RADIOLOGICAL HAZARD ASSESSMENT IN OUTLET ZONE USING HIGH PURITY GERMANIUM DETECTOR AROUND KALITY WASTE WATER TREATMENT PLANT, ADDIS ABABA.

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A THESIS SUBMITTED TO CENTER FOR ENVIRONMENTAL SCIENCE, IN PARTIAL FULFILLMENT FOR THE REQUIREMENT OF THE DEGREE OF MASTERS IN ENVIRONMENTAL SCIENCE.

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APPROVAL SHEET

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ABSTRACT

Radioactive substance happens when there is unstable nuclei in the atom and can emit energy through high speed charged particle to become a stable state. Natural radioactivity is defined as the release of high energy radiation substance into water, air, land caused by internal, terrestrial, and cosmic radiation. If an atom becomes unstable, it will divide itself into smaller atoms. The main objective of this *study* is to detect both radioactivity and radio metal concentration from outlet water using a high purity germanium detector with the help of gamma accusation software.

The sample water, taken from the outlet zone, detected by high purity germanium detector, using 70 litter of liquid nitrogen with the help of gene2000 software,is the crucial research work to measure the natural radionuclide contamination of U-238, Th-232, and K-40. The activity concentration for radionuclide elements in the first water samples are listed: k-40 is found to be 1.0241E+002Bq/l, U – 238 is about 2.5971E +000Bq/l, and Th -232 got 8.53835E +000Bq/l. The activity concentration in the second water sample for k-40 is 9.7944E+001Bq/l. Th-232, one of the radionuclide elements has been found to be 9.134E+000Bq/l. Likewise, U-238 is found to be 3.0704E+000. In the third sample, k-40 is found to be 9.5874E+001Bq/l, U-238 become 2.5706E+000Bq/l, and TH-232 got 7.9461E+000 Bq/l .

Lastly, In the 4th sample, the activity concentration for k-40 becomes 4.330E +000Bq/l. This result shows the activity concentrations of U, TH, K are within the limit value, so the outlet water is safe from this pollutant.

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ACRONYMS

AS… .....Alpha Spectrometry

ASS .....Atomic Absorption Spectrophotometer

BOD .....Biological Oxygen Demand

Bq. ..... Becquerel

COD .....Chemical Oxygen Demand

DO..... Dissolved Oxygen

DP… .....Decay Product

DWC .....Derived Water Concentration

ERA.....Ethiopian Radiation Authority

ETP… .....Effluent Treatment Plant

Ge..... Germanium Semiconductor

GM… .....Geiger –Muller Detector

GPS .....Global Positioning System

GS. .....Gamma Spectrometry

HPGe..... High-Purity Germanium [Detector]

NaI (TI) .....Thallium –Activated Sodium Iodide Detector

NORM.....Natural Occurring Radioactive Material

PCi….....Picocurie

Rad ..... Radiation Absorbed Dose

TDS ..... Total Dissolved Solids

TSS..... Total Suspended Solids

WHO ..... World Health Organization

WWT.....Waste Water Treatment Plant

B ..... Beta Particl

CHAPTER 1

1. Introduction

1.1.Background

Natural radioactivity is defined as the release of high energy radiation substance into water, air land caused by internal, terrestrial, and cosmic radiation. If an atom becomes unstable, it will divide itself into smaller atoms.

Radioactive substance happens when there is unstable nuclei in the atom and can emit energy through high speed charged particle to become a stable state. The source of natural radioactivity relies on geographical and geological condition.(Abagale, 2013)

Both human activity and geologically can cause it. But most of the time, are affected by artificial radioactivity from the hospital, research institute, and industries.

Natural radioactivity can be found everywhere in the river, oceans, water, building materials, and homes. The natural radioactivity comes from the parent series of U-238, Th-232, and also K-40. For Example, Radioactivity in soil most often comess from fertilizer rich in phosphate while the farmer used it for agricultural purposes. (Ajayi, 2007)

Radiation also affects the water source itself by decomposing the water when it exposed to the radiation. So, the water will split into hydrogen radicals, hydrogen peroxide, asserted oxygen compounds, and hydrogen peroxide. Finally, it will convert

to oxygen to release huge amounts of energy. Some of these are explosive. When compared to beta particles and gamma rays, alpha particles are very harmful to human beings. Radioactive material emits alpha and beta particle are harmful when absorbed and injected.(Chibouski,2000)

The human being can also be affected by natural radioactivity found in water, especially uranium, thorium, and potassium 40.

Where in the outlet zone, there are many unseen and unpredictable pollutants that can't be reduced or treated by the trickling filter. These are radioactivity and heavy metal pollutants. The temperature, the pressure, and the catalytic action of the treated water will not alter the level of radioactivity because radioactivity will change when the nuclear reaction occurs in the metal. The amount of nuclear reaction relies on the amount of metal, the flux of neutron, and the chance of response. When the half-life for radioisotopes are formed, when the amount time is irradiated, irradiation occurs when the ultimate radioactivity will be determined. Radioactive metal can classified into two. These are natural and synthetic radioactive metals. Both metals can release alpha particles, beta and gamma rays.(Abagale, 2013)

Radium, thorium, uranium, actinium francium are natural radioactive metals. Of these, polonium is the highest radioactive metal because it releases a large amount of energy.

Radioactivity also cannot be affected by chemical combination, which means the element will exhibit radioactivity in Free State and a combined state. If there is a high amount of radionuclide contaminant in the outlet zone, it indicates the radioactive

accumulation around the city is also increased, affecting humans, plants, and animals.(Brown J,2008)

Whereas, ion exchange is useful to treat radioactive water. 90% of radionuclide in water was removed by ion exchange, and 98% of radium in water removed by reverse osmosis. Radioactive components can be removed by filtration, but high radiation levels cannot be treated by this methods.(Annanmaki T, 2000)

1.2 Objective of the study

1.2.1 General objective

- The main objective of this *study* is to detect both radioactivity and radio metal concentration from outlet water using a high purity germanium detector with the help of gamma accusation software.

1.2.2 Specific objectives

- To measure the activity concentration of radionuclide elements like k-40, U-238, and TH-232 in water.

1.2.3 Significance of the study

The study is crucial to know the safety of the treated water for irrigation and generally for human beings. It is also essential to provide continuous,, palatable and safe water that does not cause toxic to human and produce palatable water that free of unpleasant characteristics such as color, turbidity, taste, and odor. The purpose of waste water treatment facilities is to reduce or remove pollutants from wastewater to ensure adequate water quality before the treated effluent is reused or discharged to surface water.

1.2.4 Scope of the Study

The study covers measuring the amount of natural radionuclide concentration in effluent water using a high purity germanium detector and the effect of radio metal on the human being.

1.2.5 Statement of the problem

The main problem in the kality wastewater treatment plant is the inability to remove inorganic pollutants**.** Radionuclide pollutants found in the treated water are members of three radionuclide series i.e., uranium, thorium, and actinium, including the naturally occurring elements radium, uranium, and radioactive gas radon. and unable to do further treatment of radionuclide and Radio metal element in the outlet zone. The effect of inorganic pollutants on the water is the major problem. My role is to know wheather there is Artifical and Natural radioactivity in water,and if there is, to meaure the activity concentration in the sample water and to treat it with moringa seed by doing jar test as the seed can remove 99.8% of radioactivity in water.

CHAPTER 2

2.Literature review

2.1 Radioactivity

Radioactivity is a spontaneous process that occurs when there is an unstable nucleus in the atom, and it loses energy by releasing ionizing radiation. A kind of spontaneous emission is alpha particle, beta particle, gamma rays, and conversion electrons. Half-life is the time required for half of radioactive material atoms to decay to another nuclear form. (Chibouski,2000)

There are two types of radioactive isotopes: long live and short live radioactive isotope. U-238 is long live radioactive isotope found in the earth's crust, and its form short-lived radioactive isotopes called daughter. Most of the time, uranium-238, radium226, and radium228 can accumulate in the water. Uranium isotopes and radium226 are alpha particle emitters, but radium 228 and k-40 are beta particle emitters

If there is some level of radionuclide in water, it causes heart risk. Alpha particle emitters affect the human organ, tissue and cause biological effects. Radioactivity in soil

If there is a radionuclide pollutant in soil, it means that the environment is polluted, ffectingaffecting society. The primary source for radioactivity in the soil is the fertilizers that are used for agricultural purposes.Radioactivity in the soil will be detected by sodium gamma spectrometry.(chibouski,2000)

Natural radioactivity in the soil came from U-238, TH-232 parent series, and natural potassium. The natural origin of radioactivity comes from fertilizer. K-40, U-238, and TH-232 are found in rock and soil of terriseteral origin. The mean value for the radioactive level index of soil should not be greater than 1. Otherwise, the soil will be harmful to society. So, the recommended safe limit for u-238, Th-232, and k-40 in the soil should be less than 1. (Brown J, 2008)

2.1.1 Radioactivity in vegetables

The natural radioactivity of the vegetable will be measured in samples using gamma-ray spectrometry. The vegetable will become radioactively contaminated coming from the treated water and sludge Different types of foods needs to be irradiate. One of this is vegetables. Irradiating vegetables will not eliminate the natural radionuclide pollutant, so it cannot get rid of viruses andcannot get rid of viruses and irradiation that cause toxic chemicals, cancers, and birth defects. So irradiating the vegetables will not be the solution. The average value for U-238, TH-232, and K-40 in the vegetable should be less than one. So, the vegetable will not be hazardous with ICPR 1MSVY-1 (Chibouskis, 2000) (Brown J,2008)

2.1.2 Artificial radioactive pollution

Many facilities can release radioactivity to sewers like hospitals, universities, and industrial users of radioactive materials. Most institutes use anthropogenic radioactive materials like carbon 14 in research.

They are also prescribed to medical patients for the diagnosis and treatment of illness.

