A study of Natural Radioactivity in the Welding Workshops Waste

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Abstract: In this study, the natural radio activities of ^{40}K, ^{226}Ra,and ^{232}Th and the man- made of ^{137}Cs in samples of solid wastes of (TIG) welding process, collected from the welding workshops in different locations of Saudi Arabia (Jeddah, Asfan and Tabuk). The concentrations of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were determined by gamma-ray spectrometer using HPGe detector. The results show that the average concentrations were 44.8,50.23,431.82 and 1.5 Bq /Kg, respectively. Rradium equivalent activities of the samples under consideration were calculated with an average value of 127 Bq/Kg. The total absorbed dose in the study samples ranged between the lower value (0.027) mGy/h (sample No.4) to the higher value (0.628) mGy/h (sample No.5), with an average value of (0.19) mGy/h which is lower than the limits as recommended by (UNSCEAR 2000). Also, heavy metals analyses were done by atomic absorption spectrophotometer. The concentration's average values of Ca, Fe, K, Mg, Bi, Pb and Th elements in the samples of Welding Workshops Waste were 1.02%, 63.18%, 0.25%, 0.25%, 76.99 ppm, 62.87 ppm and 17.63 ppm, respectively. The data were discussed and compared with limits given by United Nations Scientific Committee for the effects of Atomic Radiation (UNSCEAR).
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1. Introduction

Some technological activities produces amounts of radioactive industrial wastes which may contaminate the environment. In this study the concentrations of the natural radioactive elements of gamma rays were determined, which are series of ^{226}Ra and their generated nuclides, ^{232}Th, series and ^{40}K, in addition to ^{137}Cs in some of radioactive debris from welding workshops which use tungsten poles coated by Thorium with Tungsten Inert Gas (TIG). Welding material is from tungsten which is used through it an inert gas, it is a common material used for welding stainless iron and nickel alloys and light metals such as aluminum and magnesium. An electric arc is formed between tungsten pole and the desired welding material. To avoid Oxides formation in molten material, an inert gas is used which is usually Aragon or Helium to protect the molten material from the surrounding air. Tungsten poles are usually consist of alloy which contains (1-4%) of Thorium Oxide to facilitate the beginning of electric arc formation as well as increases of electric arc stability causing low pollution for welding material and increasing the capacity of the current. Most of welding poles contain of 2 % of Thorium Oxide which Thorium's concentration (^{234}Th, ^{232}Th, ^{230}Th and ^{228}Th is about 70.000 Bq/kg. Most of materials are welded by using running current, while in Aluminum and Magnesium it is used a frequent current to cause segmental effect at oxide formation.It is not preferable to use poles which consist of Thorium alloy in cases of aluminum, however some workshops use them in all cases. There is a probability to inhale Thorium during welding process or whetting poles(because the pole's sharpened edge gives good results in welding process) which is considered a radiation risk (NORM, 2005).

(Crim & Bradley, 1995) made sure of the existence of Thorium with high concentrations in the air during welding process by using Tungsten poles coated by Thorium. Some of few advantages of this poles type in the industry process are more simplicity and stability as well as reduction of probability of metal pollution. These poles contain about 2% of Thorium Oxide, and they found that Thorium concentration in the air at work places during welding are usually low of levels which are derived for breathing air (derived air concentration) DAC which equal 0.04 Bq/m^3.

(Jankovic *et al.,* 1999) designated the radiation dosages incurred by workers as a result of using this type of poles in U.S.A. the attention was concentrated on studying the surrounding air and breathing shields. They could designate the concentration of -^{232}Th, ^{230}Th and ^{228}Th in ppm in samples of theses poles.They found that the concentrations of Tungsten poles coated by cerium to Tungsten poles coated by cerium is 124 ppm and 177 ppm respectively, because cerium belongs to Lanthanides which are elements group (La, Ce, Pr,Nd,…..Lu) while Thorium is of actinides (Ac, Th, U, Np, Pu). by analyzing breathing shields they could determine volume and concentration of ^{232}Thorium in the air by considering that pole whetting period takes 20 seconds.

(Reichelt *et al.,* 2000) measured the concentrations of radioactive nuclides during welding process by tungsten poles coated by Thorium with inert gas during common program between Technical inspection Agency and Isotopes measurement laboratory in the field of Bio and Medical Researches in Germany. Some of workshops have been selected to collect samples as well as some of samples from air have been taken in addition to measuring ^{230}Tho. Radioactive elements concentrations have been calculated by using techniques of Alpha Spectrum and Gamma low level Spectrum also radiation dose ranges from 5 to20 mSv/y when convection coefficients are used which are given from ICRP-30.

