INVESTIGATION WITH GAS FREE SINGLE CHANNEL DETECTOR TO α-β PARTICLES AND IDENTIFICATION OF ELEVATED AREAS AROUND MAKARFI L.G.A OF KADUNA STATE, NIGERIA

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BY

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Declaration

I declare that the work in this thesis entitled investigation with gas free single channel detector to alpha and beta particles and identification of elevated areas around Makarfi L.G.A. of Kaduna State has been carried out by me in the department of physics. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other institution.

_____	_____	_____
Name of the Student	Signature	Date

Certification

This thesis entitled INVESTIGATION WITH GAS FREE SINGLE CHANNEL DETECTOR TO ALPHA AND BETA PARTICLES AND IDENTIFICATION OF ELEVATED AREAS AROUND MAKARFI L.G.A.OF KADUNA STATE, by Ahmad Bala GAZARA meet the regulations governing the award of the degree of Masters in Radiation Biophysics of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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Abstract

Thirty one water samples from boreholes and wells from Makarfi Local Government Area of Kaduna state Nigeria were collected in order to know the response of gas free single channel proportional detector also to know the elevated areas. The total dissolved solids (TDS) was determined for the water samples. An aliquot of each sample was evaporated to dryness, based on the total dissolved solids (TDS) of the sample, and the residue counted for gross alpha and beta activity using the proportional counter (MPC 2000 Desktop). The counter has low background of 92.69cpm for Alpha and 95.65cpm for Beta also has the efficiency of 59.12% and 44.09% for the respective alpha and beta calibration sources and good plateau, which were all reproducible. The result of the counting modes show that alpha activity concentration range from $2.70 \times 10^{-4} \pm 0.40 \times 10^{-4}$ to $60.4 \times 10^{-4} \pm 4.20 \times 10^{-4}$ BqL^{-1} which has the average of $31.55 \times 10^{-4} \pm 2.3 \times 10^{-4}$ BqL^{-1} and that of Beta activity concentration range from $3.87 \times 10^{-4} \pm 1.05 \times 10^{-4}$ to $51.8 \times 10^{-4} \pm 3.27 \times 10^{-4}$ which has the average of $27.84 \times 10^{-4} \pm 2.15 \times 10^{-4}$ BqL^{-1} also the average alpha activity concentration in the boreholes water sample is 12.86×10^{-4} BqL^{-1}, in the wells water samples is 12.87×10^{-4} BqL^{-1}. The average beta activity concentration in the boreholes water samples is 16.04×10^{-4}B/L, that in the wells water sample 17.77×10^{-4} BqL^{-1}.The distribution pattern shows the elevated areas for the alpha activity are T/Yari B and Mayere W, for the beta activity are Mayere W, Gimi W and D/Damisa. The overall result shows that both alpha activity and beta activity in the study area are far

below the practical screening level of radioactivity in drinking water of 0.5 BqL^{-1} for alpha and 1 BqL^{-1} for beta, as recommended by CEC – FAO and WHO.

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CHAPTER ONE

INTRODUCTION

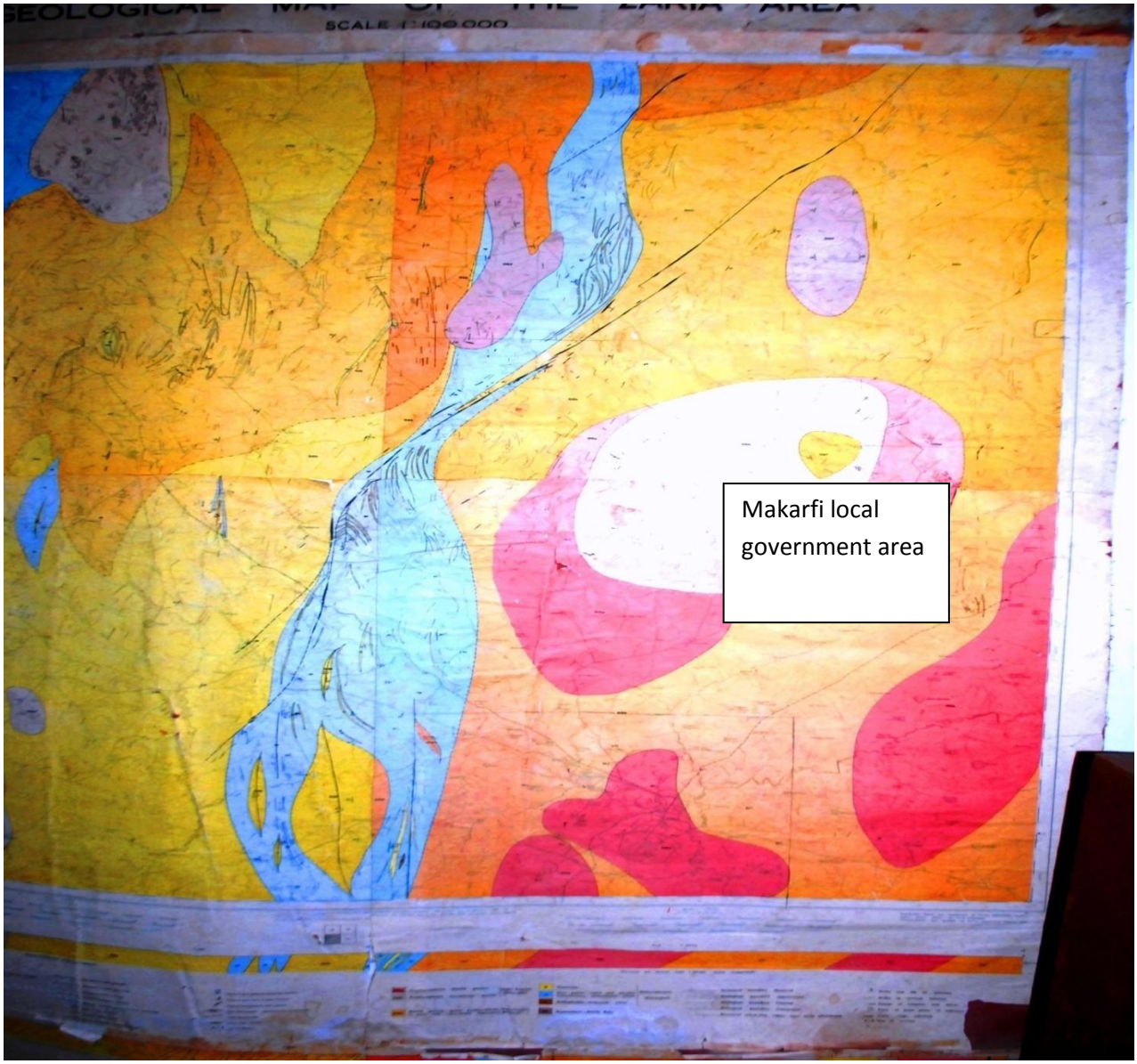
Water is an essential substance to man, animal and all that surrounds them. It has been in existence right from the origin of the universe itself. Water forms greater percentage of man and animal blood and tissue with about 75%(Ahmed and Salisu,1999).