Drinking water treatment facilities removes the radioactive material from raw water

by ion exchange, precipitation, coagulation, or filtration. Two other domestic sources of radioactive material in sewage are food and medicine.

Iodin131, technetium-99, and thulium -201 are used in the diagnosis and treatment of medical conditions (chibouski s 2000)

2.1.3 Source of high–let radiation

Uranium 238 and thallium 232 are found in the earth's crust. They are also an alpha emitters. Radium, radon, and polonium are also alpha emitters. In outlet water, the natural alpha emitters appear to be the bone seekers. High amounts of radiation dose are produced by radium 226 and radium 228. Alpha emissions in water are also caused by the decay of radium

There are three types of radiation. These are cosmic, terrestrial, and internal radiation. Cosmic radiation obviously comes from the universe or outer space, and it penetrates thoroughly in the atmosphere to cover the earth. Another type of radiation is internal radiation, comes from an ingested natural radioactive substance. For example: potassium -40, which is found in foods like banana, etc.(Brown. J, 2008)

2.1.4 Radioactivity in Ethiopia

Last year, radioactivity for the activity concentration of U-238, TH-232, and K-40 in soil, water, and vegetable was detected using sodium gamma spectrometry and high purity germanium detector. Twelve soil samples, four coffee samples, and four Zuway Lake water samples were taken from the terrestrial origin of Zuway, Shasmne, and est Arsi zone .

The mean value for the activity concentration of ^{238}U, ^{232} Th, and ^{40}K in the soil samples was 45.83, 100.525, 845.65Bq/Kg, respectively. These values were higher than the average world recommended values for ^{238}U, ^{232}Th, ^{40}K, ,which are 35, 30, and 400 Bq/Kg for ^{238}U, ^{232}Th, ^{40}K, respectively. (Rukiya Ali, 2020)

an average value of 7.5 ±0.76 Bq/L, and the activity concentration of ^{40}K varies from 98.12 ± 4.16154 to 101.99 ± 4.91556 with an average value 99.77±4.80Bq/L

During theseexperimental activities, study detects and identify only potassium-40 in all the coffee samples i.e., 591.185 Bq/Kg. Average values of ^{40}K concentrations were higher than the acceptable value (412 Bq/kg)(Rukiya Ali, 2020)

The soil from the sampling area was detected to be very harmful and a hazard to the society, because its radioactive level index was above 1. It is found that radioactive levels varied from 1.19 to 2.395 Bq/kg, with the average value was found to be 1.917Bq/kg (Rukiya 2020), and the average values of the radioactive level index for soil should be less than 1 or equal to 1 (Rukiya, 2020)

For the coffee, the Radioactivity level index varied between 0.36 to 0.475 Bq/Kg with an average value of 0.4 Bq/Kg. The coffee did not affect society because the average value of the Radioactivity level index was lower than the recommended safe limit ≤ 1 (Rukiya 2020) The radionuclide concentration of Lake Zuwaye water didn't affect the community (rukiya2020), because the annual effective dose calculated was varied from 0.081 to 0.09 mSv/y with an average of 0.086 mSv/y. This value, when compared with the ICPR standard value of 1 mSvyr-1 was deficient (Rukiya, 2020).

CHAPTER 3

3.Methodology

3.1 Experimental Approach:

The study covers identification of natural radionuclide from outlet water, assessment of radioactivity in treated water, treatment and implementation strategies for radioactive waste water. Water samples were collected and analyzed to detect the radioactive isotopes from kality waste water treatment plant by using high purity germanium detector found in at Ethiopian Radiation Authority.

Water samples were collected from the outlet zone found in kality waste water treatment plant. This was done to know the amount of radionuclides and radio metal contaminates present in the outlet zone and to perform further treatment.

This study includes qualitative, quantitative, and experimental research, generated a well-documented, synthesized, and organized report on cleaning the effluent water from the treatment plant.

3.1.1 Study area

Presence of natural radioactive and radio metal pollution was conducted at the kality treatment plant located in the Addis Ababa Ethiopia in Kaliti sub-city (9° 09' 39" N and 38° 45' 03" E) 15km east of the city (Fig 1 and Fig 2). The Kality wastewater treatment plant was selected for the case study. It is currently the largest wastewater treatment plant in Ethiopia, with a design capacity of 100,000m3/day. The detailed

analysis focuses on radionuclide contamination in outlet water of the Kality wastewater treatment plant.

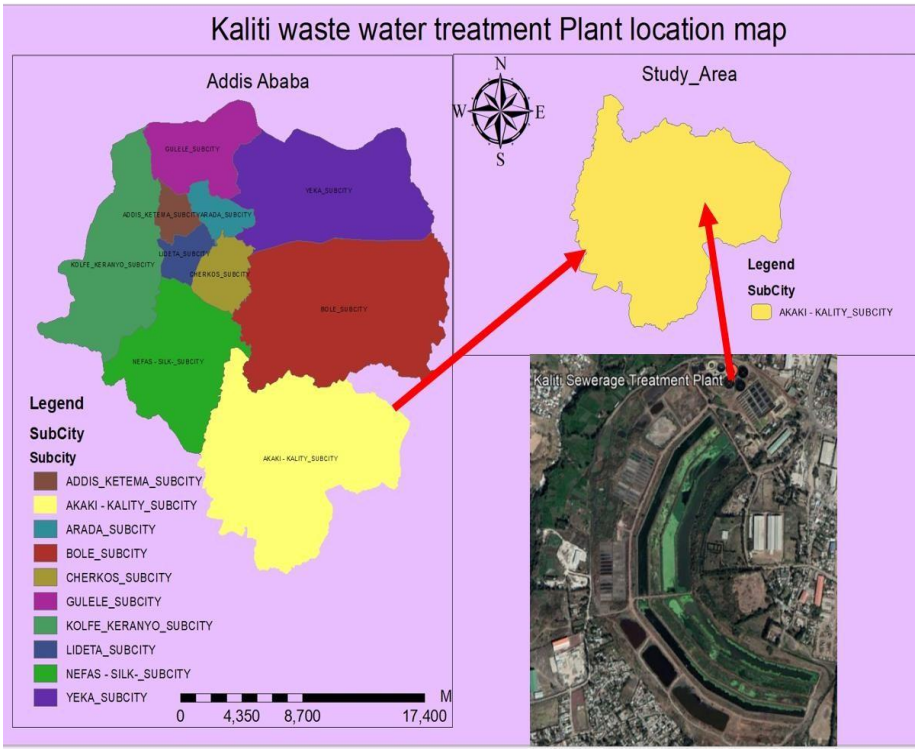


Figure 1. Kality Waste Water Treatment Plant Location Map

3.1.2 Sample collection and processing

Twelve treated water samples were taken from the outlet water of the Kality wastewater treatment plant and mixed to 4 samples, because composite sample must be used, and four sample is enough to determine the radioactive pollution from the outlet zone. The outlet zone is one and found in the kality waste water treatment plant. The reason why sample water is taken from the outlet water is because after the water is treated it will be used for irrigation purpose and to do further treatment on natural radioactive pollution.

3.1.3 water sample processing

The treated water samples from the outlet zone of the Kality wastewater treatment plant were collected in clean large bottles (which is about 24 litter) washed with tap water, and dried to avoid contamination**.** The samples were taken in three different consecutive days.

Three large bottles of water samples per day for the four days were collected from the outlet zone of the Kality wastewater treatment plant . Then all these 12 bottles of water samples were sent to Ethiopian radiation laboratory, Addis Ababa, Ethiopia, and allowed to stay for one month, to stabilize radium in the equilibrium state. A composite sample was used for further analysis. The sample was analyzed using a high purity germanium detector with 70 litter of liquid nitrogen produced from the air.

3.1.4 Activity concentration of radioactive element counting

The activity concentration of TH-232, K-40, U-238 and Cs-137 at 137^0 deree Celsius in water samples were determined using a high purity germanium detector using energy calibration of Cs, co, ce, sn, and sr. The background radiation and the sample were counted. Background rdation is a measure of the level of ionizing radation present in the enviroment at a particular location which is not due to deliberate introduction of rdation source . The activity concertation of cs, K, Th, and U were determined using gamma lines. The net count rate photo peak of all radionuclides was calculated by reducing the count rate from the background spectrum found for similar counting time.

3.1.5 Methods

Environmental sampling is a very useful tool to distinguish the source of contamination, manage sanitation process, and provide an early warning of problems that need to be solved. It is also essential to take the sample to save money. Data was collected from the water effluent to characterize pollutant levels.

The environmental samples and GPS points at each water sampling location were recorded, the point on the sampling form, record sample ID, noted on the sampling form, and placed all environmental sample together in one bag after completed. I used GM detector to detect alpha, beta, and gamma radiation in Ethiopian Radiation Authority

3.1.6 Instrumentation and Instrument Set Up

- ✓ HPGe- gamma ray spectrometry

- ✓ GR- 39 detector
- ✓ X ray diffraction (XRD)

A hyper pure germanium coaxial detector was mounted on 70 liter liquid nitrogen.

Spectroscopy amplified the total of the low noise system. Analog to digital converter (ADC) tries to give the final in resolution, stability, and linearity. Multichannel analyzer with 8192 channel, and with counting capacity of 28 count per channel. Data acquisition, display, and analysis of gamma ray spectra was performed using genie 2000 software.