(Gafvert *et al.,* 2003) studied the radiation exposure as a result of welding process by tungsten poles coated by Thorium with inert gas. The absorbed radiation dose was determined annually for samples taken from poles whetting and ventilation area collected from different workshops to be found that they are less than 0.3 mSv from welding point and 10 µSv from whetting point. But the annual limited effective dose is about 1mSv for welding and 60 µSv from whetting point (Gafvert *et al.,* 2003). At the same topic of studying radioactive doses as a result of welding process by tungsten poles coated by Thorium, (Saito *et al.,* 2003) in Japan designated levels of radiation exposure doses resulting from welding using ^{232}Th in the air and radiation background. He designated radioactive materials concentrations in the air by Becquerel per cubic meter during Aluminum and steel welding as well as, Poles whetting where the annual value of ^{232}Th shouldn't exceed 1.6×10^2 Bq. He recommended in order to reduce the dose of ^{232}Th exposure is by replacing thorium coated poles by another empty poles, moreover using ventilation systems. and breathing shields and the necessity of notifying workers that tungsten poles coated by thorium containing of radioactive material.

The aim objectivities of this work are to quantify the presence of natural radionuclides in the most commonly samples of solid wastes of (TIG) welding process, collected from the welding workshops in different locations of Saudi Arabia and to estimate the radiological hazard associated with the natural radioactivity levels of these materials.

2.Experimental Technique

2.1 *Samples collection*

Nine samples of solid wastes of (TIG) welding process, were collected from the welding workshops in different locations of Saudi Arabia (Jeddah, Asfan and Tabuk). Samples were crushed into homogenized material of particle size 1 mm using a grinder machine and then dried in oven at 110 °C. For gamma measurements, 250 cc of each dried sample sieved and packed in Marenelli beakers (its weight is calculated) and stored for 1 month to reach secular equilibrium between ^{238}U- ^{226}Ra and ^{232}Th-series and their progenies.

2.2 *Counting*

To estimate the activity levels of different radionuclides in samples of solid wastes, a closed-end coaxial high-purity germanium (HPGe) detector (Model GC 3020 Canberra) coupled with computer-based multichannel analyzer acquisition board (Accuspec-A, Canberra) was used. The HPGe has relative efficiency 25 % at 1332 keV 60Co gamma-ray. The system was calibrated using 137Cs and 60Co for their known energy and peak width of ɣ-ray emission while the efficiency calibration was determined with a 152Eu liquid source, sealed in a Marginally beaker of the same geometry as that of the samples beaker. The background was measured regularly under the same conditions of sample measurement.

For the measurements, The concentrations of ^{238}U were calculated from its daughter ^{234}pa (1001.0 keV), ^{226}Ra concentrations were determined by means of its progeny photo peaks of gamma-ray lines: ^{214}Pb (295.21 and 351.9 keV) and ^{214}Bi (609.3, 1120.27, 1764.49 keV). The concentration of ^{232}Th was determined through its progeny photo peaks of gamma-ray lines: ^{228}Ac (338.32, 911.21 and 968.97 keV), (727.25 keV) ^{212}Pb and (583.02, 2614.48 keV) ^{208}Tl, considering ^{228}Ra and ^{228}Ac are in secular equilibrium with ^{212}Bi and ^{212}Pb- (Saito&Moriuchi, 1985, Saiato *et al.,* 2003). The activity of ^{40}K was measured directly from its gamma-ray energy peak of 1460.8 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 3 samples readings standards were run to make sure that the obtained results were within ranges.The mass of the sample under study is 5cc.The activity concentrations of the natural radionuclides in the measured samples were computed using the following relation (Noorddin, 1999; El-Taher., 2011):

$$\mathbf{A_S\ (Bq/\ kg) = C_a / \varepsilon\ P_r\ Ms} \quad \text{..... (1)}$$

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).

2.3. *Hazards Indices calculations*

To assess the radiological hazard of the considering samples(solid wastes), it is useful to calculate an index called the radium equivalent activity (Ra_e), defined according to the estimation that 1 Bq/kg of ^{226}Ra, 0.7 Bq/kg of ^{232}Th and 13 Bq/kg of ^{40}K produce the same -ray dose (Beretta & Mathew 1985). This index Ra_{eq} is given as (UNSCEAR1993):

$$\mathbf{Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.077A} \quad \text{.....(2)}$$

Where: A_{re}, A_t and A_K are specific activities of ^{226}Ra,^{232}Th and ^{40}K,respectively, in Bq/kg.The maximum value of Ra_e in materials must be less than 370 Bq/kg for safe use i.e., to keep the external dose below1.5mSv.y^{-1} UNSCEAR (1993).

