kev (46.1%), 1120.0 Kev (15.0%) and 1764.5 Kev (15.9%) of 214Bi were used for ^{226}Ra determination; 583.1 Kev(33.2%) of 208Tl,338.3 Kev (13.0%) and 911.2 Kev (30.3%) of ^{228}Ac gamma energy transition for ^{232}Th determination; while energy transitions of 1460.7 Kev (10.8%) were used to determine ^{40}K. Quality control and quality assurance of the measurements using IAEA reference materials (soil-6, IAEA-326). Also duplicate samples were added to insure the analysis consistency of the measurements. Blank samples were added to insure that cross- contamination is not occurring to the samples.

B- Measurements of Activity concentration

The activity concentration (A) in Bq /gm of each radionuclide was determined using the equation

$$A=c/\mu.y.m. \quad (1)$$

Where C is the full-energy peak count rate of the measured radionuclide (in counts per second), η is the efficiency of detection for the specific energy, y is the correspondent gamma-ray yield, and m is the mass of the sample, expressed in grams, **Azouaziet al.**, **2001**.

Radium equivalent

The radium equivalent index is used to represent the sum of activities of ^{226}Ra, ^{232}Th and ^{40}K by single quantity, which takes in account the radiation hazard associated with them. Radium equivalent activity (Raeq) in Bq kg−1 is used to compare the specific activity of materials
containing different concentrations of ^{226}Ra, ^{232}Th and ^{40}K. It is assessed using the following equation (Alaamer 2012; Al- Ghamdi et al. 2016):

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$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.07C_k$ Where C_{Ra} , C_{Th} and C_K are the activities (Bq/Kg) of ^{226}Ra(^{238}U series),^{228}Ra(^{232}Th series) and ^{40}K, respectively.

The external absorbed (D) dose rate in air at a height of 1 m above ground level due to the measured activities of ^{226}Ra, ^{232}Th, and ^{40}K in soil assuming that the contribution of other radionuclides and the ^{235}U series can be neglected as their contribution to the total dose is very low (Alaamer 2012; Al-Ghamdi et al. 2016). The calculations were performed using the following equation (UNSCEAR 2000):

$D = 0.462C_{Ra} + 0.604C_{Th} + 0.042C_K$,

Where D is the dose rate in nGy/h and C_{Ra}, C_{Th}, and C_K as defined previously.

In estimating the outdoor annual effective dose, the factors that must be taken into account include (1) the conversion coefficient from absorbed dose in air to effective dose to the tissue and (2) the outdoor occupancy factor. Using the dose rate data obtained from the activity concentration values of natural radionuclides in soil, selecting the conversion factor of 0.7 Sv/Gy from absorbed dose rate in air to effective dose received by adult persons and considering that people, on the average, spent 20% of their time outdoors (UNSCEAR 2000), the annual effective doses AED (Sv year− 1) were calculated as: Annual effective dose (Sv year−1) = D × 24 × 365.25 × 0.7 × 0.2

C-Trace element analysis by Inductively coupled plasma mass spectrometer (ICP-MS)

Water and digested solid samples were analyzed using the ICPMS spectrometer. The analysis was performed using Perkin Elmer multi-element ICP-MS (type ELAN9000) equipped with a standard torch, flow nebulizer, nickel sampler and skimmer cones. Certified Reference Material was used as quality control measures. For digestion of this reference material and the samples, an acid mixture (3 ml HNO3 ultrapure 60%, 2 ml HF 40%) was added to 0.1 g of sample in Teflon receptacles and tightly closed. Six such receptacles were inserted in equipment made of six stainless steel cylinders mounted between two flanges, to confer pressure resistance. The whole system was inserted in an oven at 200 °C for 12 h. A clear solution resulted and ultrapure water was added up to 50 ml. Soil samples have been treated as the reference materials. Detection limits were equal to three times the sample standard deviation of several measurements of the constituent in a blank solution analyzed as a sample. Relative standard deviation for each analytical method is determined from the measurement of an analyte concentration at least ten times the detection limit.

III. RESULTS AND DISCUSSION

A- The physicochemical parameters (such as, pH, EC and TDS) of water samples are given in Table- 2

Table- 2 Physicochemical parameters in water samples from Al-Leith city, Saudi Arabia

parameters	Alsaydea Well	Almgerma Well	Gadm Alieth well	Water Treatment Station (sea water)	Fishing boat (sea water)	Alieth coast (sea water)
pH unit	6.71	6.80	6.87	6.50	6.46	6.53
Oxidation Reduction Potential ORP (m.v)	616	516	554	558	551	541
Hydrogen Dissolved Oxygen HDO (mg/l)	7.78	7.65	7.60	6.02	6.10	6.07
Total dissolved solids TDS (mg/l)	3728	3704	3752	42180	42070	42000
Specific Conductivity (µs/cm)	5826	5787	5863	65950	65660	655590

B- **Natural reactivity measurements**.