Figure 2: computer connected with sodium iodide spectrometry

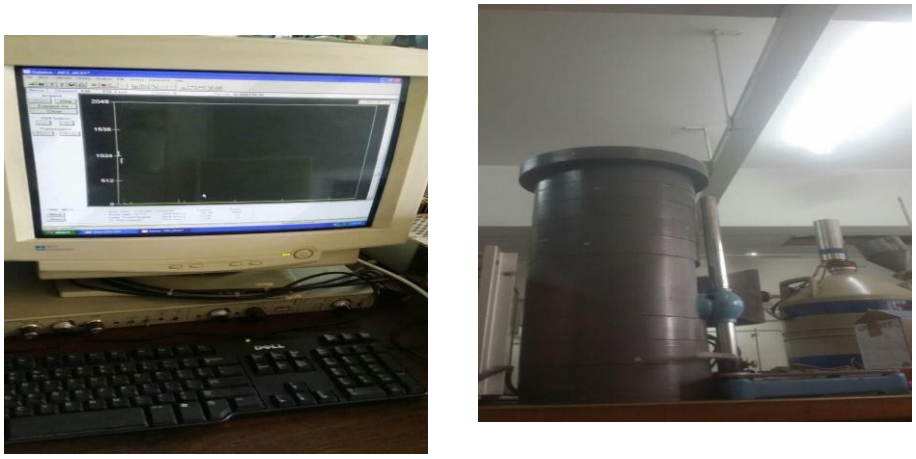


Figure 3 High purity germanium detector

CHAPTER 4

Result

Radionuclide sample1	Activity (Bq/kg)
K-40	1.0241E+002
U-238	2.5971E+000
TH-232	8.53845E+000
Radionuclide sample2	Activity (Bq/kg)
K-40	9.7944E+001
U-238	3.0704E+000
TH-232	9.134+000
Radionuclide Sample 3	Activity (Bq/kg)
K-40	9.5874E+001
U-238	2.5706E+000
TH-232	7.9461E+000
Radionuclide sample 4	Activity (Bq/kg)
K-40	4.3330E+000

EPA stated uranium should not be abouve 0.03mg/l because if there is high amount of uranium, it can affect kidney and the remaining uranium in water can be removed by reverse osmosis, but before that uranium should be converted to uranium oxide and tritum octooxide which is easy to remove as a radioactive waste. It is also stated that the maximum contaminant level

of thorium should not be above 15 picocurries per litter.because if thorium is injected it will store in bones and cause bone cancer. It can beremoved by ion exxhange and adsorption. this table show the maxium contaminate level of radionuclide in water so thorim 232 is not above 1 so the outet water is safe to use for irrigation,and the Mcl level of uranium238 is not above 0.03mg/l so the water is safe from uranium contamination.

Radionuclide	Guidance level
Thorium-232	1
Uranium 238	0.03

The natural radionuclide concentration in the outlet zone of kality waste water treatment plant are therefore has little radionuclide. So the water is safe to use for irrigation. So that crop will not be affected by radionuclide.

Table 1. Sample 1(Nuclide Identification Result)

Nuclide Name	Energy(Kev)	Yield (%)	Line MDA (Bq /L)	Nuclide MDA(Bq /L)	Activity (Bq /L)
K-40	1460.81	10.67	6.3229E+000	6.32E+000	1.0241E+002
CO-57	122.06 136.48	85.51 10.60	2.7112E-001 2.2193E+000	2.71E-001	-7.5631E- 002 1.2401E-001
CO-60	1173.22 1332.49	100.00 100.00	2.6646E-001 2.2829E-001	2.28E-001	-8.8148E- 002 -6.5862E-003

Y-88	898.02 1836.01	93.40 99.38	2.6478E-001 1.8450E-001	1.84E-001	1.1377E-002- 2.5915E-002
Ag-108M	621.001050.10	98.0014.60	3.1284E-001 2.1105E+000	3.13E-001	-5.3733E-002 8.4640E-001
133 Ba	81.00356.01	33.31 62.05	8.1079E-001 4.4454E-001	4.45E-001	-3.7722E+000 6.1607E-001
CS-134	569.32 604.70 795.84	15.43 97.60 85.40	1.6343E+000 2.9218E-001 2.9668E-001	2.92E-001	6.4565E-001 5.0986E-002 -2.2717E-001
CS-137	661.65	85.12	2.9237E-001	2.92E-001	1.5444E-002
BI-214	609.31 1120.29 1764.49	46.30 15.10 15.80	6.1887E-001 1.9052E+000 1.7239E+000	6.19E-001	2.0086E+000 3.6182E+000 6.1575E+000
PB-214	295.21 351.92	19.20 37.20	1.4348E+000 7.2299E-001	7.23E-001	7.0475E-001 4.9669E-001
AC-228	911.21 968.97	26.60 16.20	2.3773E+000 3.9571E+000	2.38E+000	7.0116E+000 1.0653E+001

Table 2. Sample 2 (Nuclide Identification Result)

Nuclide	Energy(keV)	Yield (%)	Line MDA(Bq /Kg)	Nuclide MDA(Bq /Kg)	Activity(Bq /Kg)
K-40	1460.81	10.67	6.1816E+000	6.18E+000	9.7944E+001
CO-57	122.06 136.48	85.51 10.60	2.7295E-001 2.2216E+000	2.73E-001	4.6406E-002 1.3464E+000
CO-60	1173.22 1332.49	100.00 100.00	2.6037E-001 2.3034E-001	2.30E-001	1.2468E-002 1.1133E-001
Y-88	898.02 1836.01	93.40 99.38	2.6501E-001 1.7734E-001	1.77E-001	3.5733E-002 1.1568E-001
Ag-108M	621.00 1050.10	99.38 98.00 14.60	3.1586E-001 2.1707E+000	3.16E-001	1.7905E-001 1.9942E-001
133 Ba	81.00 356.01	81.00 62.05	8.0613E-001 4.4498E-001	4.45E-001	5.2713E+000 6.7609E-001
CS-134	569.32 604.70 795.84	15.43 97.60 85.40	1.6338E+000 2.8836E-001 2.9143E-001	2.88E-001	7.0509E-001 1.3462E-001 3.9344E-001
CS-137	661.65	85.12	2.9479E-001	2.95E-001	1.8769E-001
BI-214	609.31	46.30	6.0854E-001	6.09E-001	1.3911E+000
	1120.29 1764.49	15.10 15.80	1.8902E+000 1.8044E+000		3.5544E+000 7.4414E+000

PB-214	295.21 351.92	19.20 37.20	1.4398E+000 7.2876E-001	7.29E-001	1.4599E+000 1.5055E+000
AC-228	911.21 968.97	26.60 16.20	2.3920E+000 3.8550E+000	2.39E+000	7.2110E+000 1.1057E+001

Table 3. Sample 3 Nuclide Identification Result)

Nuclide	Energy	Yield	Line MDA	Nuclide MDA	Activity
K-40	1460.81	10.67	6.1128E+000	6.11E+000	9.5874E+001
CO-57	122.06 136.48	85.51 10.60	2.7076E-001 2.2148E+000	2.71E-001	1.0407E-001 1.0964E+000
CO-60	1173.22 1332.49	100.00 100.00	2.6113E-001 2.2906E-001	2.29E-001	1.7901E-001 1.2136E-001
Y-88	898.02 1836.01	93.40 99.38	2.5840E-001 1.8248E-001	1.82E-001	3.7873E-002 1.0646E-001
Ag-108M	621.00 1050.10	98.00 14.60	3.1075E-001 2.0897E+000	3.11E-001	3.3625E-002 1.2451E+000
133Ba	81.00 356.01	33.31 62.05	8.0437E-001 4.4359E-001	4.44E-001	5.3487E+000 9.4887E-001
CS-134	569.32 604.70 795.84	15.43 97.60 85.40	1.6043E+000 2.8969E-001 2.9129E-001	2.90E-001	1.3170E+000 2.6218E-001 2.4165E-001
CS-137	661.65	85.12	2.9078E-001	2.91E-001	9.9094E-002
BI-214	609.31 1120.29	46.30 15.10	6.1377E-001 1.8832E+000	6.14E-001	1.5385E+000 3.6306E+000

	1764.49	15.80	1.7815E+000		5.8495E+000
PB-214	295.21 351.92	19.20 37.20	1.4063E+000 7.2864E-001	7.29E-001	3.9558E-001 1.4391E+000
AC-228	911.21 968.97	26.60 16.20	2.3656E+000 3.8858E+000	2.37E+000	7.0629E+000 8.8293E+000

Table 4. Sample 4 (Nuclide Identification Result)

Nuclide	Energy	Yield	Line MDA	Nuclide MDA	Activity
K-40	1460.81*	10.67	4.8146E+000	4.81E+000	4.3330E+000
CO-57	122.06 136.48	85.51 10.60	2.4518E-001 2.0030E+000	2.45E-001	1.1642E-001 1.4699E+000
CO-60	1173.22 1332.49	100.00 100.00	2.3780E-001 2.0704E-001	2.07E-001	1.1494E-001 4.7073E-002
Y-88	898.02 1836.01	93.40 99.38	2.3599E-001 1.6197E-001	1.62E-001	9.2335E-002 5.5259E-002
Ag-108M	621.00 1050.10	98.00 14.60	2.9775E-001 2.0717E+000	2.98E-001	3.8586E-001 5.7331E-001
133 Ba	81.00 356.01	33.31 62.05	7.2837E-001 3.9857E-001	3.99E-001	1.4502E+000 2.3378E-001
CS-134	569.32 604.70 795.84	15.43 97.60 85.40	1.4782E+000 2.7031E-001 2.6020E-001	2.60E-001	2.7536E-001 8.3226E-001 6.7583E-002
CS-137	661.65	85.12	2.5917E-001	2.59E-001	8.4075E-002
BI-214	609.31 1120.29 1764.49	46.30 15.10 15.80	5.6518E-001 1.7447E+000 1.6105E+000	5.65E-001	1.6337E+000 4.4681E+000 7.1660E+000
PB-214	295.21 351.92	19.20 37.20	1.2873E+000 6.5544E-001	6.55E-001	4.0021E-001 1.6522E+000
AC-228	911.21 968.97	26.60 16.20	2.5391E+000 4.0891E+000	2.54E+000	8.6558E+000 1.1284E+001

