Concentrations of the Naturally Occurring Radioactive Materials in Waste Samples from Iron Production, the Carbon Filters used in Saudi Arabia

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Abstract: Industrial activities as mineral production, water filtration produce a huge amounts of radioactive industrial wastes, some of them have low radioactive levels others have high radioactive level. As these wastes are produced with huge amounts, where they are used in other industrial production, such as cement production (iron slag), and bricks production. So, the natural radioactivities of ^{40}K, ^{226}Ra, and ^{232}Th and the fallout of ^{137}Cs present in various samples of the naturally occurring radioactive materials (NORM) were analyzed by gamma-ray spectrometer using HPGe detector. Samples were collected from different locations in Saudi Arabia, samples of carbon filters used for drinking water filtration from Jazan city, iron slag samples from factories of Saber company in AI-Jubail city and iron scrap samples from workshops of iron manufacturing and recycled in iron industry. In order to assess the radiological hazards to human health, radium equivalent and the exposure dose were calculated The specific effective radioactivity of raw material is calculated. It is shown that, the raw material has no restrictions on use in manufacture welding materials under the radiating factor. Also, the samples were analyzed by the atomic absorption spectrometer to determine concentrations of elements of Calcium (Ca), Iron (Fe) Potassium (K), Magnesium (Mg), Manganese (Mn), Bismuth (Bi), Lead (Bp) and Thorium (Th). The results were compared with limits given by United Nations Scientific Committee for the effects of Atomic Radiation (UNSCEAR).
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Key Word: waste iron production, Carbon filters, Natural radioactivity, gamma spectrometry, total dose rate.

1.Introduction

Most of earth ores for some elements such as Tin, Aluminum, iron and earth rare elements as well as Phosphate in crystalline rocks contain of high concentrations of Uranium and Thorium. Wastes of these industries which depend on those ores, natural radioactive materials concentrate in them producing massive quantities may be infiltrating to environment leading to increasing doses of radiation exposure. If its production doesn't be organized and recycled there will be no available areas to store it. Recycling means using the wastes as raw materials in some industries such as producing building and construction materials. (Ibrahim *et al.,* 2000), studied the radiation level for wastes resulting from iron and steel industry in Egypt where coal is used as a raw material in addition to different iron ores in this industry. They found that the concentration in Bq/Kg in iron slag for 238Uranium was from 41 to 90 and the group of Thorium from 24 to 34 and Potassium was 97 but the concentrations of fly ash in Bq/Kg was from 15.5 to 41 for group of ^{238}Uranium and the group of ^{232}Thorium from 8.5 to 11 and ^{40} Potassium was 93.5. It has been deduced that the resulted doses from these wastes pose no risk for workers or the public if these wastes are used in paving roads.

In the annual book which talks about slag in industry of iron and steel, (Vann Oss, 2002), summarized the types of slag formatting from the industry of iron and steel issuing from burning furnace where oxygen and impurities are reduced from ores of iron oxides by carbon at high temperatures. Most of impurities and running factors are combined to create molten silicates which called (iron or furnace blast) and floated over the molten iron, so they are separated from the molten iron. The Iron ore is carried then to steel furnace where the content of carbon decreases from 4% to 0.5 % and the other impurities are removed. This process needs limestone and silicates to be added. Solid iron slag is added in scrap iron and steel furnaces and iron slag.These wastes form big quantities need to be stored before selling for mega construction projects, most of these components are low values so it can't be exported commercially where iron slag sales depends much on the needs of local constructions.

Gaffer T& Holm, (2002) studied in Sweden the wastes in two of nonnuclear industries to observe the existence of radioactive nuclides whether natural or artificial. Also identifying the workers' doses of radiation exposure by two studies. First one concerning to removing radioactive elements, especially surface water. Natural elements as well as artificial nuclides like ^{137} Cesium (^{137}Cs), ^{90}Strontium (^{90}Sr), also ^{239}Plutonium and 240Plutonium (^{239}Pu + ^{240}Pu) resulted from of falls from nuclear experiments

and the incident of Chernobyl Accident which was studies by using coagulation compounds for sticking with particles for precipitation then filtration by sand layer. Results showed removing big part of Uranium, Thorium, Polonium and plutonium while the precipitation of Radium, Strontium and Cesium which is possible to reach to the main net for distributing water without any decrease in its radioactivity.