The activity concentrations of ^{40}K, ^{232}Th and ^{226}Ra were measured in (5 water , 3 plants and 4 soil) samples. The average values of natural radionuclides in Al-Leith area were considered compared to the world median values of 35, 30 and 400 Bq/kg for^{226}Ra, ^{228}Ra, and ^{40}K, respectively (UNSCEAR 2000).

C-Trace element measurements

The concentrations of heavy metals in µg/L in 12 samples were measured and The concentrations of **As, Cd, Ni, Pb and Zn** were below the detection limits of the ICP-MS.

The concentrations of 5 elements in µg/L (ppm) in water samples were measured and are given in Table 4

. were below the detection limits of the ICP-MS. As it was mentioned previously, As is considered as the main expected source of heavy metals is the interaction of water with the rock matrix in its way to the earth's surface. Most heavy metal concentrations in all analyzed water samples including highly toxic metals such as Cd, Zn, Ni and Pb did not exceed the

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maximum contaminant limits (MCL) set by USEPA (2009) and WHO (2008) for safe drinking water (Table 4).

Table (3) Activity concentrations of natural radionuclides, Radium equivalent activity (Raeq), absorbed dose rate (D), annual effective dose (AED) and annual gonadal dose equivalent (AGDE) of natural radionuclides in samples

Table -3 Activity concentrations of natural radionuclides, Radium equi valent activity (Raeq), absorbed dose rate (D), annual effective dose (AED) and annual gonadal dose equivalent (AGDE) of natural radionuclides in samples

Sample	^{226}Ra	^{323}Th	^{40}K	Ra_{eq} (Bq·kg−1)	D (nGy·h−1)	AED (μSv·y−1)
Alsaydea Well (surface water)	0	2.9	0	4.147	1.924	2361.1
Alsaydea Well (ground water)	0	6.11	5.33	8.774	3.912	4800.3
Fishing area (sea water)	0	5.717543	2.49928	8.223	3.572	4383.1
Water Treatment Station (sea water)	6.8	2.932	0	4.225	1.77	2172.5
Fishing boat (water sample)	0	5.303	0	7.58	3.519	4318.8
Alsaydea Well (Plant sample1)	6.17766	11.76399	225.774	24.48	19.37	23771.4
Alsaydea Well (Plant sample2)	13.0412	12.82452	860.916	37.39	49.66	60944.4
fishing boat costal plant	3.78104	3.173108	877.371	14.37	40.24	49384.4
Alsaydea Well Costal soil	7.05587	9.757573	433.461	24.03	27.22	33405.7
Atfel cement factory (soil)	15.1041	14.08708	844.892	41.28	50.714	62238.5
Water treatment station (Costal Soil)	15.1657	10.7398	326.416	32.86	27.096	33253.3
Fishing boat (costal soil)	9.53080	8.686032	411.001	24.81	26.78	32865.9

Table- 4 Concentrations of As, Cd, Ni, Pb and Zn Measured by ICP-MS.

Sample ppm	Alsaydea Well (surface water)	Alsaydea Well (ground water)	Fishing area (sea water)	Water Treatment Station (sea water)	Fishing boat (water sample)	Water treatment	MCL EPA	MCL WHO
AS	**12**	**10**	**13**	**20**	**20**	**10**	**10**	**10**
Cd	**0.15**	**0.61**	**0.55**	**0.32**	**0.42**	**0.51**	**100**	**5**
Ni	**7.8**	**7.6**	**7**	**10**	**12**	**14**	**5**	**70**
Pb	**<0.2**	**<0.2**	**<0.2**	**0.5**	**0.3**	**0.4**	**15**	**10**
Zn	**5**	**4**	**5.5**	**4**	**5**	**4**	**5000**	**-**

IV. CONCLUSION

The activity concentrations of natural radionuclides in samples collected from Al Leith City, Red Sea Coast, Saudi Arabia. had been measured using gamma ray spectroscopy method. The radium equivalent activity (Raeq), absorbed dose rate in air and the annual effective dose were calculated from the activity concentrations of ^{238}U series, ^{232}Th series, ^{40}K. The results of the Raeq and external hazard index are within the recommended safety limit, the annual effective doses due to the samples are less than the recommended limit of 1 mSv·y−1 to the general public. Also The concentrations of As, Cd, Ni, Pb and Zn elements within the recommended safety limit did not exceed the maximum contaminant limits (MCL) set by USEPA (2009) and WHO (2008) for safe drinking water.

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