4.1.1 Gamma ray energy spectrum sample 1

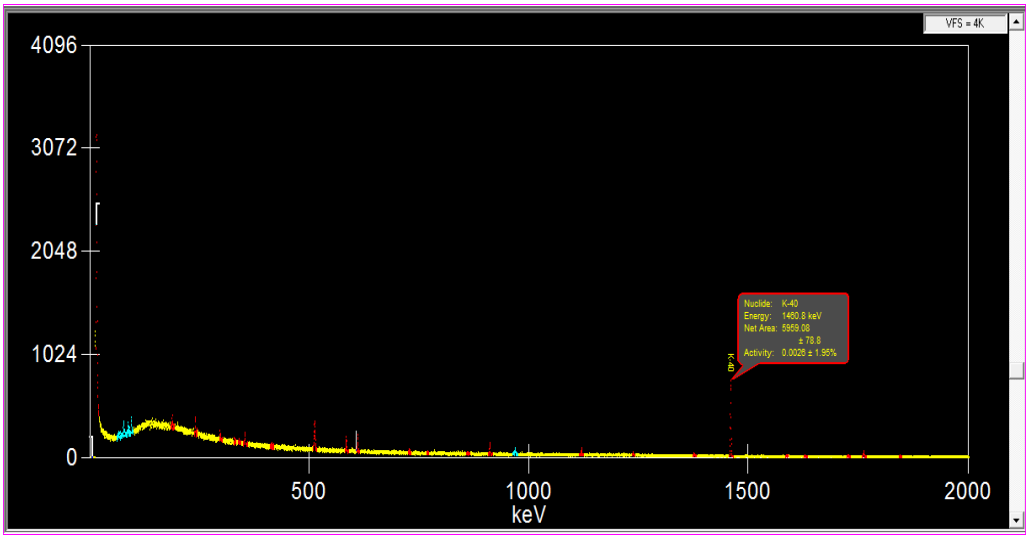


Figure 4: Gamma ray energy spectrum by color sample1

The whole graph in the sample is called gamma ray energy spectrum. It means energy distribution gamma rays in a given sample + background. Y axis is the gamma ray intensity in terms count per second, and X axis is either channel or energy, because using a standard source, we can calibrate channel. We also can convert a channel to energy.

Standard means the known gamma ray like cs -137, co-60, Mn 54, EU-europium 152. Each channel has one energy corresponding to energy .In one channel, there is one gamma rays. Multichannel means there is one gamma rays. One channel means one particular height pulse. It may be volt or multi volt. The whole graph is called energy spectrum of gamma rays. The sharp lines above the x axis is called the photo peak.

Gamma rays go inside the material which is high purity germanium detector, they interact mostly by photo electric effect, Compton Effect and pair production.

Photo peak means total energy absorption of gamma rays. Gamma rays interacting with the atom gaves total energy to atomic electron. Spend some of the energy in

making electron free (binding energy of electron).

Rest of the energy of gamma rays is taken by electron. Electron are multiplies flows off current forms electrical pulse which is called photo peak means energy equal to total energy of gamma rays. 6000 is maximum which is called the photo peak of potassium -40. To find the frequency from the above graph, we must use the formula for energy. Which is the product of planks constant and new coefficient.

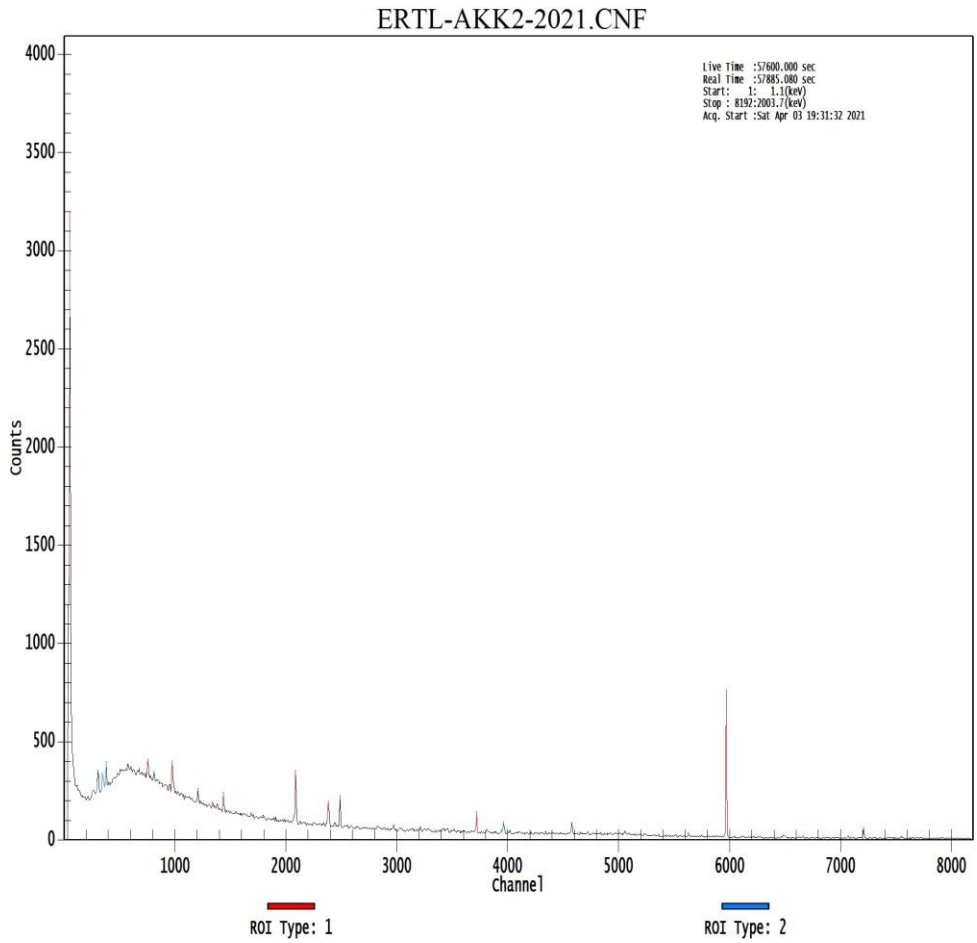
Channel number correspond to energy by amplifier. Amplifier amplifies pulse from high to low or from low to high.

Centroid channel is the center of photo peak. It can be converted to energy. Centroid uncertainly means error in a measurement. Centroid channel can + or – the centroid uncertainly. Centroid channel correspond to energy, and pulse can be at any place. ROI means the region of inters from where the peak starts from where the peak ends. Net peak area gives the intensity of gamma ray. Continuum means the cunts below the peak that can be back ground. It should not include in the intensity of gamma rays. Total spectrum –background spectrum = net intensity of the gamma rays. Total activity means total counts collected in the counting time. Activity means total activity divided by time. That is also peak area per unit time. .Activity concentration means per unit mass or per unit volume. In the nuclide identification the radionuclide element are the known standard, and annual dose means exposure in a year, or how much dose is absorbed in a body.

Table5:Sample1 Radionuclide Concentration Result

Radionuclide	Activity (Bq/kg)
K-40	1.0241E+002
CS-137	1.5444E-002
U-238	2.5971E+000
TH-232	8.53845E+000

4.1.2 Gamma ray energy spectrum sample2



Sample2

Figure 5: Gamma ray energy spectrum sample2

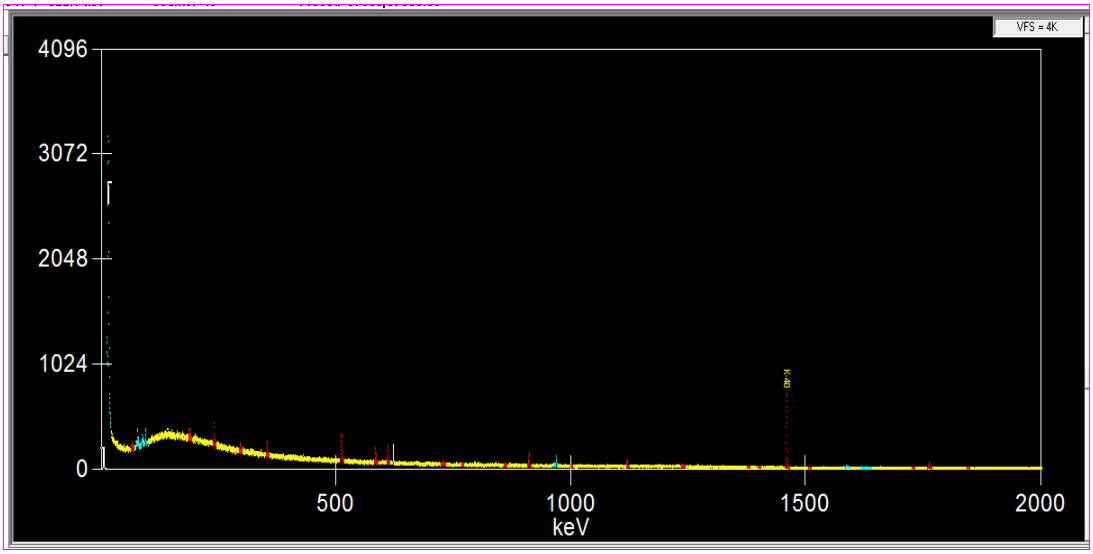


Figure 6: Gamma ray energy spectrum by color sample2

If we have photon interaction with nuclie and if we could limit it entirely to photoelectric interactions, then we would have the same energy coming from air scientillator at all time.

The photon from the material sample will be absorbed , so you will not get full energy back out, photoelectricevent will not always there. Sometimes Compton event will be there and introduce noise in to signal.

In full energy phtot peak we can have a simple photoelectric interaction and capture all of the kinetic energy from the photoelectron

Another way is that we would have a Compton scatter and the photon coming from the Compton scatter is captured by photoelectric event in the detector. All this happens so quickly that the enegy shous up in the photopeak.