Man uses water for many purposes in areas such as power generation, agriculture and above all for domestic purposes. Water for human consumption should be free from chemical, microbiological and radiological contaminations,but unfortunately in developing countries like Nigeria most people are not opportune to have access to such safe drinking water. In Makarfi local government area (Kaduna State) people totally rely on the ground sources comprising hand wells and borehole (deep and shallow). Tap water is mostly not provided, so most of the populace rely heavily on untreated ground water as their source of drinking water. Thus, it becomes necessary to investigate the radiological content of drinking water in the area through the response of gas free single channel detector. This makes the ground water quality an area of increasing focus and importance soas to protect lives against the hazardous environmental effects, one of which is radionuclides in drinking water. Radioactivity in ground water was formerly limited to natural sources such as radon, radium, or uranium, but release from fertilizers, agrochemicals, medical and research facilities have added the dimension of man-made radioactivity finding its way into the drinking sources.

This is to say that radioactivity in drinking water comes mainly from two sources: naturally occuring and artificially induced. Artificial radioactivity is usually found in surface water due to human activity while naturally occurring radioactivity comes from the bedrock. The natural radioactivity is mainly due to contamination as a result of leaching of minerals in the earth crust. Contamination in well water is mainly due to human activity in agriculture, medicine, and industry. This contamination may also pose a potential health hazard and therefore the need for investigation is very important.

The geology of the area shows that the area fall into thebiotite granite gnessis, porphyroblastic in part with subordinate magmatites (Dahomeyan - Birrimian). Detail on the geology of sector is contained in the Geology map of zaria area.

However some portions of the study area fall in the region underlain byporphyroblastic hornblende granite, while the remaining, portion in underlain by fine medium grained biotitegranite(Zaria area geology map Geology Department A.B.U.).



KEY:

:GGbBiotite granite gnessis,Porphyroblastic, with subordinate magmatite(Dahomeyan-birrimian)

: OGpPorphyroblasticbiotite granite (older granite, katangan)

Gf Fine – medium grained biotite granite

GhPorphyroblastic hornblende granite (older granite, katangan)

Fig 1.1 Geology Map of the Study Area

Naturally occurring radionuclides of terrestrial origin, also called primordial radionuclides, are present in the environment. Among the primordial radionuclides, the main contributors to external and internal exposure are ^{238}U and its daughters such as ^{40}K, and ^{232}Th(Yarar et al., 2005). In sense of lives health and environmental pollution, determination of the radioactivity in water (in drinking as well as usage water) is useful (Ozmen et al., 2004).

The measurement of radioactivity in drinking water allows the determination of population exposure to radiation from the habitual consumption of water. The occurrence of radionuclides in water and edibles (terrestrial and aquatic) items causes human internal exposure, due to decay of radionuclides taken into the body through ingestion. They act when they are incorporated as part of the human food chain. Since the doses from these pathways are strongly related to the amount of radionuclides present, an important objective from the point of view of the radio ecological protection of the population is the accurate evaluation of the amounts received in dietary intake.

Water quality is an important parameter of environmental studies(Karahan et al., 2000). Natural water contain both α- (e.g., U^{238}) and β-(e.g., K^{40}) emitters in widely varying concentrations which are responsible for a generally small fraction of the total dose received from natural and artificial radioactivity (UNSCEAR, 1993). Gross alpha and gross beta radioactivity measurements are ofparticular interest for routine monitoring purposes. Radioactivity in ground water is an easy means of man's internal contamination with radionuclides. A wide range of radionuclides are known to occur in ground water, there include ^{131}Cs,^{51}Cr,^{60}Co,^{131}I,^{59}Fe,^{210}Ld-,^{32}P,^{238}U,^{65}Zn,zirconium-96, (Larry, 1996) These radionuclides are known to decay by alpha,beta and other emissions and hence pose hazards when ingested into human body through drinking water.

Table1.1 gives the details of such radionuclides found in water. These nuclides emit radiations of various energies and could affect the cellular composition of an organism. Alpha particles, for instance amongst the most hazardous forms of radiation. They have high linear energy transfer LET, meaning that they lose energy within a very short distance in dense media, thereby causing significant damage to the surrounding bimolecules if ingested into the body. A typical 4meV alpha emission from ^{238}U is by hundreds of thousands times more energetic than the week hydrogen bond between the purine and pyrimedine bases of the Deoxyribonuclieacid(DNA), it is similarly more energetic than all the molecular binding energies of the phosphoric acid backbone of the DNA and could therefore cause devastating result on molecular scale when deposited into the nucleus.

Another devastating effect of radiation in the body is observable by direct ionization of the abundant water molecules in the body. This ionization leads to the production of highly reactive species such as H_2O_2 which in turn damages body tissues. The essence of the evaluation of the gross alpha and gross beta activity is to ensure that the reference dose level {RDL} of committed effective dose of 0.1 mSvfrom one year consumption of drinking water is not exceeded. The RDL of 0.1 mSv is equal to 10% of the dose limit for members of the public recommended by the international commission of radiation protection (ICRP 1991) and the international Basic safety standards(IBS)International Atomic Energy Agency (IAEA 1996) and are acceptable toWorld Health Organization (WHO) member states European commission and the Food and Agriculture Organization(FAO).

Table 1.1 Radioactivity in water

Nuclide	Half life	Average concentration in water
Naturally occurring		
Uranium – 238 (α)	4.5 x 10^9 yr	(0.02 – 200) µg /L
Radium – 22.6 (α)	1.6x10^3 yr	(0.01 – 0.1)pci./L
Radon – 222 (α)	3.82 days	1pci/l surface water
Uranium -235 (α)	7x10^8 yr	>1000pci/L equifer
Radium – 223 (α)	11.4 days	(0.02 – 200)µg/L
Radium – 223 (β)	5.8 yr	
Radium - 224 (α)	3.6 days	
Radon – 220 (α)	< 1 min	(0.005 – 0.1)pci/L
Tritium –(^{3}H) (β)	12.3 yr	
Carbon – 14 (β)	5,730 yr	10 – 25 pci/L
Potassium – 40 (β)	1.3x10^9yr	6pCI/g/cm^3
Rubidium – 87 (β)	5x10^{11}yr	<4pCi/L
Polonium – 210 (α)	138 days	
Nuclear fission products		
Strontium – 90 (β)	30 yr	0.5pCi/L
Iodine – 131 (β)	30 yr	0.1pci/L
Tritium (^{3}H)	8.1 days	NA
Carbon – 14	12.5yr	(10 – 25)pci/L
Pharmaceuticals		
Iodine – 125		
Iodine – 131	8.1 days	
Technetium – 99m	6.0hr	
Nuclear fuel		
Tritium (^{3}H)		
Plutonium	12.5 yr	10.25pci/L
Iodine – 129	24,360yr	

Source: (Muhammad B.G. et al 2010)

1.1 Statement of research problem

Gas free single channel detector it is the instrument used to know the level of radionuclide in some particular area, so to know the respond of the detector is of paramount important.Makarfi is one of the local government areas of Kaduna state in Nigeria with a population of nearly 250,000 people according to National population commission (NPC) data of 2006 census, and its geological studies indicated that itis rich in granite deposit.According to IAEA (2001), sustainable human development is dependent on the availability of water as it was estimated that more than one third of the global food production is based on irrigation, a significant portion of which may rely of unsustainable ground water sources. Thomas et al (1987) reported that majority of areas with high radon concentration are those areas underlain by granite rocks that contain higher levels of radon precursors.