Wiser, (2003) studied the balance of natural nuclides in drinking water resources, he reviewed the types of radioactive nuclides and the health effects because of the existence of Uranium, Radium, Radon and polonium in drinking water, also he discussed the types of water filter used in drinking water processing under the light of geological and radiation studies and legislations in European Union and Canada, in addition he calculated the resulting doses for the individual.

(Elena Botezatu and Grecea, 2004) assess the radiological impact of oil and gas industry on the environment and population.

(Mass *et al.,* 2006), studied the effect of re cleaning the environment from natural radioactive wastes resulted from technological activities in Southwest of Spain including phosphate industries sites because of high containing of natural radioactive elements, they studied the efficiency of this process regarding to radiation point of view according to European Union standards, they found that the rate of dose decreased much in addition to special care to the workers at these un cleaned regions, by applying a model to calculate the radiation doses allowing to conclude the negative effects for using these industrial wastes**.**

(Alfred Żak *et al.*(2008) tend to outline the radioactivity of the waste materials with respect to other raw and materials used in the construction industry and show the possibilities for the use of by-products originating in the power stations and heat- and power stations (mainly ashes, slag and hinter) in the construction of dwellings and roads.

The objective of this study was to assess the radiological impact on the environment and population of the carbon filters used for drinking water filtration from Jazan city, iron slag samples from factories of Saber company in AI-Jubail city and iron scrap samples from workshops of iron manufacturing and recycled in iron industry that is non-nuclear industry but uses and can produce materials, with an enhanced content of naturally occurring radionuclides

2. Materials and Methods

2.1 Samples collection and preparation

A total of 7 waste samples were collected from various locations in Saudi Arabia, the samples investigated were 3 samples of carbon filters used for drinking water filtration from Jazan city, 2 iron slag samples from factories of Saber company in AI-Jubail city and 2 iron scrap samples from workshops of iron manufacturing and recycled in iron. In order to measure the natural radioactivity in the samples under study, they were dried in an oven at 110°C for 24 hours until constant dry weight (Benke and Kearfott 1999; Veiga *et al.,* 2006). The dried samples were crushed and allowed to pass through micro sieves to maintain the uniform grain size to obtain affine-grained homogenous l sample for the measurement (IAE, 1989). About 640cc of the homogenized samples were transferred into polyethylene containers (its weight is calculated). The measurements were performed four weeks later to ensure secular equilibrium between ^{226}Ra and ^{228}Ra, and their progenies (Mollah *et al.,* 1987). Hyper pure germanium (HpGe) detector with a low background shield, 25% efficiency and 2 keV resolution at 1332 keV gamma line of ^{60}Co were employed for all the measurements. The system were calibrated with a standard reference material from IAEA for gamma ray activity determination in all the samples. The background was measured regularly under the same geometry as the samples conditions.

The activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K were determined by using intensive and appropriate photo peaks—^{226}Ra (351.9 keV of ^{214}Pb; 609.3, 1120.3 and 1764 keV of 214Bi), 232Th (338.32, 911.21 and 968.97 keV of 228Ac, 727.25 keV of ^{212}Pb and 583.02, 2614.48 keVof Tl-208) and ^{40}K (1460.83 keV).

The (661.66 kev) ^{137}Cs concentrations were lower than the detection limit (LDL) in most samples. Sampling and sample preparation has been done obeying the report by the methodology sub-group to the Radioactivity Research and Environmental Monitoring Committee (Radrem, 1980).

Heavy metals (Ca, Fe, K, Mg, Mn, Bi, Pb and Th) were analyzed using an atomic absorption spectrophotometer (A Analyst 700 from Perkin Elmer, OPTIMA 4000 DV Series) reagents blank determinations were used to correct the instrument readings. Also, after every 4 samples readings standards were run to make sure that the obtained results were within ranges, taking into account that the mass of the sample under study 5cc.

2.2. Theoretical calculations:

2.2.1 Radionuclide activity concentrations

The activity concentration of radionuclide was determined by applying the equation (1) (Noorddin, 1999; El-Taher, 2011):

$$\mathbf{A_S\ (Bq\ kg^{-1}) = C_a / \varepsilon\ P_r\ Ms} \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(1)}$$

Where: C_a is the net gamma counting rate (counts per second), ε the detector efficiency of the specific γ–ray,

P_r the absolute transition probability of Gamma–decay and Ms the mass of the sample (kg).