For single Compton events, we see that Compton background in the continuum . we did not derive the equation , but there is a maimum energy that can be given to the Compton electron, and that is represented by Compton edge . it is theorically epect

zero counts in the Compton valley(multiple Compton scatter, because Compton cant get that much energy in to the detector . photoelectric cant and pair production cant get it there either . what produce this much energy in the detector is a gamma that undergoes at lest two Compton scatter and the last scatterd photon escape from the detector and the backscatter peak , there is an energy from higher enegy gamma rays from background and low enegy rise (electronic Noise). We are amplifying things enough that the noise in the electronics shows up at the low end of the spectrum.

Table 6 Sample 2 Radionuclide concentration result

1Radionuclide	Activity (Bq/kg)
K-40	9.7944E+001
CS-137	1.8769E-001
U-238	3.0704E+000
TH-232	9.134+000

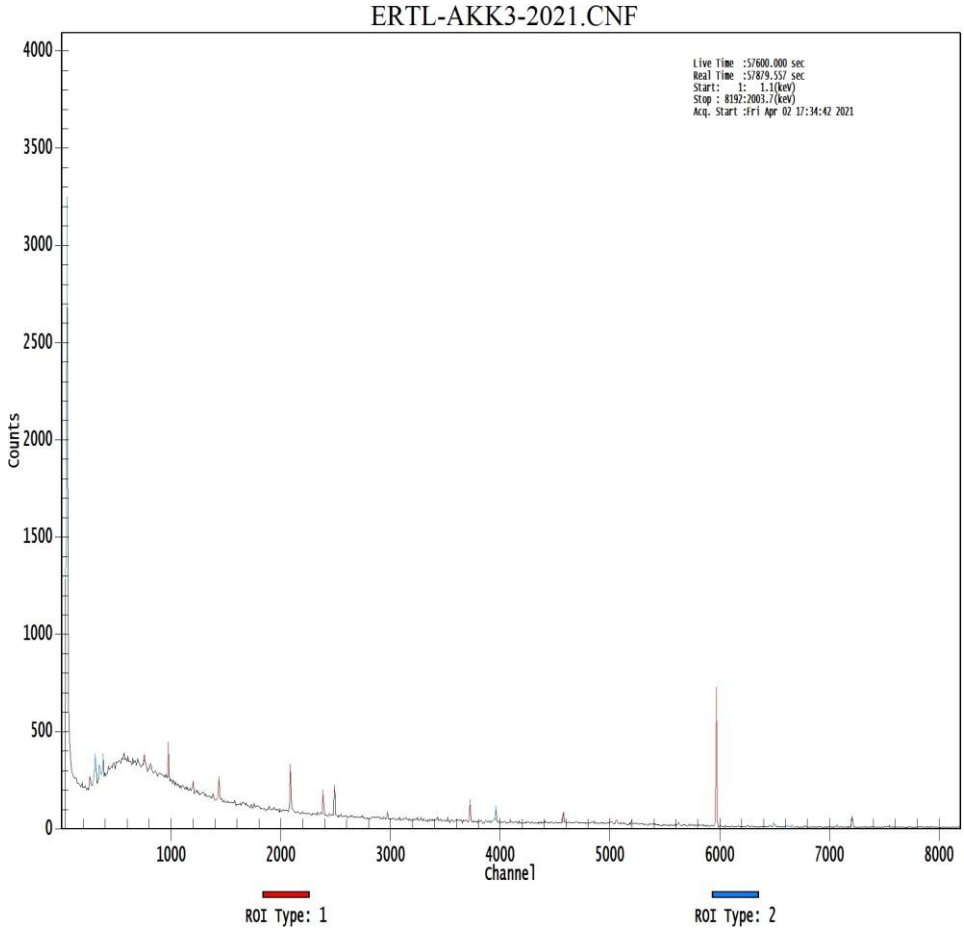


Figure 7: Gamma ray energy spectrum sample3

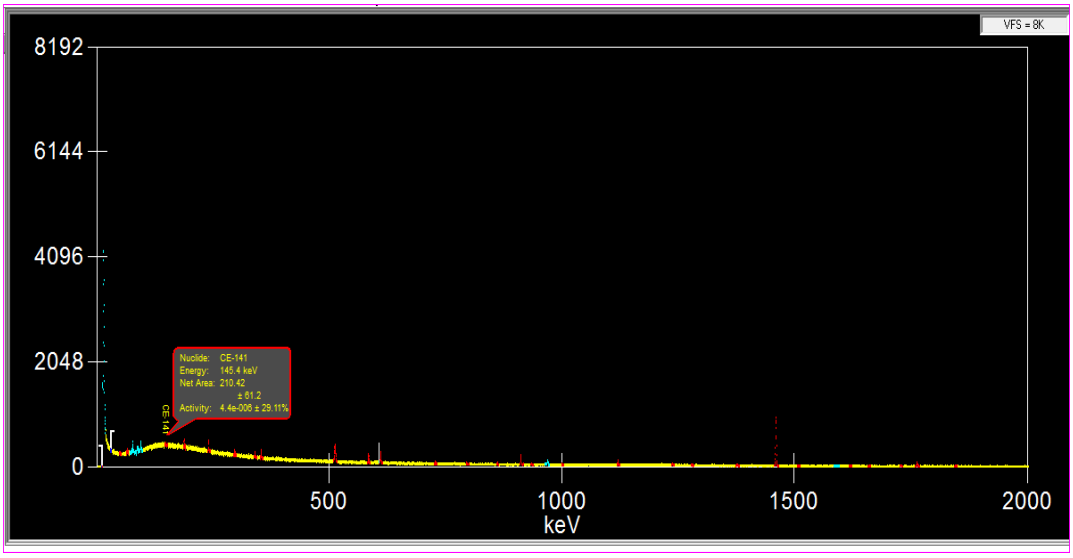


Figure 8: Gamma ray energy spectrum by color sample3

Table 7.sample3 result

Radionuclide	Activity (Bq/kg)
K-40	9.5874E+001
CS-137	-9.9094E-002
U-238	2.5706E+000
TH-232	7.9461E+000

4.1.3 Gamma ray energy spectrum by color sample4

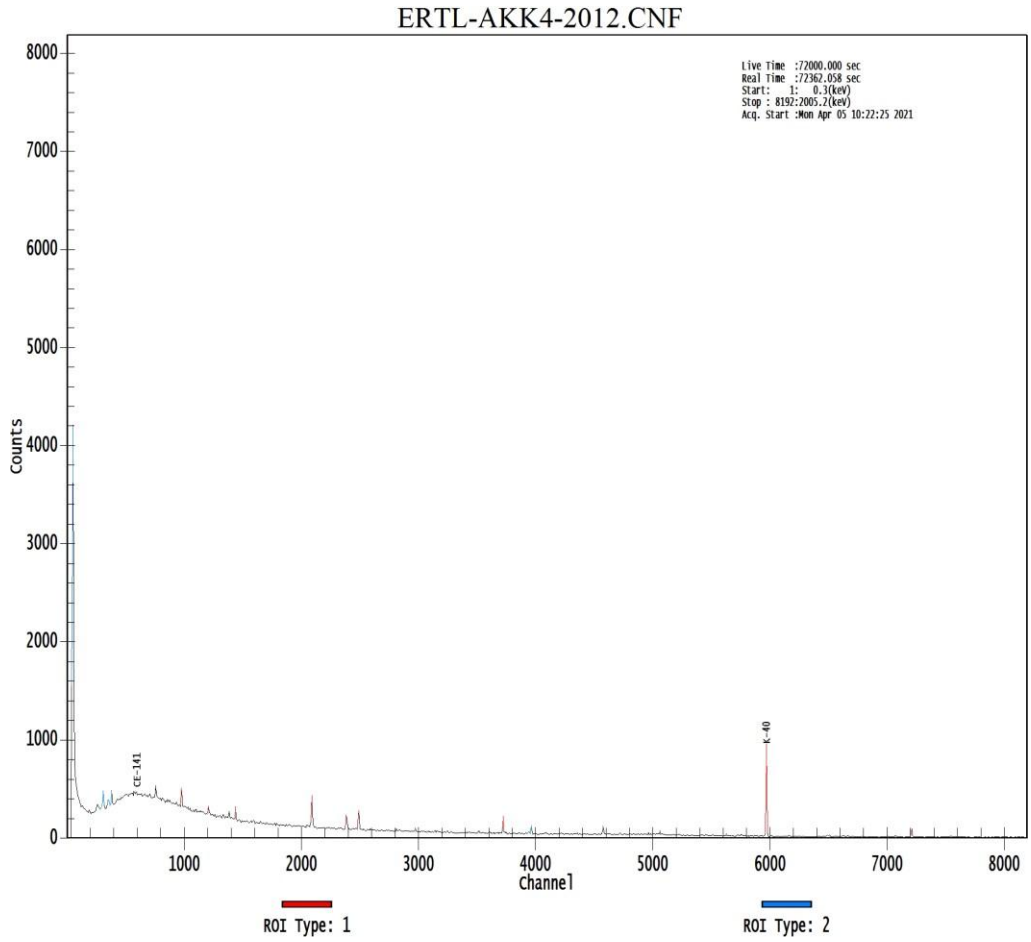


Figure 9: Gamma ray energy spectrum sample4

If we have a small detector, the photo electric raction will produce electrons and almost always . we will collect all of the electron energies because the range of electrons in solid is on the order of a few millmeters.

For Compton interaction , all of the Compton scatterd photon escape, so we gather noise information from the Compton interaction.

For pair production , again ,since we are assuming a small detector , we assure that 511 gamma escape and so that we end up with double escape peak for those photons interacting , the detector that have more than 1. 022mev. The double escape peak is set down

from the gamma enegy by 1. 022 mev . if we have large detectors photoelelectric events are captured .