The U.S. Environmental Protection Agency (USEPA) has estimated that the additional lifetime risk of cancer associated with drinking water that emits alpha-particle radiation at 15 picocuries per liter (pCi/L) of water, or has acombined concentration of radium-226 and radium-228 of 5 pCi/L of water, isabout 1 in 10,000. The risk doubles to 2 in 10,000 at 10 pCi/L and triples to3 in 10,000 at 15 pCi/L. This analysis means that if 10,000 people were toconsume 2 liters of water containing 5 pCi/L of radium every day for 70 years,one additional fatal cancer incident would be expected in the 10,000 people exposed(USEPA, 1999).Consequently, USEPA regulations set the drinking water standard at an averageannual concentration of gross alpha particle radioactivity in drinking waterto 15 pCi/L and the average annual combined concentration of radium-226and radium-228 to 5 pCi/L. The increased cancer risk from long-term ingestion of radium should be viewed in the context of current cancer statistics. Analysis of cancer statistics presented by the American Cancer Society on the World Wide Web at http://www.cancer.org/cid/509.00/index.htmindicates that approximately 4,400 in 10,000 Americans will develop cancer at some point in their lifetimes, and approximately 2,200

of the 10,000 eventually will die of cancer.On the other hand pollution, may also constitute heavy element as well as some radionuclides whose presence could pose a great health risk. Therefore, data on radionuclide in drinking water is necessary in order to determine the quality and health risk such water could have on the populace(Williams, 1926).In Nigeria, Makarfi local government area in particular, there is yet no established data on gross alpha and beta concentration in drinking water sources despite the fact that most of the inhabitants of the country especially those in the rural areas, depend solely on groundwater and surface water sources for drinking, household activities and for agricultural purposes, and it may be possible that the water they use contains a high concentration of gross alpha and beta. A statistics by country and regions for cancer prevalence has been reported on a page updated on 14th May, 2010 on (www.wrongdiagonosis.com) in which Nigeria has recorded a cancer prevalence of 81,501 per anum. The significance of exposure from natural radioactivity in our living environment and the potential risk for causing health detriment has not received adequate attention in Nigeria. Cancer has become a major cause of mortality in the recent times and now the public interest in the long-term effects of radiation on humans has assumed great prominence following the establishment of a nuclear regulatory body in Nigeria (Obed et al 2006). Therefore, going by the above facts it becomes necessary for us to investigate the activity of some naturally occurring radionuclides in our environment, which may end up emitting radiation especially gross alpha and gross beta . Also, to know the response of gas free single channel to such radiation and there is need to compare between bore holes water and well water in order to know which one is more hazard. The main aim of this research is to investigate the response of gas free single channel to such radiation also to know theconcentration of gross alpha and beta and to contribute to the baseline data, in drinking water in the study area.

1.2Aim and objectivesAim

The aim of this research is to investigate the response of gas free single channel detector to α - β particles and identification of elevated areas around MakarfiL.G.A

.**Objectives**

- To investigate the response of the gas free single channel counter to alpha and beta Particles
- To evaluate the gross alpha and bata radioactivity in water from some well and boreholes in Makarfi local government area of Kaduna state.
- To identify possible elevated areas
- To compare the concentration of alpha and beta between borehole water and the well water
- To establish the distribution pattern of radioactivity measured in the area so as to assess the safety of the ground water for drinking.

1.3JUSTIFICATION

Dissolved radoinuclides in ground water may pose public health threat when used for domestic supply. The determination of their effects will therefore help in environmental protection, strategic planning as well as protection of human health. Also to know the respond of gas free single channel detector is also of another important.Similarly, a work of this kind has never been carried out in the area and so the work will provide a baselinedata of the radioactivity level of the water in the area.This data can further be utilized in future planning by the government against environmental pollution and potential threats to human health due to radon and other nuclides.Also the data may used in the feturereaserach with the detector, it may also be possible that the radioactivity level of the drinking water in the area is above acceptable level. This research will therefore provide useful information on the detector and radiological safety of drinking water in Makarfi local government area, Kaduna state.

CHAPTER TWO

LITERATURE REVIEW

2.1 Water Pollution

Water pollution means the contamination of water by the discharge of noxious substances. As defined by the International Oceanographic Commission (IOC) for the United Nations Educational and Scientific Commission (UNESCO), water pollution is the introduction by man, directly or indirectly, of substances into the water body resulting, in such deleterious effects as harm to living resources, hazards and to human health, or hindrance to marine activities and reduction of amenities (Williams, 1926). This supposes that man is a major contributor of water pollution, even though there are natural sources of water pollution. Sources of water pollution can therefore be classified as: natural sources of water pollution and man-made sources of water pollution.

Natural sources of water pollution arise from rocks, rain, flood, oil spillage, aquatic growth and death, NORMs. Igneous rock formed by the solidification of melts, are the major component of the earth's crust, which is now land. These rocks are mainly silicic and basaltic types in the ratio of 2:1 (Johnston, 1976). The major component minerals of these rocks determine fairly predictably the trace elements that solidified out with them. For instance magnesium rich rocks yield chromium ores together with nickel. Basaltic rocks yield copper, zinc and granite rocks yield potassium, beryllium and lead. The weathering of these rocks produces sedimentary rock and unconsolidated sediments (Johnston, 1976). Rivers and streams encounter these sedimentary and igneous rocks and consequently the water is contaminated by the trace elements present in the rocks.

Rainstorm carries dust particles and aerosols from the atmosphere; and also inorganic silt from soil erosion. All these are discharged into the streams and rivers as pollutants. Oil spillage is also a serious source of water pollution. The oil deposit can be spilt through natural forces like earthquake, leakage can also occur through the oil pipelines through vandalization; or oil spilt from transporting vehicles that are fallen down. In all these ways, the spilt oil can find its way to the water bodies contaminating the water seriously(Johnston, 1976).

The death and decomposition of aquatic plants and animals adds significantly to the organic pollution and which depletes the dissolved oxygen particularly if residues are deposited and accumulated in underground water. The dead plants and animals are quickly oxidized by a series of biological activities into stable mineral forms, which are used again by other living things. The water body itself provides the oxygen for this concentration and indirect measure of the organic load, which is a function of the amount of oxygen required in the process. This is referred to as biochemical oxygen demand (Onoja, 2004). The microbes of primary concern in rivers and streams are bacteria, viruses, protozoa and other forms that may be pathogenic to man.The naturally occurring radioactive materials (NORMs) in the earth's crust comprise of Uranium, Thorium, Radium, with their radon-gas progeny and potassium- 40. These materials seep into the ground water, introducing radioactivity into the water body.Major water pollutants introduced by man's activities include pathogens, chemicals, sediments, toxic organics and inorganic, radionuclide from radioactive wastes, acids and bases among others. Pathogens are introduced in water mainly through untreated sewage from individual households, industrial or passenger ships and other vessels. Large water bodies like

rivers, seas, oceans have been the major dumping grounds for sewages the world over. In fact, a substantial volume of sewage of about 2.2 x $10^5 m^3/d$ (48million gallons) are disposed in the Southampton per day of which about 50% are untreated. Pathogenic bacteria and viruses from these sewages are therefore introduced into the water (Helliwell,1975).