2.2.2 Radium equivalent activity

Radium equivalent activity (Bq/kg) is a convenient index to compare the specific activities of samples containing different concentrations of ^{226}Ra, ^{232}Th (^{228}Ra) and ^{40}K. It is defined based on the assumption that 10 Bq/kg of ^{226}Ra, 7 Bq/kg of ^{232}Th and 130 Bq/kg of ^{40}K produce the same gamma dose rate. It is calculated using the following equation:

$$Ra_{Eq} = C_{Ra} + 1.43C_{Th} + 0.077C_{K} \text{------- (2)}$$

Where: C_{Ra}, C_{Th} and C_K are the specific activities (Bq/kg dry weight) of ^{226}Ra, ^{232}Th and ^{40}K, respectively (**Beretka and Mathew, 1985**).

2.2.3 Gamma-dose rates

For materials containing naturally occurring radioactive materials such as ^{238}U, ^{232}Th and ^{40}K, the absorbed dose rate $\dot{D}$ can be defined if the radionuclide concentrations are known. It can be obtained in units of nGy h^{-1} using the formula proposed by **UNSCEAR (1988)**:

$$\dot{D} = \sum_x A_x C_x \text{----------(3)}$$

Where: A_x (Bq /kg) are the mean activity of ^{226}Ra, ^{232}Th and ^{40}K, and C_x (nGyh^{-1}per Bq/kg) their corresponding dose conversion factors. In the present work, the dose conversion factors reported by (Quindos, 2004), namely 0.4551, 0.5835 and 0.0429 nGy/ h per Bq/ kg for ^{226}Ra, ^{232}Th and ^{40}K, respectively.

3. Results and Discussion

3.1. Activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K analysis of waste from Iron production:

Table (1) shows the concentrations of ^{238}U series, ^{226}Ra, ^{232}Th, ^{137}Cs and ^{40}K in Bq/Kg for dry weight of two samples of slag iron and two samples of scrap iron.

Series of ^{238}U and ^{226}Ra

The concentrations of ^{238}U were calculated from its daughter ^{234m}Pa, since ^{238}U is in secular equilibrium with its daughter ^{234m}Pa. In iron slag samples, the concentrations in Bq/Kg ranged from 1.00 ± 0.31 (s. no.1) to 1.66 ± 0.56 (s.no.2) with average value of 1.33, there is no detection (ND) in scrap samples (s.no.3) and (s.no.4). For ^{226}Ra the concentrations in Bq/Kg were 113.9 ±0.95 (s.no.1) and 107.4 ± 1.86 (s.no.2) with an average value of 110.65. In scrap samples (s.no.3) and (s.no4) the concentrations in Bq/Kg of ^{226}Ra were 26.22 ± 1.47 and 46.92 ± 1.11 respectively, with average value of 36.57.

Series of ^{232}Th

The concentrations in Bq/Kg of ^{232}Th in iron slag samples were 95.2 ±1.2 (s.no 1) and 109.6 ± 2.58 (s.no.2), with an average value of 102.4. The concentrations in Bq/Kg for the two samples of scrap iron (s.no.3) and (s.no.4) were 43.24 ± 2.48 and 52.79 ± 2.27 respectively, with an average value of 48.02.

^{40}K

The concentrations in Bq/Kg of ^{40}K in slag samples were 18.9 ±3.6 (s.no.1) and 2.27 ± 0.03 (s.no.2) respectively, with an average of 10.58. For the scrap samples the concentrations in Bq/Kg were lower than the detection limit (LDL).

^{137}Cs

The concentration of ^{137}Cs is found to be less than the minimum for the count (LDL) for all samples.

Comparing the current results with the concentrations for the two series of ^{238}U and ^{232}Th series in the identical samples were 150 Bq/kg (**UNSCEAR, 2000**) which are convergent with the current results of ^{232}Th series. Also, a comparison of the average concentrations determined in the present study with the reported values as 53.4, 28.8 and 97.4 Bq/Kg for ^{238}U series and ^{232} Th ^{40}K respectively, for iron slag samples produced in Egypt (**Ibrahiem *et al.*, 2000**), we found that the values in the present study are somewhat higher than these values, this is referred to the geological structure for the ores used in the industry.