After all initial Compton interaction , the scatterd photon undergoes multiple Compton scatter until the lasr scatterd photon is low enough enegy . they are finally soaked up by photoelectric interaction.

All of this happens so fast that this signals appears as a full enegy peak.

A gamma has pair production event ,and the 511 mev photon are both captured with in the detector ,and so every thing shows up as full enegy peak.

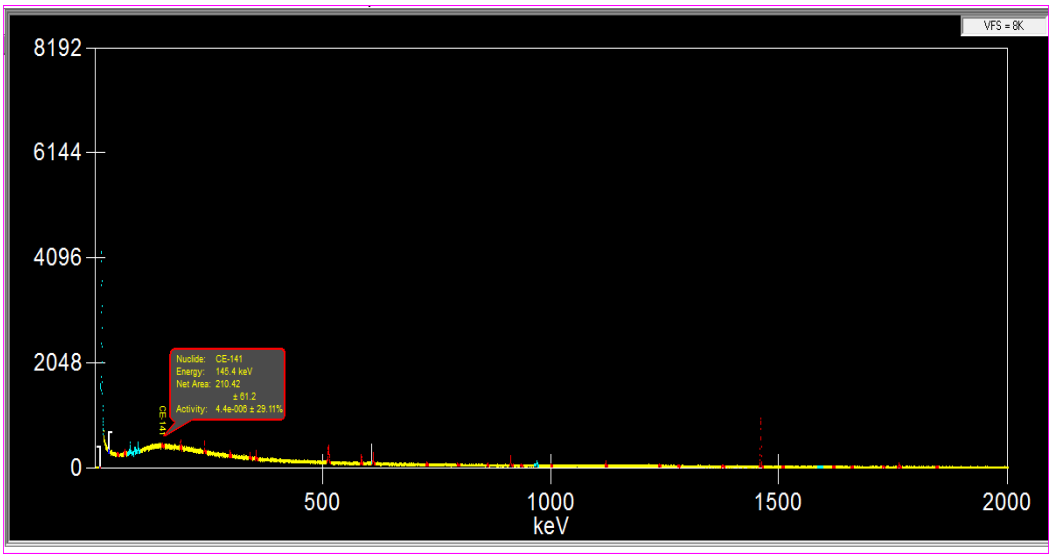


Figure 10: Gamma ray energy spectrum by color sample 4

Table 8. Sample 4 radionuclide concentration result

Radionuclide	Activity (Bq/kg)
K-40	4.3330E+000

Another name for the photo peak efficiency is the full energy peak efficient. It is expressed as the number of counts in the photo peak divided to the number of gamma rays. The photo peak energy is released by the source. NP represent the number of gamma ray, and No represent the photo peak energy that is emitted. Full energy peak is generated from the total or over all absorption. It also include pair production, Compton scatter, and photo electric absorption. There are two types of peak, the single and the multiple photo peak. The single peak in the energy spectrum is caused when the total electron energy correspond to the incident gamma ray. Another types of peak is back scatter. The peak due to pair production in a gamma ray spectrum is called double escape peak. They escape from the Sen Stative part of the detector of two photon. Peak efficiency can be calculated by using radioactive cylindrical source using ET which is referred to as the efficiency transfer principle. The calculation relay on in a full energy peak efficiency of the cylindrical detection with respect to radioactive point source. Coming up, there are also three types of efficiency. These are detection efficiency, absolute efficiencies, and geometric efficiency. The percentage of radiation that the detector detect from overall yield emitted from the source are called detection efficiency.

When the number of counts recovered by the detector to know the ratio of the number of count to the number of gamma rays by the source are called absolute efficiency.

Absolute efficiency relays on detector properties. The relative sample detector position and sample properties, when comes to geometric efficiency is referred to the particles or photon incident on the detector in a given interval divided by the number released by the radiation source.

Particles or photon are called the number of radiation quanta. The detection also have energy resolution is the ability of the detector to detect the energy of the incoming radtion.

During annihilation peak, electron pair production is possible interaction for high energy of gamma rays.

If one annihilation photon is absorb, the second annihilation of photon appear on the crystal.

High energy of gamma ray, during annihilation of peaks, should be greater than 1.02 mev. After the second annihilation of photon is absorbed, then 0.51 mev should be canceled from the photon peak. These cause the secondary peak to be lower under the photo peak.

Compton Effect increase in the gamma radtion that have elastically scattered by electrons. Here radian energy also absorbed in water. When high energy is deposited to full back scatter, it is called Compton edge. When photon is least equivalent to mass of two electron, then it will result pair production. PCR measure peak to Compton ration. It appears when the height of photo peak is divided to the Compton continuum. It is also the ratio of height of the photo peak to average height of the Compton peak. When the number of counts vs the amplitude of the counts is indicted by a display,

It is called pulse height spectrum. This is done by multichannel analyzer. The effect on matter need to be looked to detect the gamma rays. A gamma ray interact or collide with the electron and bounce like Compton scatter. It is also have photo electric ionization which measure when electron are bounce to a high energy level. To find energy calibration we have to know the relationship between the energy of the released particle and the channel number of the peak. It is simple to get the energy of unknown source, if the energy calibration is known. RE measure detector resolution. .

It is calculation from using an equation of Re= FWHM/E (5%). FWHH is refer to the full width at half of the maximum height

Another types of detection is planner detection.

They have low capacitance. They are the best energy resolution.

They are very good for detailed spectroscopy, for the analysis of complex low energy of gamma ray. Another types of efficiency is intrinsic efficiency, which is calculated by dividing the number of photon detected to the number of photon incident on the detector surface.

Full energy peak efficiency can be defined as both intrinsic and absolute efficiency. When comes to peak centroid, the weight are given by the relative intensity. The sampling times is defined as the weighted mean of the sampling across a mass peak.

The centroid energy shows where the center of mass of the spectrum is located, and used to characterize a spectrum in digital signal processing. Centroid is the peak in a profile data is converted to bars. Full energy peak efficiency and photo peak efficiency are both detector 1efficiency.

The result of full energy peak efficiency is the distance from the scintillator detector to the radtion source. Peak consist of number of counts in a channel. Peak area is the integration of the number of channel content, over all channel with the peak. The centroid formula mathematically defined as G(x, y) = ((x1 + x2 + x3)/3, (y1 + y2 + y3)/3).The centroid of an area is the geometric center of that area.

CHAPTER 5

5 Discussion

The aim of the study is important to maintain clean water used for irrigation and for discharging clear water to the rivers ensure the water that approaches to natural state of purity after the secondary treatment is required. The key point under investigation are to know the activity concentration. The activity concentration of radionuclide element in water k-40, U-238, TH-232.

Natural radioactivity is defined as the release of high energy radiation substance in to water, air, land which is caused by internal, terrestrial, and cosmic radiation. Medical waste is one types of artificial radioactive pollutant.

Human being can be affected by natural radioactivity that is found in water especially by uranium, thorium, and potassium 40 radionuclide. It can be caused by both human activity and geologically. Natural radioactivity can be found everywhere, where in the river, oceans, water, building material, and homes. The natural radioactivity comes from parent series of U-238, Th-232 and also K-40. There are two types of radiation. These are ionizing and non-ionizing radiation. When some amount of energy transfer to the atom, ionizing radiation exist. When the amount of energy is the same to reducing of kinetic energy, it creates ionization.

Notice that small concertation of radioactive substance ingested to human body can cause biological effect.

Where in the outlet zone, there are a lot of unseen and unpredictable pollutant which

can't be reduced or treated by the trickling filter. These are radioactivity and heavy metal pollutant. The temperature, the pressure, and the catalytic action of the treated water will not alter the level of radioactivity, because radioactivity will change, when the nuclear

reaction occur in the metal. The amount of nuclear reaction is rely on the amount of metal, the flux of neutron, and the chance of reaction. The main objective of this *Project* is to detect radioactivity Using high purify germanium detector with the help of gamma accusation software, and to know the activity concentration of radionuclide element in water like k-40, cs-137, U-238, TH-232.

5.1 Lake Zeway

Rukalia ( ) has detected radioactivity for the activity concentration of U-238, TH-232, and K-40 in soil, water, and vegetable using sodium gamma spectrometry and high purity germanium detector respectively. 12 soil samples, four coffee samples, and four Zuwaye lake from terrestrial origin from the the place called Zuway , Shasmne, and West Arsi Zone .

The mean value for the activity concentration of ^{238}U, ^{232}Th, and^{40}K in the soil samples was 45.83, 100.525, 845.65Bq/Kg respectively. Activity concentration of ^{238}U in Lake Zuwaye Water was vary from 2.94±0.25 Bq/L to 3.02±0.27 Bq/L with an average value of 2.99±0.267 Bq/L, ^{232}Th was vary from 6.9±0.73 Bq/L to 8.39±0.82 Bq/L also with an average value of 7.5 ±0.76 Bq/L and the activity concentration of ^{40}K varies from 98.12 ± 4.16154 to 101.99 ± 4.91556 with an average value 99.77±4.80Bq/L.

During her experimental activities, she detect and identify only potassium-40 in the coffee samples.

Lake Zeway Last year

The soil from the sampling area was detected to be very harmful and hazard to the society, because its radioactive level index was above 1. It is found that radioactive level was vary from 1.19 to 2.395 Bq/kg with average value was found to be 1.917Bq/kg (rukiya 2020), and the average values of radioactive level index for soil should be less than 1 or equal to 1

For the coffee, radioactivity level index varied between 0.36 to 0.475 Bq/Kg with average value was 0.4 Bq/Kg. The coffee did not affect the society, because the average value of radioactivity level index was lower than one the recommended safe limit ≤ 1 The radionuclide concentration of Lake Zuwaye water didn't affect the community (rukiya2020), because the annual effective dose calculated was varied from 0.081 to 0.09 mSv/y with an average of 0.086 mSv/y. This value, when compared with the ICPR standard value of 1mSvyr-1 was very low.