Chemical pollutants are introduced into the water through two different pathways, first by direct drain of rain run off into the water. Secondly is by accumulation of these chemicals as industrial impurities in the atmosphere in which they are dispersed with air masses and are deposited on water surfaces through atmospheric precipitation. Of these chemicals is the petroleum, hydrocarbon, which accounts for 50 to 90 millions tonnes per year of man-made hydrocarbons in the forms of atmospheric currents (Patin, 1982).

Among the heavy metals mercury, lead and cadmium are most common water pollutants these elements (mostly mercury and lead) enter the atmosphere during the combustion of fossil fuels and arc deposited on water surface through atmospheric precipitation. It has been estimated that the average daily mercury intake in Southampton, England was about 25% from eating fish (Helliwell, 1975). Though this is within the safe limit, diseases associated with high dose of mercury include disease of the gum and kidney; tremor, mental disturbances, convulsion and even death, in severe cases (HelliwelI, 1975).

Fertilizers constitute a serious pollution problem when they are washed by flood or rain into various wells, rivers and streams. Most fertilizers contain phosphate, potassium and nitrate products. These substances are nutrients to plants, but some of

them constitute serious health risks especially to infants, due to interference of the chemical with blood oxygen transport (Ruesel, 1966). Some of these substances in the fertilizer are radioactive and constitute radiological hazards to man when they contaminate water sources. Table 2.1 shows the activity concentration of natural radionuclide in phosphate fertilizers of some countries.

Table 2.1: Activity Concentration (Bq/kg) of Natural Radionuclides in Phosphate Fertilizers

Phosphate	**Country**	**^{226}Ra**	**^{232}Th**	**^{40}K**
Super Phosphate	Germany	520	15	140
	USSR	110	44	120
	USA	790	20	
	Belgium	910	<25	<180
Tri-superphosphate	Germany	230	44	52
	USA	780	48	
PK-Fertilizers	Germany	370	15	5700
NP-Fertilizers	Germany	310	30	44
Ammonium Phosphate	USSR	100	48	
Nitro Phosphate	USSR	850	10	
N.P.K	USSR	9	54	1200
	Germany	270	15	5200
	Belgium	210	<15	5900

(Pfiscer et al., 1976)

Chlorination is one of the processes of water purification in public drinking water supply, mostly tap water. This introduces chlorinated hydrocarbon into drinking water. The case study by the US National Cancer Institute established epidemiological

significance of chlorine reaction, products in water. About 8000 people, including 2805 with bladder cancer were examined and significantly higher cancer risk was found from people who drink chlorinated surface water for at least 40 years (Belloni, et al., 1995).

Furthermore, radionuclides from radioactive wastes find their ways into water bodies. Radioactive wastes are generated from radioactive ore mines nuclear reactor operations, hospitals and industries where radioactive sources are used. When these radioactive wastes are disposed, especially through ground repository and water disposal the containment can give way after sometime. The radionuclides from the radioactive wastes thus, can seep into water body and consequently contaminating water supplies leading to man's exposure to ionizing radiation (Winn, 1995).

2.2.1 Radioactivity

For any element there is limited number of neutrons within the nucleus for it to remain stable. Any deviation from this number will result in an unstable atom. An unstable atom can become more stable by emitting energy in the form of radiation. Such atoms are said to be radioactive and the process is called radioactivity. Radioactivity is therefore defined as the spontaneous transformation of unstable nuclei that results in the formation of new elements with the emission of particles and radiations (Cember, 1996).

The emitted particles are alpha particle, beta particle, or positron and gamma radiations; whose emission only accompanies alpha or beta particle emission. (Cember, 1996). The exact mode of radioactive transformation depends on two factors (i) the type of instability-that is whether the neutron to proton ratio is too high or too low. (ii) the mass-energy relationship between the parent nucleus, daughter nucleus and the emitted

particle. Henry Becquerel first discovered the fact that some elements are naturally radioactive in 1896. He observed the blackening of photographic emulsions in the vicinity of a uranium compound and this was subsequently attributed to radiation being emitted by the Uranium (Martin, 1986). This discovery by Becquerel was prompted by an earlier discovery by Roentgen in 1895. In his study of the fluorescence by cathode rays in the Crooke's Tube, Roentgen suddenly discovered that the screen he was using in a dark room fluoresced when the tube was turned on even when the screen was some distance away and he called the resulting radiation x-rays (Turner, 1995). Further intense discoveries revealed that x-rays and gamma rays (from radioactive substances) belong to electromagnetic radiations of same velocity and slightly differing wavelengths. They are ionizing radiation, which can discharge a charged electroscope. Alpha and beta particles are also ionizing radiations. The essential difference between x-rays and gamma rays is their origin. Whereas gamma rays result from changes in the nucleus, x-rays are emitted when atomic electrons undergo a change in orbit (Martin, 1986). Apart from uranium, other natural radioactive elements were discovered. In1898, the Curies discovered Polonium and Radium (Turner, 1995). Thorium and Potassiurn-40 are also natural radioactive materials.

2.2.2 Radioactive Decay Law

The instability of a nucleus describes a statistical phenomenon hence; the associated transformation process is probabilistic (random in nature). The random behaviour of a particular radioactive sample is expressed in the radioactive decay law which states that if N represents the number of atoms in radionuclides in a given sample

at a time, then the change in the number of nuclides dN during a time interval dt is proportional to N thus

$$\frac{dN}{dt} = -\lambda N \qquad (2.1)$$

Where λ is called the decay or transformation constant. The negative sign shows that N decreases as time, t increases.

$$\frac{dN}{N} = -\lambda dt \qquad (2.2)$$

Solving equation 2.2 by integration and taking natural log will result in equation

$$N=N_0 e^{-\mu t} \qquad (2.3)$$

Where N_0 is the number of atoms of the radionuclide at time t = 0. Equation 2.3 is the radioactive decay law.

2.2.3 Half Life ($T_{1/2}$)

Different radionuclides are transformed at different rates, and each radionuclide has it own characteristic transformation rate. Thus the time required for any given radionuclide to decrease to one-half of its original quantity is called the half-life (T) of the radionuclide (Cember, 1996). The half-life of a radionuclide is a measure of the speed with which it undergoes radioactive transformation. From equation (2.3), at half-life, $N=N_0/2$ and $t=T_{1/2}$ so that the equation transforms to

$$\frac{N_0}{2} = N_O \ell^{-\lambda T_{1/2}} \quad (2.4)$$

Solvin the equation, gives

$$T_{1/2} = \frac{1n2}{\lambda} = \frac{0.693}{\lambda} \quad (2.5)$$

2.2.4 Activity

The activity of a radionuclide is the number of atoms of the radionuclide that decays per unit time. It describes the rate of transformation of a radionuclide. The activity of radionuclides increases as in the sample increases; and decreases exponentially with time. It is given by

$$A_t = A_0 e^{-\mu} \quad (2.6)$$

Where A_0 is the activity at time t_o and A is the activity at time, t.