3.2 Radium equivalent and Effective Dose

In order to assess the radiological hazards to human health, radium equivalent and the exposure dose were calculated. The results displayed in Table (2) show Ra_{eq} values varied from 88.41 ± 1.28 Bq/kg (s.no.3) to 264.30± 0.66 Bq/kg (s.no.2) Bq /kg with an average value 105.58 Bq/Kg. These values are lower than the permissible maximum value of 370 Bq/ kg (UNSCEAR, 1988; Kumar *et al.,* 2003).

Workers' total exposure dose in the year at the factories of Iron and steel at Sabek Co. from measured samples was calculated with a work rate 8 hours daily for 330 days as indicated and the total exposure dose in the year was calculated for the workers at iron manufacturing workshops with a work rate 12 hours daily for 350 days as indicated in the Table (2).

Table (2) represents the total dose exposure for the workers at Iron and Steel factories is almost very similar equals to 0.29 mGy/y and 0.30 mGy/y for the samples (s.no.1) and (s.no.2) respectively. The total effective exposure dose in the year for the workers at Iron manufacturing workshops ranges between 0.10 mGy /y in (s.no.3) and 0.14 mGy /y (s. n. 4). The average value of the total exposure (0.12 mGy/y) and all values of total dose rate were lower the limits as recommended by (UNSCEAR, 2000).

Table.(1) : Concentrations in Bq/kg for of waste samples from iron production.

Series Nuclie / Sample Code	^{238}U Series		^{238}Th Series	^{40}K	^{137}Cs
	^{234m}Pa	^{226}Ra			
DL*	ND #	0.4 ± 0.07	0.3 ± 0.07	4.6 ± 0.5	0.08 ± 0.03
Slag Sample_01	1.0 ± 0.31	113.9 ±0.95	95.2 ±1.2	18.9 ±3.6	LDL**
Slag Sample _ 02	1.66 ± 0.56	107.4 ± 1.86	109.6 ± 2.58	2.27 ± 0.03	LDL
Slag Sample (Average)	1.33	110.65	102.4	10.58	LDL
Scrap Sample -03	ND	26.22 ± 1.47	43.24 ± 2.48	LDL	LDL
Scrap Sample _04	ND	46.92 ± 1.11	52.79± 2.27	LDL	LDL
Scrap Sample (Average)	ND	36.57	48.02	LDL	LDL

*** Detection Limit. ** Lower Detection Limit**

Table (2) Radium equivalent Bq/kg and the exposure dose from ^{226}Ra, ^{232}Th series^{40}K nGy/ h and total dose rate mGy/y from iron production

Sample Code / Ex posure	Sample-01	Sample-02	Slag Sample (Average)	Sample -03	Sample-04	Scrap Sample (Average)
Ra_{eq} Bq/kg	251.49 ± 0.66	264.30 ± 1.37	257.89	88.41 ± 1.28	122.76 ± 1.14	105.58
Ra- 226 nGy/h	51.84 ± 0.43	48.88 ± 0.85	50.36	11.93 ± 0.67	21.35 ± 0.51	16.64
Th- 232 nGy/h	55.55 ± 0.70	63.95 ± 1.51	59.75	25.23±1.45	30.80 ±1.32	28.01
K- 40 nGy/h	0.81±0.15	0.10± 0.001	0.45	0.20 ± 0.02	0.20 ± 0.02	0.20
Total Exposure/y mGy/y	0.29 ± 0.0007	0.30± 0.002	0.295	0.10 ±0.002	0. 14± 0.002	0.12

3.3. Activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K analysis of waste from carbon filters samples

Table (3) shows the concentrations of ^{238}U series, ^{226}Ra, ^{232}Th, ^{137}Cs and ^{40}K in Bq/Kg dry weight of three samples of carbon water filters as the flowing :

Series of ^{226}Ra

The concentrations in Bq/kg of ^{226}Ra ranged between 2.82(s. no.3) to 7.3 (s. no.1), the concentrations were calculated from the nuclides ^{214}Pb at energies (295.2, 351) kev and ^{214}Bi at energies (609, 1120, 1764) kev. The average value of ^{226}Ra concentration is 4.41 Bq/Kg.

Series of ^{232}Th

The concentrations of Thorium series were calculated from the nuclides ^{228}Ac, ^{212}Pb, ^{212}Bi and ^{208}Ti where the concentrations in Bq/Kg of ^{232}Th series ranged from 5.00 (s. no. 1) to 9.10 (s.no..3) with an average value 6.75.