5.1. Methods

I took environmental sample and record GPS point at each water sampling location. Recording the point on the sampling form, recording sample ID, and notes on the sampling form, placed all environmental sample together in one bag after completed. I used GM detector to detect alpha, beta, and gamma radiation in Ethiopian Radiation Authority. Dead time is the time after each event when the system is not able to record another event. The events are particle and nuclear detection.

5.1.1 Water Sample counting

The activity concentration of thallium, potassium, uranium, and cesium at 137 degree Celsius in water sample were determined using high purity germanium detector using energy calibration of cs, co, ce, sn and sr. Then the background radiation and the sample were counted. The activity concertation of cs, K, Th, and u were determined using gamma lines. The net count rate photo peak of all radionuclide was calculated by reducing the count rate from the background spectrum found for similar counting time.

5.1.2 Equipment

Gamma spectrometry is a system that is connected with different types of detector (BEGe, HPGe etc., which is used to measure radioactivity and the distribution of the intensity of gamma radiation vs the energy of each photon.

Detector is used to measure the energy of incident gamma rays. It is measured by comparing the measure energy to the known energy of gamma rays generated by radioactive isotopes.

5.1.3 Explanation

Complete photoelectric absorption of gamma rays causes the region of the pulse height spectrum which is the photo peak. It is caused by the scintillator crystal of a gamma camera. The peak also has its wave length. It is the single wave length were the radiometric emission spectrum become at highest point. Other name of photo peak efficiency is the full energy peak efficiency. Here we can obtain the photo peak efficiency by dividing the number of counts in photo peak to the number of gamma rays, where NP is the number of counts in the photo peak the number of gamma energy. The photo peak energy released by

its source. The relationship between peak wave length and temperature is the wave length of peak emission relay on the temperature of an object emitting radiation. When there is shorter wave length, there will be higher temperature. Both annihilation peak and photo peak are found on the spectrum. The annihilation photon escape the detector, because the gamma rays interact in detector via pair production. We found the energy deposited by subtracting the original gamma ray energy from annihilate of photon by these case a single escape appears on the spectrum. When the radiation power density multiplied by the square distance we can find the intensity of radiation. Activity counts the number of Curie (Ci) 1 Ci =

3.7 x 1010 B 1 Bq = 1 disintegration/sec. Exposure expressed as Roentgen (R) which is the amount of ionizing radiation that generate 2.58 Coulombs rate as R/hr per cm3 When the total amounts of energy taken from rad it is called the absorbed dose 100 rad = 1.0 Gy 1 Gy = 1.0 J/kg

When the nucleus is unstable, it means the activity of radioactive element is decayed per second**.** The unit of activity is the Becquerel (Bq). A source that release one particle per second has an activity of one Bq. Activity is measured by counts per minute. 1 Bq = 1 decay/s.. Activity (R) or decay rate is the number of nuclei decayed per second R = |dNdt|, and unit for the activity called Curie(Ci).

Activity = λN. Half-life is the time it takes for half of the unstable nuclei to decay .Count- rate is the number of decays recorded each second by a detector, such as the Geiger-Muller tube.

Sample 3 result

Nuclide	Energy	Peak no	Peak Significance	Centroid channel	Centroid uncertainty	Half life
Ti -44	78.01	6	5.67	315.51	0.2372	48 hrs.
Th -234	93.43	9	8.18	378.58	0.1894	24 day
Ra -226	186.50	10	5.48	758.31	0.2166	1602 years
Pb-212	239.28	11	13.84	975.13	0.1402	10.64 hrs.
As -77	295.80	12	6.41	1206.30	0.2076	38.7 hrs.
Pb-214	352.37	13	11.60	1437.70	0.1433	26.8 minute

5.1.4 Lead

It has three stable nuclides with three natural decay series which is lead 206, lead 207, and lead 208. Uranium decays to lead 206. Actinium decays to lead to 207, and Thorium decays to lead 208. Lead is not radioactive, and it is not spontaneously decay into lighter elements. Lead ($_{82}$Pb) has four stable isotopes: ^{204}Pb, ^{206}Pb, ^{207}Pb, ^{208}Pb radioisotope, and of this 210Pb is used to study the sedimentation chronology of environmental. It is also an unstable (radioactive) isotope.

It is produced as a result of the decay of ^{222}Rn, which comes from the decay of ^{214}Po (99.98%), and ^{214}Bi by $^{219,}Tl$ (0.02%). The half-life of lead-210? Is 22.26 years and very useful for sedimentation in water bodies,

5.1.5 Barium

It release a gamma rays, very toxic to human, and is used in the oil and gas industry. It is also used in medicine as an x ray radiocontrast agent. Even one gram of barium in water kills.

We can find gamma ray from the nucleus, but barium 133 and co-57 decay can be obtained when an electron is absorbed in to the nucleus. When comes to Barium 137, it rise the number of proton in the nucleus to rebalance the energy when the gamma rays is emitted. Barium carbonate is insoluble in water, but it will be soluble in gastro intestinal tract.

Barium is found in the out let water, because (barium sulfate and barium carbonate) do not combine well with water. They do not dissolve in the water. Barium nitrate, barium hydroxide, Barium chloride are produced from barium sulfate. Barium hydroxide, barium acetate, barium chloride, barium nitrate, and barium sulfide very soluble in water than barium sulfate and barium carbonate.

Barium sulfate ore are often used in many industries. Oil and gas industries in Addis Ababa often used barium to make drilling muds. Barium sulfate is very useful to make bricks, glass, tiles, paints, and rubber. It is used to take x-ray photographs of the intestines, stomach, and also useful for medical test. Barium compounds are insoluble in water, such as barium sulfate, and barium carbonate. Barium compounds such as barium nitrate, barium hydroxide, barium chloride, that are soluble in water. It is also affect human body.

It causes breathing difficulties, stomach problem, and affect the nervous system. Barium 133 is found in the outlet water because barium carbonate and barium sulfate do not combine with in the water. They are insoluble. Any water may contain barium that have 2 ppm limit set by EPA. Barium enters in human body through water, air, and food. Barium chloride is very soluble can dissolve with the bloodstream very easily than insoluble barium sulfate. Barium compound and barium sulphate are insoluble in water. Barium is a radioactive element which does not affect human being and animals, but barium chloride, barium sulfide, barium acetate are soluble in water and affect human being.

5.1.6 Cobalt

The EPA recommended that the drinking water must not contain more than 2.mg/l in water. The purpose of co is used for the schilling and a medical test. Beside it is used as radiolabel for b12. , but co-60 is used in radiotherapy. Co-60 produced two gamma rays energy 1.33 Mev and 1.7 Mev. It is very harmful, because it is cancer causing radionuclide element. It releases gamma of 1.17 and 1.33 to be precise

Co-60 is very useful to generate high energy of gamma rays. It is very dangerous to human being, because it cause external and internal hazard including cancer. When comes to radium, It is generated by the decays of thorium and uranium mining results It high level of radium in water near it. Plant also taken up some amounts of radium from the soil. If human and animal eat radium, it will accumulate in the bone and cause bone cancer. 90% of radium can be removed from water by reverse osmosis, lime softener, and ion exchange especially 90% of radium in water hardness can be destroyed by ion exchange. Ion exchange is also called water softener

Radon gas is the daughter of radium that cause cancer, internal, and external hazard to human being, because both radon and radium release gamma and alpha rays during their decay that kills the cell in human.

If human are highly exposed to radium, it leads human to have breast, bone, and liver cancer.

There are two types of radium, these are radium 228 and radium 226 s, but no more than 5 picocuries / liter of both radium are allowed to be in water. Picocuries measure the decay of radioactive element.

When comes to cesium -137 high amount of cs-137 lead human being to be sick and death. It rise the level of cancer in human, because it release a huge energy of gamma radiation.

Most often cesium is used in Geiger Muller counter for calibration of radiation detection. It is also used as an application in medical radiation therapy to treat cancer. 30 year is the half-life for cs 137, and cs137 release both beta particles during its decay to barium137. Barium 137 has a half-life of 2.6 minute.

5.1.7 Cs-137

It release high energy of beta particle and medium energy of gamma rays, and affect human being. It also decays to gamma rays emission, and generate fission emission. Ba decays to the ground state .Colorless cesium hydroxide and hydrogen gas are produced when cesium react in water, but of radioactive isotopes strontium-90 is the most dangerous one.

Thallium is one of the radionuclide element that affect the lung, heart, liver, and nervous system in the body. Thallium hydroxide is formed when thallium dissolve in water as it is highly soluble in water. It cause cancer if there is large amount of it in water. Most often thallium is found in the ores of zinc, copper, and lead. It is also have a nature to stay in the water for a long time. It is also taken up by plants. It affects human being by causing effect on the gastrointestinal, liver, cardiovascular, and respiratory system.

Maximum level of thallium in water set by EPA is 2 microgram per liter. High level of thallium is caused by both natural and anthropogenic. Naturally, it is caused by deposition and atmospheric emission from the industrial source.

When comes to uranium, EPA has set the maximum contaminate level in drinking water should be 0.03 mg/like thallium, uranium is very dangerous to human being. It damage kidney

EPA recommend MCL for uranium in drinking water is 30 micro gram per litter.

The best technique to remove uranium from water is by reverse osmosis, coagulation, lime softening, and filtration. 70- 200 days are the half-life of uranium in bones.

Uranium is radioactive, thorium-234, and proactium-234 are its decay product, and they release beta particles.

Thallium pollution, most often in the city of Addis Ababa are caused by cement factories, burning coal, power plant and metal. The main reason for high concentration of thallium in a water is the leaching of thallium ore processing operation. Thallium are insoluble in water. Beta energy is released by radioactive decay of atomic nuclide in the process of beta decay. There are two types of beta decay, these are beta minus decay, and beta plus decay. Beta minus generate electron and beta plus generate positron. If there is radionuclide element that is emitted by beta decay in water, they are injected to the plant, then to the body and both beta and alpha particles are released from radioactive material are very harmful to human being.