It is necessary to calculate radiation exposure doses for the workers in the field of welding workshops which use tungsten poles coated by Thorium with inert gas, Tungsten Inert Gas. (TIG).Workers' total exposure dose in the year was calculated on a height of 1 meter above the ground surface for the uniform distribution of radionuclides were calculated based on guidelines provided by UNSCEAR, 2000:

$$\mathbf{D_R\ (nGy\ h^{-1}) = 0.4551C_{Ra} + 0..5835C_{Th} + 0.0429C_K} \text{.....(3)}$$

Where: C_{Ra}, C_{Th} and C_K are the activity concentrations (By kg^{-1}) of^{226}Ra, ^{232}Th and ^{40}K respectively, in the samples. 0.4551, 0.5835 and 0.0429 $nGyh^{-1}$/Bq/kg are the conversion coefficients of ^{226}Ra, ^{232}Th, ^{40}K respectively (Quindos,2004).

3. Results and Discussion

3.1. Gamma Spectroscopy

The series of ^{226}Ra, ^{232}Th, ^{40}k and ^{137}C in Bq/Kg for dry weight samples collected from different locations in Saudi Arabia were represented in Table (1)

For all samples, the ^{226}Ra activity or ^{238}U activities assumed to be in radioactive equilibrium. The concentrations of ^{238}U is calculated from (^{234}Pa) at energy 1001.2 keV, and it ranged between 0.98 Bq/ kg (sample No.1) to 2.2 Bq/ kg (sample No.2) with an average value 1.46 Bq/Kg. The results in Table (1) showed that there is no detection (ND) in the samples No.4, 6 and 9. For ^{226}Ra series, the concentrations were calculated from (^{214}Pb) at energy (295.21 and 351.9 keV) and (^{214}Bi) at energies (609, 1120 and 1764 keV). The concentrations of ^{226} Ra, ranged between less than detection limit (LDL) (sample No. 4) to 29.9 Bq/kg (sample No.5).The average value is 44.8 Bq/Kg

The concentrations of ^{232}Th were calculated from the nuclides ^{228}Ac, $^{21}2Pb$, ^{212}Bi and ^{208}Tl.The concentrations of ^{232}Th series ranged from 10 Bq/ Kg (sample No.4) to 128.6 Bq/kg (sample No.5) with an average value 50.23 Bq/Kg as showed in Table (1). Thorium used in welding process is extracted from ores which have different geological structure and the resulted Thorium would be a mix of ^{232}Th, ^{228}Th, (^{232}Th series), ^{234}Th and ^{230}Th (^{238}U series), ^{228}Th availability ratio depends on storage period (Ore age), if there is a radioactive equilibrium before separation process,this equilibrium will be unsettled after separation, ^{228}Th ratio reaches to ^{232}Th till the minimum 0.42 after a period of (4.7 y) and after (22.4 y) this ratio reaches to 0.9 and there will be a building for ^{228}radium radiating Beta particles in welding poles according to the ore which Thorium has been extracted from it (Gaffer *et al.,* 2003).

(Ludwig et al. *et al.,* 1999), observed the existence of ^{230}Th with different ratios where its radioactive concentration constitutes a ratio less than 20 % from ^{232}Thorium radioactivity (^{232} Th half- life = 1.39×10^{10} year) and (^{230}Th half- life = 8×10^4 year).Welding process Operators don't use breathing protective masks, so the analyzed samples were collected from welding place ground and no samples were collected from air filters and recommended welding process workers to put breathing protective masks as well as air samples of welding worker's breathing area should be analyzed to determine thorium ratio in the air during welding process.

^{40}K concentration was calculated directly from the energy 1460.8 keg following to ^{40}K decay by electronic capture, so 1 gram of natural potassium is equivalent to 29.6 Becquerel from gamma ray.It observed for the samples under investigation,that the concentrations ranged between less than the detection limit (LDL) (samples No. 4, 6,7,8 and 9) to 749.4 Bq / kg (sample No.5). The corresponding average value is 431.82 Bq /Kg.