^{40}k

The concentrations in Bq/kg of ^{40}K ranged between less than the minimum of the count (LDL) (s. no. 3) to about 35 (s. no. 2) with an average value 22.88.

^{137}Cs: ^{137}Cesium concentrations were calculated from the energy 661.66 kev, where its concentrations found to be less than the minimum for the count (LDL) for all samples.

Table (3) : Concentrations in Bq/kg for the dry weigh in carbon filters.

Series Nuclie / Sample Code	^{226}Ra	^{232}Th	^{40}k
DL.*	0.40 ± 0.07	0.30 ± 0.07	4.60 ± 0.50
Sample_01	7.30 ± 0.50	5.00 ±1.00	10.80 ±0.20
Sample _ 02	3.12 ± 0.31	6.19 ± 2.22	34.97±0.44
Sample _03	2.82 ± 0.14	9.06 ± 1.46	LDL**
Average	4.41 ± 0.00	6.75±0.00	22.88±0.00

* Detection Limit. ** Lower Detection Limit

3.4 Radium equivalent and Effective Dose of waste from carbon filters samples

As presented in Table (4), radium equivalent ranged between lower value 15.28 Bq/kg (s. no.1) and top value 16.13 Bq/kg (s. no. with an average value 15.35 Bq/Kg, these values are less than the allowed limit 370 Bq/kg (UNSCEAR, 1988; Kumar *et al.,* 2003)

Radiation exposure doses in the year was calculated for the workers in the field of water

treatment plant by using Activated Granulated Carbon Filters with a rate of 8 hours of work a day for 312 days as indicated in the Table (4). The average annual dose is 0.02 mGy/y for the three samples, which is less than the average value recommended by UNSCEAR (1993).

Table (4) Radium equivalent (Ra_{eq}) Bq/kg and the exposure dose (nGy/h) from ^{226}Ra, ^{232}Th and ^{40}K

Sample Code / Exposure	Sample_01	Sample_02	Sample_03	Average
Ra_{eq} Bq/kg	15.28 ± 0.50	14.66 ±1.06	16.13 ± 0.69	15.35
Ra-226 nGy/h	3.32 ± 0.23	1.42 ±0.14	1.28 ± 0.06	2.0
Th – 232 nGy/h	2.91 ± 0.58	3.61 ± 1.29	5. 29± 0.85	3.93
K- 40 nGy/h	0.46 ± 0.008	1.50 ±0.02	0.20 ± 0.02	0.72
Total Exposure / y (mGy/y)	0.02 ± 0.0005	0.02± 0.001	0.02 ± 0.0007	0.02

3.5 Analysis by Atomic Absorption

3.5.1 Heavy elements analysis in waste from Iron production:

Table (5) shows the concentrations of the following isotopes Ca, Fe, K, Mg, Mn, Bi, Pb and Th in the slag iron and scrap iron samples. The concentrations were calculated in ppm and percentage to compare with the results of gamma analyzer. The average concentrations of slag iron samples were calculated in percentage as following: 15.76%, 27.11%, 0.3%, 5.96 %and 1.38% for the elements Ca, Fe, K, Mg and Mn respectively. While the concentrations of Pb, Bi and Th elements were designated in ppm, their average concentrations were 56.80 ppm, **<7.50** (LDL) and 25.45 pm, respectively. The average concentrations for the scrap iron samples in percentage were : for Ca (0.17%), for Fe (65.28%), for K (0.01%), for Mg (0.05%) and for Mn (0.42%). The concentrations of Bi, Pb and Th elements were calculated in ppm, their average concentrations were 50.16 ppm, 24.14 ppm and 20.41 ppm, respectively. Comparing the results of gamma analyzer and isotopic analysis of K for the two slag iron samples (No.1 and No.2) in percentage were (0.06%, 0.16%) and (0.007%, 0.44%) respectively. The difference between the results of isotopic analysis and gamma analyzer is because the probability of no mixing of both samples is well, the mass of the samples which were analyzed by atomic analysis were (1.19 and 0.52 gram) respectively, while for gamma analyzer, their masses were (517.5 and 118.8 gram) respectively and were analyzed in the size 640cc. For the two samples No. 1 and 2, Comparison the results of gamma analyzer with atomic analysis of Th in ppm were (23.4 ppm, 23.7 ppm) and (26.9 ppm, 27.2 ppm) respectively, which to be found that the results are very convergent.