Both of them can be absorbed in to the blood stream. The properties of alpha, beta and gamma particle are Beta particle are a negative charge and gamma particle are neutral

and alpha particles have a positive charge. Gamma rays are also called photon or wave of electromagnetic wave.

Beta particle have high energy of electron, beside alpha particle is composed of two neutron and two proton. When a neutron changes in to high energy electron and proton, beta particle will be formed .When a nucleus in the center of atom release a beta particle, the atomic number increase by 1. When the nucleus in the atom are with many proton and neutron, one of the proton and the neutron is transformed in to the atom electron. [Diab H (2014) N By the emission of an electron, beta decay of a neutron change in to the proton then a proton is changed in to a neutron by the emission of positron with a neutrino these is called positron emission. There are three types of beta decay, there are electron capture, positron emission, and electron emission. Positron emission is also called positive electron emission. Beta minus indicate the ration of neutrons to protons in the nucleus became high. The gamma energy from sample 1,2,3,4

Pb-210, Th-234, Ba-133, *Th-228, Th-234,* Ac-228, *Co-57,* Co-57, *U-235, Pb-212,* Y-88, Tl-208, Eu-152, *Zn-65.*

The gamma energy from sample 1,2,3,4

Pb-210, Th-234, Ba-133, *Th-228, Th-234,* Ac-228, *Co-57,* Co-57, *U-235, Pb-212,* Y-88, Tl-208, Eu-152, *Zn-65.*

MCL and RDL Gamma-Ray /Beta-Ray Emitting Radionuclides in drinking Water
MCL stands for Maximum Contaminant Level

RDL stands for Required Detection Levels

Radionuclide	Drinking Water MCL [1] pCi/L (mg/L)	Drinking Water RDL [6] pCi/L (mg/L)
Cs-137	200 (2.3×10–9)	20 (2.3×10–10)
Co-60	100 (8.8×10–11)	10 (8.8×10–12)
Tc-99	900 (5.3×10–5)	90 (5.3×10–6)
Pd-103	900 (1.2×10–11) [5]	90 (1.2×10–12)
Ra-228 [3]	5 (1.8×10–11)	1.0 (3.7×10–12) [7]
Ac-227+DP [4]	15	1.5

MCL and RDL for Alpha-Emitting Radionuclides in Water

MCL stands for Maximum Contaminant Level RDL stands for Required Detection Levels

Radionuclide	Drinking Water MCL [1] pCi/L (mg/L)	Drinking Water RDL [6] pCi/L (mg/L)
U-238	20 (3.0×10–2	2.0 (3.0×10–3)
Th-228	15 (1.8×10–11	1.5 (1.8×10–12)
Ra-226	5 (5.1×10–10)	1.0 (1.3×10–10)
Th-230	15 (7.3×10–7)	1.5 (7.3×10–8)
U-Nat	20 (3.0×10–2)	2.0 (3.0×10–3
Th-232	15 (1.4×10–1)	1.5 (1.4×10–2)

5.2 Radio analytical Parameters

Uncertainty for Gross Alpha Screening Analysis Radionuclide

(ADL) and Required Method	Half-Life	Additional Emissions	ADL	Required Method Uncertainty [4, 5] (u_{MR}	ADL	Required Method Uncertainty [4, 5] (u_{MR}
U-238	4.468×10^{9} y	(DP	3.5×10^{3}	2.1×10^{3}	700	430
Th-232	1.41×10^{10} y	(DP	800	490	160	97

Radiological Laboratory Sample Analysis Guide for Incidents of National Significance Radionuclides in Water Analytical Decision Levels (ADL) For Gross Beta or Gamma Screening Analysis Radionuclid	**Emission Type**	**Half-Life [1**	**ADL**	**Required Method Uncertainty [3, 6] (u_{MR}500 mrem**	**ADL**	**Method Uncertainty [3, 6] (u_{MR}) 100 mrem**
Cs-137	$(	30.07 y	$2.9\times10_4$	$1.8\times10_4$	$6.0\times10_3$	$3.6\times10_3$

Required Method Uncertainties for Alpha-Emitting Radionuclides at 100-mrem AAL When Using Radionuclide-Specific Methods Radionuclid	**100-mrem ADL [1] pCi/L**	**Required Method Uncertainty at or Below 100-mrem AAL [2, 3, 4] u_{MR} pCi/L**
U-238	990	180
Th-232	230	40

– Required Method Uncertainties for Beta- or Gamma-Emitting Radionuclides at 100-mrem AAL When Using Radionuclide-Specific Methods	100-mrem ADL	Required Method Uncertainty at or Below 100-mrem AAL
Cs-137	$8.5\times10_{3}$	$1.5\times10_{3}$
Cs-134	$6.1\times10_{3}$	$1.1\times10_{3}$
Co-60	$4.7\times10_{3}$	830
Ac-227+DP	160	28
Ra-228	23	4.0
Pd-103	$1.1\times10_{5}$	$2.0\times10_{4}$
Sr-90	$1.7\times10_{3}$	300

CHAPTER 6

6 Conclusion

The natural radionuclide content of U-238, 232Th, and 40K in the environment was measured by using gamma-ray spectroscopy. The mean activity concentrations, mean radium equivalent activity, and different radiological parameters was estimated. The results will be used to assess the heath effect of the society in the environment. We are exposed to this natural and artificial occurring radioactive material (NORM), and artificial radioactive element through water are within our environment. Monitoring radioactive material are therefore importance for human and environmental protection, because the radiation from radio nuclide can cause damage and living tissuesThe water in the outlet zone was detected by high purity germanium detector using 70 l of liquid nitrogen produced from air in order to do further treatment along with the radionuclide contamination around kality waste water treatment plant. The main goal of the research is to know the activity concertation of radionuclide pollutant in water used for irrigation purpose. The activity concentration for radionuclide element in the sample 1 k-40 was1.0241E+002Bq/kg, for cs-137 1.544E+000Bq/kg for U – 238 is 2.5971E +000Bq/kg, for Th -232 is 8.53835E +000Bq/kg and the activity concentration in the sample 2 were k-40 9.7944E+001Bq/l ,cs-137 ,1.8769e+000Bq/l and Th-232 9.134+000Bq/l ,U-238 3.0704E+000 and in the sample 3 k-40 9.5874E+001Bq/kg , cs- 137 -9.9094E-002Bq/l,U-238 2.5706E+000Bq/l ,TH-232 7.9461E+000 and in the sample 4 the activity concentration for k-40 was 4.330E +000Bq/kg.

This show the activity concentration of U, TH,K are within the limit value so the outlet water is safe from this pollutant , but other radionuclide pollutant in the water affect the environment and human being even with low concentration it will cause cancer and other effects.

CHAPTER 7

Recommendation

If activity concentrations of radionuclides do not above the levels of standard parameter, then the water in the outlet zone is protected from the negative effects of ionizing radiation. The concentrations of radionuclides in the water sample can be compared directly with the standard on radioactive contamination parameters. Radioactive pollution affect the water, because the water faced to ionizing radiation form hydroxyl, free radicals of hydrogen, and peroxide radicals.

Water that has radionuclide can be disinfect by carbon filtration, water softening, ion exchange, and reverse osmosis, but if there is high amount of radiation in the water, It cannot be treated. The radiation in the out let zone in kality waste water treatment is small. So, the water can be used for irrigation. The microorganism in the water can be disinfect by chlorination.Moringa seed is also the best and cheap method to remove 99% of radioactivity in water. The EPA set legal limit called MCL which is referred to as maximum contaminant level for water pollution including radionuclide.

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GLOSSARY

Absorber: when ionizing radiation ceases by any material.

Activity: The rate of radioactive decay.

Alpha particle: alpha releasing substance inhaled or injected through water are very dangerous to human body.

Annihilation: the loss of the mass energy and its existence in another parts of energy.

Background radiation: The radiation occur in the natural environment.

Becquerel: 1 Bq = 27 pCi.

Beta particle: An electron of e (e^+ or b+) or (e, e^- or b-) released by an atomic nucleus. **Currie** is a unit that represent the intensity of radioactivity. 1curie= 37* 10 the power of 9disintegrations per second and is the radioactivity of one gram of radium. It is also replaced by Becquerel.

Daughter, is formed by parent radioactive nuclide.

Decay, The conversation of one radioactive nuclide into another nuclide by the spontaneous emission of radiation it also forma very stable nucleus.

Decay rate: activity divided by the number of radioactive atoms.

Decay time the time needed for a quantity to fall to *1/e* times the original value.

Delayed neutrons: Neutrons emitted by fission products up to many seconds after fission. These makes to control of the fission in a nuclear reactor.

Detector: an instrument used to measure radiations.

Dose represent the effect of absorption of a quantity of radiation or energy absorbed.

Gamma ray is most penetrator type of nuclear radiation and released from the nucleus. **Kev** 1000 electron-volts

Life time represent the mean life of a radioactive nucleus. This is = to the decay time.

Mev 1000000 electron-volts.

Parent a radionuclide that decays to give daughter nuclide.

Photon is a full of electromagnetic energy. And have both P and E with 0 rest mass or electrical charge.

Radioactivity The spontaneous decay of an unstable atomic nucleus accompanied by the emission of radiation.

Radioactive isotope is a general term for a radionuclide.

Radioactive waste Materials that are radioactive has no further use.

Radionuclide. An unstable isotope of an element that decays to emit radiation. **Scintillation counter** a devise that detects and measures gamma radiation by counting the light flashes (scintillations) induced by the radiation

Secular equilibrium a state of parent-daughter equilibrium that is gained when the half- life of the parent is much longer than the half-life of the daughter.

Transmutation the change or the transfer of one element into another by a nuclear reaction.