^{137}Cs concentrations was calculated at the energy 661.66 KeV. Table (1) shows that the concentrations range between LDL (samples No. 1, 6, 7, 8 and 9) to 2.3 Bq/kg (sample No.2) with an average value 1.5 Bq/Kg**.** These concentrations were from radioactive atomic loss indicating that a part of soil on which wastes fell on was taken with the collected samples.

The radium equivalent activity of the samples calculated on the basis of the aforementioned relationship are shown in Table(2). Ra_e concentrations values varying from the lower value 15.54 Bq/kg (sample No. 4) to the upper value 334.50 Bq/kg (sample No. 5). With an average value of 127 Bq/Kg. However, all the values obtained here for radium equivalent activity are below the internationally accepted value of 370 Bq/kg (`UNSCEAR,1988, Kumar *et al.,* 2003). Consequently, all of these types of Welding Workshops Waste do not pose a significant radiological hazards on human health.

Table (1): Concentrations in Bq/kg dry weight, for the welding workshops waste Samples.

Series Nuclei / Sample Code	^{238}USeries		^{232}Th Series	^{40}K	^{137}Cs
	^{234m} Pa	^{226}Ra			
DL.*	ND #	0.7 ±0.17	0.5 ±0.14	7.06 ±0.64	0.1±0.06
Sample_01	0.98 ± 0.73	42.5 ± 0.98	51.3 ± 2.2	255.02 ± 2.7	LDL**
Sample _ 02	2.20 ± 0.74	81.6 ± 2. 3	32.4±1.8	445.71±4.3	2.3±0.3
Sample _-03	1.60±0.70	56.3±1.6	28.0±3.2	277.16 ± 2.9	2.1 ± 0.11
Sample _04	ND	LDL	10.0 ± 1.1	LDL	0.6 ± 0.12
Sample _05	1.50 ± 0.77	92.9 ± 1.3	128.6 ± 2.6	749.4 ± 8.3	1.0±0.3
Sample_06	ND	14.5±0.71	92.6 ±1.53	LDL	LDL
Sample_07	1.12±0.48	21.1±0.67	33.5±1.11	LDL	LDL
Sample_08	1.36±0.64	27.8±0.85	38.9±2.5	LDL	LDL
Sample _09	ND	21.7± 0.76	36.8±2.3	LDL	LDL
Average	1.46	44.8	50.23	431.82	1.5

 # Not detected. * Detection Limit. **Lower than Detection Limit.

The calculated absorbed dose rates of ^{226}Ra, ^{232}Th series and ^{40}K and total dose rate from the welding workshops waste Samples are tabulated in Table (2). It is observed that the average value of the absorbed dose rate calculated from activity concentration of ^{226}Ra, ^{232}Th and ^{40}K in air were 18.15, 29.31, and 8.38 nGy/h respectively.

The total absorbed dose in the study samples ranged between the lower value 0.027 mGy/y (sample No.4) to the higher value 0.628 mGy/y (sample No.5), with an average value of 0.234 mGy/y, while the corresponding values of the Thorium equivalent rate in the total dose is 90% (s.no.4) and 50% (s.no.5) respectively. The total value of the effective absorbed dose in sample No.5 is higher than the allowed limit 0.5 mGy/y (UNSCEAR,2000) while the effective dose for other samples were less than this limit, so it is necessary to remove these solid wastes continuously.

In order to reduce ^{232}Th exposure, it is recommended to replace thorium coated poles by another empty poles, moreover using ventilation systems and the necessity of using breathing shields to ensure of lack Thorium access to respiratory system and the must of notifying workers that tungsten poles coated by thorium contain radioactive material (Saito *et al.,* 2003).

Table (2) Radium equivalent (Ra_{eq}) Bq/kg and the absorbed of ^{226}Ra, ^{232}Th- series and ^{40}K by nGy/h and total dose rate from the welding workshops waste Samples & the contribution % of Th- series.