Comparing the results of gamma analyzer and isotopic analysis of K in percentage for the scrap iron samples (No. 3 and 4) were (LDL, 0.01%) and (LDL, 0.02%) respectively. The result of Th for the two samples No. 3and 4 in ppm were (10.62 ppm, 21.95 ppm) and (12.97ppm, 18.87 ppm) respectively. The difference between the results of isotopic analysis and gamma analyzer is because of the probability of no mixing of both the samples well.

Wiser, (2003) found that the radiation level in the undeveloped filters were very low from the series of ^{226}Ra, very few concentration of ^{226}Ra was observed about 20Bq/kg for dry weight, which matches the results of radiation analysis of ^{226}Ra which the concentration of the series of ^{226}Ra didn't exceed 7.3 Bq/kg. According to European laws can be neglected also indicating that the water which is filtered by water filtration systems, the concentrations of radioactive elements (^{226}Ra, ^{232}Th, ^{40}K, ^{137}Cs) in the wastes from used carbon filters were low and poor. As well as the filtered water is previously filtered at the main filtration stations before distributing.

Table (5): Elements concentrations in ppm &% measured by ICP-Atomic Absorption Analyzer.

Elements	Ca	Fe	K	Mg	Mn	Bi	Pb	Th
DL.	0.01	0.01	0.01	0.01	0.01	10.0	7.5	1.0
Units	%	%	%	%	%	ppm	ppm	Ppm
Sample-01	16.16	27.80	0.16	6.11	1.43	55.11	<7.50	23.7
Sample-02	15.35	26.42	0.44	5.80	1.33	58.50	<7.50	27.2
Slag Sample (Average)	15.75	27.11	0.3	5.95	1.38	56.80	<7.50	25.45
Sample-03	0.14	69.10	0.01	0.06	0.41	90.31	40.75	21.95
Sample-04	0.21	61.46	0.02	0.04	0.43	<10.0	7.54	18.87
Scrap Sample (Average)	0.17	65.28	0.01	0.05	0.42	50.16	24.14	20.41

3.5.2 Heavy elements analysis in waste from carbon filters samples

The concentrations of the following elements were calculated: Ca, Fe, K, Mg, Mn, Bi and Pb. The concentrations were calculated in ppm and percentage, where the results are tabulated in Table (6). The average values of concentrations were o.22 %, 0.19%, 0.25% and 0.03% for the elements Ca, Fe, K and Mg. For the elements Mn, Bi and Pb, the average concentrations were lower than the detection limit (LDL), while the concentration of Th in samples No.1 and 2 were less than the minimum for the count, and 1.97 for the sample No.3.

Comparing the results of gamma analyzer with isotopic analysis of Potassium in percentage for the samples No.1, 2 and 3 were (LDL, 0.02%), (0.11%, 0.03%) and (0.036%, < 0.01%) respectively. The difference between the results of isotopic analysis and gamma analysis is because of the probability of no convergence of the samples well.

The results of gamma analyzer and atomic analysis for Th in samples No. 1, 2 and 3 (1.23 ppm, <1.0 ppm), (1.52 ppm, <1.0 ppm) and (2.23 ppm, 1.97ppm) respectively.The result of gamma analyzer was found to be convergent with the result of elemental analysis for the sample No. 3.

Table (6): Elements concentrations in ppm &% for the carbon filters measured by ICP-Atomic Absorption Analyzer.

Elements	Ca	Fe	K	Mg	Mn	Bi	Pb	Th
DL.	0.01	0.01	0.01	0.01	0.01	0.01	7.5	1.0
Units	%	%	%	%	%	Ppm	ppm	Ppm
Sample-01	0.03	0.53	<0.01	<0.01	<0.01	<0.01	<7.50	<1.0
Sample-02	0.03	0.02	0.03	0.01	<0.01	<0.01	<7.50	<1.0
Sample-03	0.60	0.03	0.02	0.05	<0.01	<0.01	<7.50	1.97
Average	0.22	0.19	0.025	0.03	<0.01	<0.01	<7.50	----

4. Conclusion

The observed concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Waste Samples from Iron Production and Carbon Filters used in Saudi Arabia. The radium equivalent and absorbed dose values of all studied samples are below the internationally accepted values.The calculated mean Ra_{eq} values are also lower than the internationally recommended maximum level of equivalent of 370Bq/kg for materials. The study has shown that all the present wastes samples can safely be used as a construction material and poses no any radiological complication.

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