2.2.5 Specific Activity

Although, activity is used as a measure of the quantity of the radionuclide present, it does not consider mass or volume of the radioactive material. The relationship between the activity and the mass of the radioactive material is called the specific activity; which is the activity per unit mass of the radioactive material (Cember, 1996). Specific activity is the measure of activity concentration of a radioactive material; expressed as.

$$A_{SP} = \frac{Act}{A} = \frac{\lambda N_A}{A} \qquad (2.7)$$

Where N_A the Avogadro number and A is the atomic mass of the radionuclide.

2.2.6 Sources of Radioactivity

There are two main sources of radioactivity: Natural and Artificial Radioactivity..

(a) Natural Radioactivity

Natural radioactivity originates from primordial radionuclides in the earth's crust and from nuclear reactions in the stars. These are called terrestrial radiations and cosmic radiations respectively. Cosmic radiations emanate from the sun and interstellar space; and constitute primarily of 87% proton, 11% alpha particle, 1% heavy ion and 1% electron. These particles produce secondary cosmic radiation, which consists of80% neutrons and 20% electrons (Martins, 1986) and these secondary cosmic radiations are the ones that get to the earth's surface. The annual external dose rates from cosmic radiations depend largely on the altitude and slightly on the latitude. Table 2.2 shows the altitude dependence of cosmic radiation dose rate in some countries.

From Table 2.2, it implies that a pilot constantly flying is exposed to an appreciable dose of cosmic radiation. The latitude effects arise from the fact that the charged particles of cosmic rays on coming towards the earth's surface are deflected by the earth's magnetic field, away from the equator and towards the poles, thus the dose rate increases with increasing latitude (Martins, 1986)

Table 2.2: Altitude Dependence of Cosmic Radiations Dose Rate in some Countries.

Altitude	**Dose Rate mSv/y**	**Example**
Sea level	0.31	Los Angeles
1,525	0.55	Denver
3,050	1.37	Leadville; Colo
9,140	19.00	Normal Jetliner
15,240	87.57	Concorde
24,340	127.00	Spy Plane

(Adopted from Goilnick, 1988)

. Cosmogenic radionuclides, from the reactions of cosmic rays with the particles of the atmosphere, include ^{3}H, ^{7}Be, ^{14}C and ^{22}Na with their respective annual doses as 0.01mSv, 0.03μSv, l2μSv and 0.151μSV (Turner, 1995). Carbon-14 is produced by the reaction $^{14}N(n, p)^{14}C$. It diffuses into the lower atmosphere, oxidized to carbon dioxide ($C0_2$) and becomes incorporated in plants, animals, or seeps into the water (Cember, 1996). Carbon-14 is an important tool use in radio carbon dating.

Terrestrial radiation results form the primordial radionuclides, which include ^{238}U, ^{232}Th, ^{26}Ra and ^{40}K (Peter, 1989). They exist in the three naturally occurring radioactive decay series, which undergo transition at very slow rate because of their long half-lives and produce several decay products (Progeny). These progeny include ^{266}Ra, ^{210}Po, ^{210}Pb and ^{222}Rn. The Radon gas gets into the atmosphere through emanation and diffusion via soil capillaries and as an inert gas, it has greater residence time in the atmosphere and higher probability of human irradiation (Ibeanu, 1999). The daughter products of ^{222}Rn such as ^{210}Po and ^{210}Pb being solids, attach themselves to the atmospheric aerosols there by contaminating the air inhaled by man. Radon gas and its decay products contribute about 55% of the background radioactivity to man. The primordial radionuclides are present in rocks, soils and building construction materials. Mining and processing of radioactive ores contribute significantly to the enhancement of terrestrial radiation fields in the environment (Ibeanu, 1999). These radioactive rocks and soils are constantly encountered by flowing rivers, streams and ground water and consequently they contaminate the water sources.

Our food typically contains about l0Bg/kg of 40K, our body incorporates them into soft tissues and bone irradiating the body continually, and hence our body is naturally radioactive. This is referred to as NORM internal to human body. The activity in the body of a reference person of 70kg is about 4,000Bq, mainly as a result of the presence of ^{40}K and ^{14}C (Alison, 1968). This delivers a dose of about 7μSV per year to the skeleton (Eisenbud, and Paschoa, 1989).

(b) Artificial Radioactivity

Artificial or man-made radioactivity results from a number of man's activities leading to the designing and building of many types of apparatus that produce radiation and/or radioactive materials. These human activities include the use of X-rays for diagnostic and therapeutic purposes in medicine, research, industry and agriculture; the generation of electricity through nuclear power plant. All these activities introduce radioactivity into the environment.

Production of fertilizer for agriculture is a major source of artificial radioactivity to the soil, as a part of the constituents of fertilizer is radionuclides. Spalding and Sackette (1972) observed the leaching of Uranium from phosphate fertilizer as in a North American river. Clergy (1958) measured the mean activity concentration of 1464 Bq/kg, which is a factor of about 58 times the mean activity, concentration worldwide in a normal environment.

The phosphate fertilizers are to have more concentration of radium followed by potassium and then thorium. The PK and the NPK fertilizers have higher concentration of potassium than radium (Ibeanu, 1999). When these fertilizers are applied to the soil, they add radioactivity to that of.the Uranium and other decay series present in the soil (Eisenbud and Pachoa, 1989).

Seventy percent of the earth's surface is radioactive substances from fertilizers; terrestrial radiation and cosmic radiation return to the water through dry out, rain out or wash out directly into the surface of water. However, an important portion of the active

substances pass through the hydrosphere and is leached out from the soil and arrives in rivers, lakes and seas (Szabo, 1993).

2.2.7 Radionuclides in drinking water

The occurrence of desolvedradionuclidessuch as ^{238}U. ^{226}Ra. ^{222}Rn in water pose a serious health hazard through exposure of living tissues. Studies have shown that there is no safe radiation dose; accumulation of these radionuclides in the body overtime may lead to several type of cancers and extremely high doses can cause death. Radium and uranium are known to be alpha emitters and when injested into the body pose a variety of health problems (Cohen, 1987). Radon for instance has similar chemical properties with calcium thus it accumulates in bone tissue. Inducement of bone cancer appears to be the greatest health threat posed by intestine of radium (National Research Council, 1988). The toxicity of uranium is also two fold: as a heavy metal, it may cause kidney damage and as a radionuclide it may induce cancer. (National Research Council, 1988).