Samples Code	Ra_{eq} (Bq/Kg)	Absorbed dose ($nGyh^{-1}$)			Total absorbed dose mGy/y	Contr. Of Th %
		^{226}Ra	^{232}Th	^{40}K		
Sample-01	135.50± 1.10	19.34 ±0.44	29.93±1.28	10.94±0.11	0.253 ±0.002	50%
Sample-02	162.25 ±1.15	37.14±1.05	18.90±1.05	19.12±0.18	0.316 ±0.002	25%
Sample-03	117.68 ± 1.61	25.62± 0.73	16.34±1.86	11.89 ± 0.12	0.226 ± 0.003	30%
Sample-04	15.54 ±0. 53	0.32 ±00.07	5.84±0.64	0.30± 0.02	0.027 ± 0.009	90%
Sample-05	334.5 ± 1.33	42.28 ± 0.59	75.04±1.52	32.15 ± 0.36	0. 628 ± 0.002	50%
Sample-06	147.25 ± 0.76	6.60 ± 0.32	54.03±0.89	0.19 ± 0.002	0.255 ± 0.001	89%
Sample-07	69.54 ± 0.57	9.60 ±0.30	19.55±0.65	0.30 ± 0.02	0.124 ± 0.001	66%
Sample-08	83.97±1.22	12.65±0.39	22.69±1.46	0.30 ± 0.02	0.150±0.002	64%
Sample-09	74.87± 1.12	9.87± 0.35	21.47±1.34	0.30 ± 0.02	0.133±0.002	68%
Average	126.78	18.15	29.31	8.38	0.234	----

3.2. Atomic Absorption Spectroscopy

Three samples of welding material in Thorium Poles used in different workshops of the type J421E6013, E6013 and E6013 were analyzed by using atomic absorption spectroscopy to get sure the existence of Thorium. Th concentrations were found to be 80.7 ppm for the first type and ranged between 58.4 ppm and 43.7 ppm respectively for the second type, this constitutes for Th were the total ratio of (^{234}Th, ^{232}Th, ^{230}Th, ^{228}Th).

Welding workshops wastes were analyzed, the concentrations were calculated in ppm and reported in Table (3). For all elements, the calculated concentrations of element was totally so the comparison will be in gamma measurements for potassium and thorium, considering that one gram of natural potassium is equivalent to 29.6 Bq from potassium -40 and one gram of Thorium -232 is equivalent to 4.07 Bq, supposing that its existence rate is (100%).

Calcium is found in the nature as stable isotopes: ^{40}Ca (96.97 %), ^{42}Ca (0.64 %), ^{43}Ca (0.145%), ^{44}Ca (2.06%), ^{46}Ca (0.0033%), ^{48}Ca (0.185%) (Seelman-Eggebert, 1968). Table (3) showed that, calcium concentrations ranged between 0.15 % (sample No.7) to 2.82 % (sample No.2) with an average value **1.02 %.**

Iron is found in the nature as stable isotopes: ^{54}Fe with an abundance ratio of 5.82 % and ^{56}Fe, with a ratio of 91.66 % and ^{57}Fe, with a ratio of 2.19 %, and ^{58}Fe, with a ratio of 0.33 % (Seelman- Eggebert,1968). In this study, the concentrations ranged between 36.32 % (sample No.2) and 79.53 % (sample No.4) with an average value **63.18 %**. Usually these workshops worked in welding iron and steel so, the iron element in the wastes is found with high ratios.

Potassium is found in the nature as stable isotopes: ^{39}K with a rate of 93.10 %, ^{41}K with a ratio of 6.88 % and radioactive ^{40}K with a ratio of 0.0118% (Seelman- Eggebert, 1968). The concentrations of potassium-40 is identified by using gamma analysis and its half-life is 1.28×10^{9} y.

The concentrations of potassium by the atomic absorption analysis ranged from 0.01 %, as the minimum count (samples No. 6,7, 9) to 0.92 % (sample No.2), with an average value for all samples as **0.25 %** Table (3).

In consideration of 1gram of natural potassium is equivalent to 29.6 Bq potassium-40, the concentrations ranged between the minimum count in the samples No. 6, 7, 9 to 272.32 Bq/kg in sample No.2.

Magnesium is found in the nature as stable isotopes ^{24}Mg with a rate of 78.70 % and ^{25}Mg, with a rate of 10.13 % and ^{26}Mg with a rate of 11.17% (Seelman- Eggebert,1968). The minimum value is 0.07 % (sample No.9) and the higher value was 0.47% for the sample 5 with an average value **1.19 %**.

Manganese is found in the nature of the form stable isotope ^{55}Mn with a rate of 100 % (Seelman-Eggebert,1968).The minimum value is 0.37 % (sample No.7) and the higher value was 2.65% (sample No.5) with an average value **0.25 %**.

Bismuth is found in the nature of the form of stable isotope ^{209}Bi with a rate of 100 % at the end of the series of Neptunium -237 and a very few ratio in the natural radioactive isotopes ^{210}Bi, ^{214}Bi (Series of Radium -226), ^{212}Bi (series of Thorium -232) ^{211}Bi (series of Actinium- Uranium -235) (Seelman-Eggebert, 1968).