Basically, the presence of radionuclides in drinking-water results from one or more of the following sources;

i. Naturally occurring radioactive species e.g., radionuclides of the thorium and uranium decay series in drinking-water sources in particular radium-226/228.
ii. Technological processes involving naturally occurring radioactive materials e.g the mining and processing of mineral sands or phosphate fertilizer production and usage.
iii. Radionuclides discharged from nuclear fuel cycle facilities;
iv. Manufactured radionuclides produced and used in unsealed form which might enter drinking-water supplies as a result of regular discharges and, in particular, in case of improper medical or industrial use and disposal of radioactive materials;

There is evidence from both human and animal studies that radiation exposure at low to moderate doses may increase the long-term incidence of cancer. Animal studies in particular suggest that the rate of genetic malformations may be increased by

radiation exposure. No harmful radiological health effects are expected from consumption of drinking-water if the concentrations of radionuclides are below the guidance levels. Acute health effects of radiationleading to reduced blood cell counts and, invery severe cases, health, occur at very high doses of exposure of the whole body or large part of the body (IAEA, 1998). Current drinking water standards are established for Ra (5pCi/L) of ^{226}Ra plus ^{228}Ra, but new revised standard have been proposed by US, EPA to increase the limit to 20Ci/L of either ^{226}Ra plus ^{228}Ra. Standards have also been proposed for U (20µg/L) and ^{222}Ra (300pCi/L) (US EPA, 1991).

2.2.8 Physical Effects of Radiation

Ionizing radiation produces physical, chemical and biological changes in the human system. The mammalian cell constitutes typically of 70-85% of water, 10-20% of protein, 10% of carbohydrates and 2-3% of lipids (Turner, 1995). As water is the major constituent of the human cell, the radiation effects on water is given paramount attention in this study. The initial physical changes that occur when water is irradiated are the creation of ionized and excited molecules, and free sub excitation electrons as in Turner (1995)::

$$H_2O \xrightarrow{Radiation} H_2O + e^-$$

$$H_2O \xrightarrow{Radiation} H_2O + e^-$$

This event occurs in a very short time of about 10-16s in local track region

(Alan, 1986). Water begins to adjust to the sudden physical appearance of the new species even before the molecules can move appreciably in their normal thermal agitation.

Radiation effects on carbohydrates include decease in melting point, reduction in optical rotation, browning and changes in absorption spectra of the carbohydrates (Wiser, 2000). In Lipids radiation induces formation of free radicals, which decay with increasing temperature, and at about 7OkGy radiation causes polymerization (hardening) of fats, which results in increase in viscosity of fats. Proteins are broken into their constituent amino acids (degradation) by radiation (Wiser, 2000). The physical effect of radiation is a function of the degrees of energy deposition of the radiation on the medium. The intensity of the radiation I is related to the thickness of the medium x, by the equation 2.8:

$$I = I_o e^{-\mu x} \qquad 2.8$$

Where t is the linear attenuation coefficient, lo is the initial intensity of the radiation. Thus high energy radiations (like x-rays and γ-rays) are less attenuated and have less energy deposition, than low energy radiations (like Cl and f_3) which are more attenuated and deposit more energy, within a short distance resulting in the physical changes (Tuner, 1995).

2.2.9 Chemical Effects of Radiation.

The chemical effects of radiation on water set at about 10-12s, after the physical changes. The initial species formed by radiation on water are mostly free radicals, very reactive chemical species. These include OH, H, e which react with themselves and with the water molecules in a series of reaction, Turner (1995):

$$OH + OH \rightarrow H_2O_2$$

$$OH + e_{aq} \rightarrow OH$$

$$OH + H \rightarrow H_2O$$

$$H_3O + e_{aq} \rightarrow H + H_2O$$

$$e_{aq} + e_{aq} + 2H_2O \rightarrow H_2 + 2OH^-$$

$$H + H \rightarrow H_2$$

The reaction of these radicals and their effects on the medium is through indirect action, which is more damaging to the medium than direct action. Thus the formation of chemical species by radiation results in chemical reactions of the species with the medium, which causes damages to biological organs (Alan, 1986).

2.2.10 Biological Effect of Radiation

Some substances formed from the chemical reactions of the radiation produced radicals, such as hydrogen peroxide, are strongly toxic to biological cells and are stable within the cell. They may be removed by enzymes that are specifically to protect against these materials (BEIR, 1980). The cell damage may be in the form of:

(i) Early death of the cell

(ii) Prevention or delay of cell division

(iii) A permanent modification (mutation) which is passed on to the daughter cells (Alan, 1986).

Biological effects of radiation can be acute or chronic. The acute radiation effect is a short term, deterministic effect in which high dose of radiation is received within a very short period. The individual or group must be exposed before acute effect can be got because there is a threshold amount of radiation dose (Alan, 1986). The acute radiation syndromes include vomiting, diarrhoea, haemorrhage, gastrointestinal disorders, neuromuscular damage, shock and even death, depending on the dose of radiation (Mark and Barnett, 1976).

Chronic or long-term radiation effects are those that manifest themselves long time after the original exposure. They result from low-level exposures over a very long time, or sparsely from previous acute dose effects. From the stand point of public health significance, the possibility of long term effects on the large number of people receiving low, chronic exposures is a cause for greater concern than the short-term radiation effects, which involves only a few individuals. Among the long-term effects of ionizing radiation thus far observed are cancer, cataracts, life span shortening, genetics mutation and embryological defects (BEIR, 1980). Thus ionizing radiation is said to be a carcinogen. However, no pathologist can say with certainty whether the cancer would not have occurred if the people were not exposed to the carcinogen. The long-term effect is stochastic, probabilistic and has no threshold and can result whether one is exposed to radiation field or not. Thus every increment of radiation dose, no matter how small, carries with it a corresponding increased probability of the long-tenn effects (Arno, 1988). Stochastic effects could be caused by radiation exposures through external contact with water, drinking of contaminated water, eating of contaminated food stuff, eating of meat or drinking of milk from contaminated animals.

2.2.11 Health Implications of Radioactivity in Water

When a radionuclide gets into the body through ingestion, inhalation or absorption through the skin, it continues to decay or disintegrate, emitting radiation such as alpha, beta or gamma radiation such that the organ or tissue is continuously irradiated. Consequently the tissue is damaged, the degree of which depends on the type of radiation. The damage is greatest with alpha, and least with gamma radiation. Some radionuclides are chemically similar to some minerals in the body and so when they are taken into the body, they mimic those minerals in the organs. For instance radium, strontium and barium are found to have chemical similarity with calcium in the bone. When these radionuclides get into the body, they are deposited at the bone (bone seeking) causing damage to the bone cells through Osseo sarcoma (bone cancer)(Arno, et al., 1988). This was the case of the radium dial painters in the early 20th century, many of whom suffered degeneration of jawbones and died of anaemia following swallowing of minute amounts of radium each time a paint brush was pointed with their lips (Cember 1996). Uranium is known to have deleterious or chemo toxic effect to the kidney (Latouche, et al., 1987).

The international commission on radiological protection (ICRP) estimates that the blood stream from gastrointestinal tract absorbs an average of 5 per unit of ingested uranium. It also suggests that the value could possibly be as high as 20 as had been shown by ICRP (Cothern, et al., 1983). Radioactivity in drinking water was estimated for gastrointestinal absorption to be 1.4% (Wrem, et al., 1985). In preliminary results from experiments that used fasting human subjects a value of between 0.5% to 1% was

suggested (Crawford Brown, 1990). In view of these results both 1.4% and 5% estimates are reasonable average level to use in risk calculations (Milla, 1990).

The radioactive radon, which has the largest single contribution to background radioactivity, has been attributed to the incidence of lung cancer. This was thought so at about 1924, following the increased incidence of lung cancer death among the miners in Schoenberg and Joachimsthal regions in the Carpathian Mountains as at the sixteenth century (Cember, 1996). It was discovered that the mine, though worked for mainly cobalt, was very rich in uranium and radium. As a consequence of high radium content of the soil, radon gas the radioactive daughter of radium, is produced and diffuses out of the ground into the air of the mine shaft, thus leading to high concentration of radon and radon daughters in the air around the mine, of the order of 3.7 x 10^5Bq/m3 (Cember, 1996). This concentration is high if compared to l000Bq/m^3 recommended by WHO. Stomach cancer is also attributed to ingestion of radon daughters (CrawfordBrown, 1990).

External contamination from low LET radiations such as X-rays and γ-rays is also detrimental to health. This is evidenced from the incidence of skin cancer discovered among X-ray workers at the early discovery of medical use of X-ray. Over 100 cases of skin cancer associated with over exposure to radiations had been recorded (Cember, 1996)

2.2.12Interaction of Radiation with Matter

The detection, characterization and effects of radiation are almost entirely dependent upon their interaction with matter.

Types of radiation are direct ionizing radiation and indirect ionizing radiation. The flows of charged particles, such as alpha particles, beta particles, electrons, are phenomena of direct ionizing radiation, because though coulomb interaction with matter it directly causes ionization and excitation of atoms. Indirect ionizing radiation (neutrons, γ-quantums) is radiation of particles or photons, which have no charge and during interaction with matter can transfer energy to charged particles, nuclei and atom electrons due to electromagnetic or nuclear interaction (ECTS, 2012).

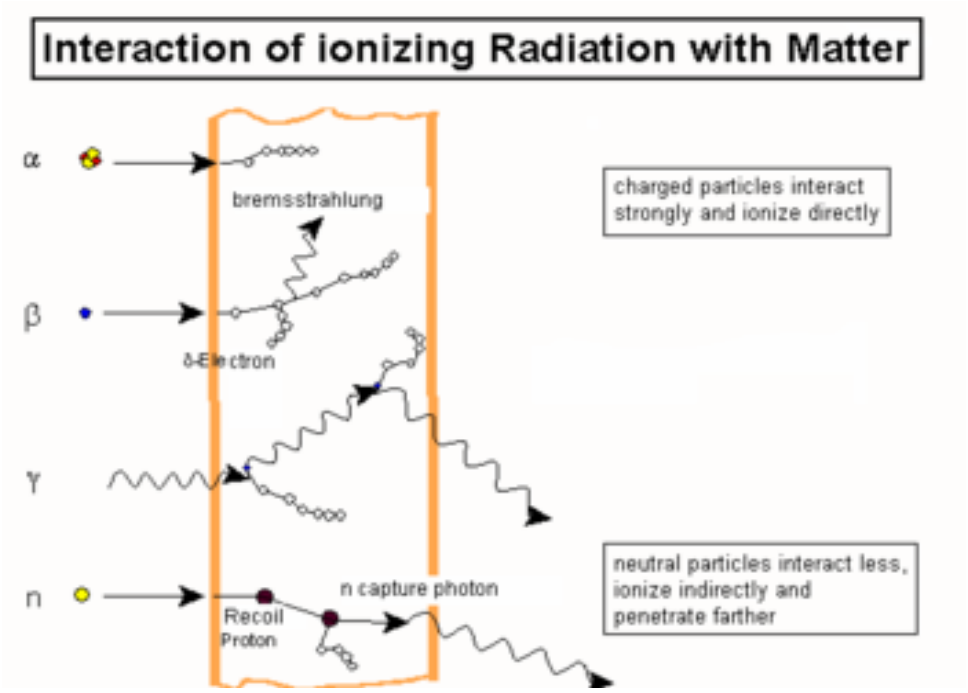


Fig 2.1 (Annunziata M. et al 2003)

Alpha particles

Because alpha particles are comparatively heavy and have a charge, they react strongly with matter, producing large numbers of ions per unit length of their path. As a

result, they are not very penetrating. For example, 5 MeV alpha particles will only travel about 3.6 cm in air and will not penetrate an ordinary piece of paper. For the other materials the average travel distance with respect to air is approximately inversely proportional to the respective densities of each material. 5 MeV alpha particles will only travel about 4 μm in mammal tissue(ECTS, 2012).

Alpha particles can interact with either nuclei or orbital electrons in any absorbing medium such as air, water, tissue or metal. An alpha passing in the vicinity of nucleus may be deflected with no change in energy (Rutherford scattering), deflected with small change in energy or absorbed by nucleus, causing nuclear transformation (this process is negligible for alphas).

The most probable process involved in the absorption of alphas, however, are ionization and excitation of orbital electrons. Ionization occurs whenever the alpha particle is sufficiently close to electron to pull it out from orbit though coulomb attraction. Each time this occurs, the alpha loses kinetic energy and is thus slowed. The alpha also loses kinetic energy by exciting orbital electrons with interactions that are insufficient to cause ionization. As it becomes slowed, the alpha has tendency to cause ionization at an increasing rate. As the alpha nears to the end of its track, its rate of ionization peaks and within very short distance, it stops, collects two electrons and becomes helium atom(Dendy,P.P 1999).

Since alpha are low in penetration ability, they themselves are usually not hazardous for external exposure, unless the alpha-emitting nuclide is deposited to organism. When internally deposited, alpha particles are often more damaging than most other types of

particles because comparatively large amounts of energy are deposited within a very small volume of tissue.

Beta particles

Beta particles can interact with electrons as well as nuclei in the medium through which they are travelling. Beta particles passing near nucleus will be deflected by the coulomb forces and losses of the beta particles kinetic energy may or may notoccur (Rutherford scattering).

The interactions of beta particles with orbital electrons are most important. Coulomb repulsion between beta particles and electrons frequently results in ionization. In the ionization process, the beta particles lose an amount of energy equal to the kinetic energy of the electron plus the energy used to free it from the atom. A beta particle may produce 50 to 150 ion pairs per centimeter of air before its kinetic energy is completely dissipated. The characteristic X-rays are emitted, when the vacant internal electron orbits are refilled with other electrons. Beta particles also cause excitation of external orbital electrons, which in turn leads to the emission of ultraviolet photons(ECTS, 2012).

The ultimate fate of a beta particle depends upon its charge. A negatively charged beta particle, after its kinetic energy has been spent, either combines with a positively charged ion, or becomes a "free electron". Positrons, however, have a different fate. In spite of the fact that they dissipate their kinetic energy just like beta particles through ionization and excitation, they cannot exist at rest in the vicinity of the electrons. When a positron has been slowed sufficiently, it will be attracted to the opposite charge of an electron. When the electron and positron collide, they are both annihilated and an amount of energy equal to the sum of the particle masses is released in the form of two photons.