The minimum value is 31.28 ppm for the sample No.7 and the higher value is 96.43 ppm for the sample No.7 with an average value 76.99 ppm.

Lead is found in the nature in the form of radioactive isotopes ^{204}Pb (1.48%, and half-life 67 min) and in the form of stable isotopes ^{206}Pb (23.6 %) at the end of the series of Uranium -238,^{207}Pb (22.6%) at the end of Actinium (^{235}U Series), ^{208}Pb (52.3%) at the end of Thorium -232 series. As well as both of ^{214}Pb and ^{210}Pb from the series of Radium -226 and ^{212}Pb from the series of Thorium-232 are found in the natural radioactive series with very few ratios (Seelman- Eggebert,1968). The minimum value is 19.41 ppm for the sample No.5 and higher value is 157.26 ppm for the sample No.8 with an average value 62.87 ppm.

Thorium is found in the nature in the form of isotopes ^{232}Th (all the isotopes of thorium are radioactive) with almost 100 %, as well as it is found in the form ^{228}Th for the same series with a very few ratio, also^{234}Th, ^{230}Th (Uranium-238 series),^{227}Th-^{231}Th (Actinium series (Uranium-235) with very few ratios (Seelman- Eggebert, 1968).

In Table (3), the thorium concentrations ranged between 9.93 ppm (sample No.2) to 31.23ppm (sample No.5) with an average value **17.63 ppm**

The difference between all results referred to that the concentrations were calculated from radioactive nuclides as in Thorium series ^{228}:Ac, ^{212}Bi and ^{212}Pb, which after storing for one month be in a status of radioactive equilibrium with Radium -228 and it is not necessary to be in a status of radioactive equilibrium with Thorium -232. The results of atomic analysis and gamma analysis were: (12.6 & 20.05) in sample No.1, (7.96 & 9.93) in sample No.2, (6.88 &17.01) in sample No. 3, (2.46 & 10.0) in sample No. 4, (31.60 & 31.23) in sample No. 5, (22.75 &15.11) for the sample No. 6, (8.23 & 15.93) for the sample No. 7, (9.56 & 20.0) in sample No. 8 and (9.04 & 19.35) in sample No.9 respectively. The results of the two samples No.2 and No.5 were found to be convergent, but for the other samples, the difference in the results referred to the size 250cc of the samples which were analyzed by using gamma analyzer more than size (5cc) of the samples which were analyzed by an atomic analyzer.There is probability that the samples were not identical, so the difference appeared in the analysis of small size samples. Comparing the results of atomic analyzer and gamma analyzer for Thorium, also the atomic analysis includes total value of Thorium -228 and Thorium -232 (Thorium-232 series) in addition to Thorium -234 and Thorium -230 (Uranium –238 Series).

4. Conclusion

Natural radioactivity such as ^{226}Ra,^{232}Th, ^{40}K radio nuclides and the man- made of ^{137}Cs in samples of solid wastes of (TIG) welding process were determined. The value of Ra_{eq} activity was found to be less than 370 Bq/kg.The mean value of total absorbed dose rate is 0.234 mGy/y, which is well below the permissible limit. Therefore, the present samples are still in the zones of normal radiation level, which

leaves the Welding Workshops Waste radioactivity there less a threat to the environment as well as the human health. However, this data may provide a general serve as a guideline for future measurement and assessment of possible radiological risks to human health.

Table (3): Element 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	1.92	54.56	0.36	0.43	1.84	68.69	57.28	20.05
Sample-02	2.82	36.32	0.92	0.33	1.34	31.28	19.65	9.93
Sample-03	1.27	59.17	0.34	0.18	2.46	63.15	28.70	17.01
Sample-04	0.69	79.53	0.07	0.45	0.43	92.40	97.11	10.10
Sample-05	1.11	58.19	0.51	0.47	2.65	81.43	19.41	31.23
Sample-06	0.67	67.63	0.01	0.12	0.70	87.67	112.29	15.11
Sample-07	0.15	74.00	0.01	0.08	0.37	96.43	32.29	15.93
Sample-08	0.36	68.40	0.03	0.08	0.54	79.56	157.26	20.00
Sample-09	0.16	70.78	0.01	0.07	0.42	92.36	41.84	19.35
Average	1.02	63.18	0.25	0.25	1.19	76.99	62.87	17.63

(DL.) Detection Limit

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