These photons are referred to as "annihilation radiation". Both annihilation photons carry energy of 0.512 MeV, which is equivalent to the rest mass of the electron or the positron. Because of this phenomenon, 0.512 MeV photons often provide a convenient means for measurement of positron-emitting radionuclides.

Like alpha particles, betas have a characteristic average traveling distance (range) through matter that is dependent upon their initial kinetic energy. Beta particle range may be expressed as distance traveled in a certain medium. For example, beta particle with energy about 2 MeV will travel up to 9 m in air and about 10 mm in water.

X-ray and Gamma Ray

The interaction of photons (γ-quantums) with matter involves several distinct processes. The relative importance and efficiency of each process is strongly dependent upon the energy of the photons and upon the density and atomic number of the absorbing medium. We shall first consider the general case of photon attenuation and then discuss some of the important processes separately(Annunziata M. et al 2003).

Rayleigh Scattering

When a photon interacts with atom, it may or may not impart some energy to it. The photon may be deflected with no energy transfer. This process is called Rayleigh scattering and is most probable for very low-energy photons(Dendy,P.P 1999).

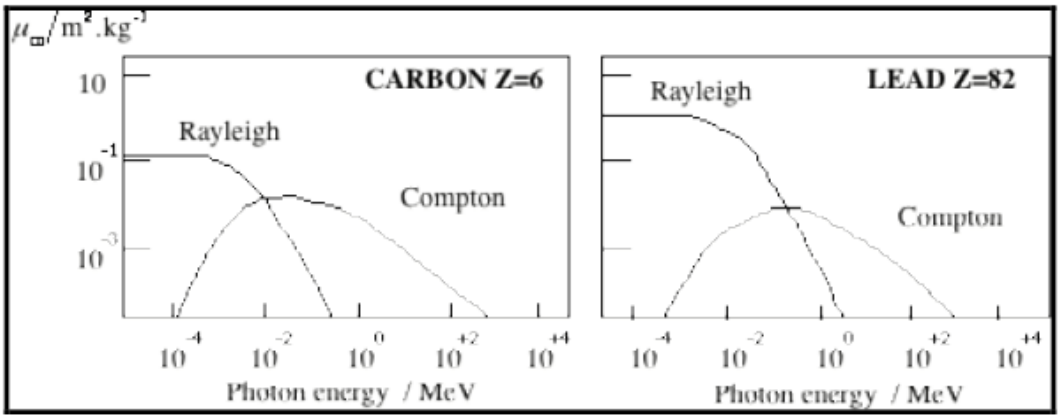


Fig 2.2:Mass attenuation coefficients for Compton and Rayleigh scattering(ECTS,2012)

Compton Effect

The Compton effect is usually the predominant type of interaction for medium energy photons (0.3 to 3 MeV). In this process the photon interacts with an atomic electron sufficiently to eject it from orbit, the photon retains a portion of its original energy and continues moving in a new direction. Thus, the Compton effect has an absorption component and scattering component. The amount of energy lost by the photon can be related to the angle at which the scattered photon travels relative to the original direction of travel(ECTS, 2012).

The scattered photon will interact again, but since its energy has decreased, it becomes more probable that it will enter into a photoelectric or Rayleigh interaction. The free electron produced by the Compton process may be quite energetic and behave like a beta particle of similar energy, producing secondary ionization and excitation before coming to rest.

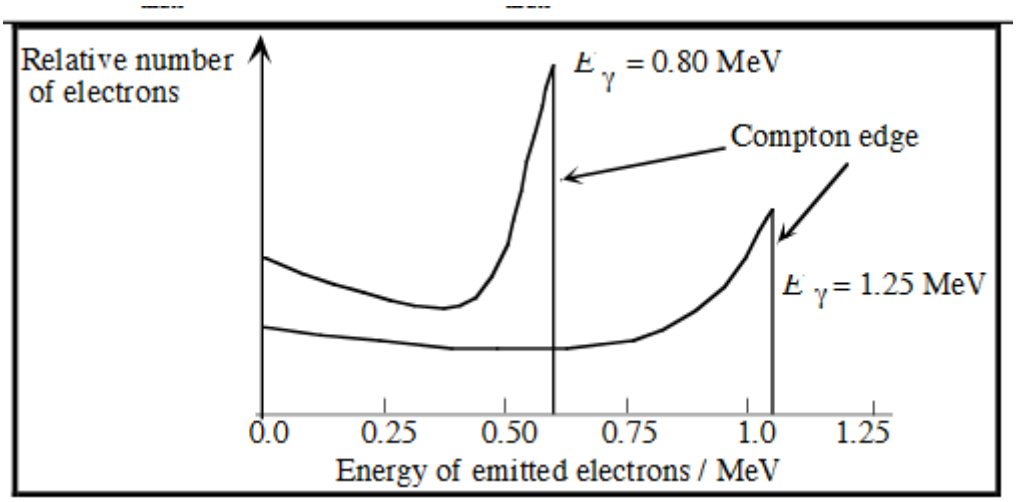
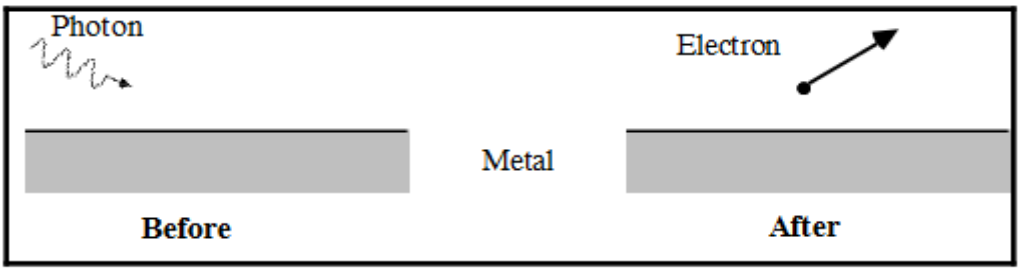


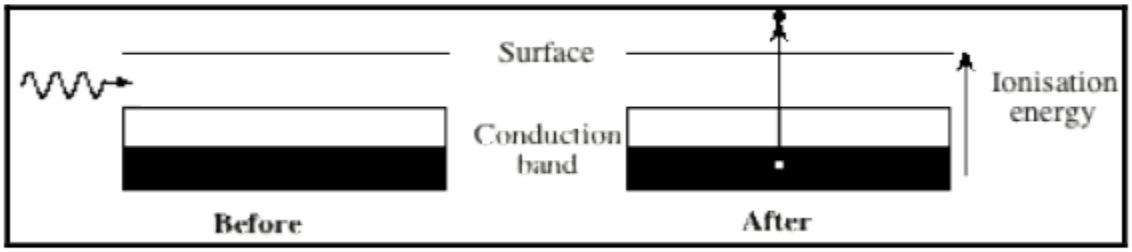
Fig 2.3:Energy distribution of Compton-scattered photons (ECTS,2012)

Photoelectric Absorption

The most probable fate of a photon having energy slightly higher than the binding energy of atomic electrons is photoelectric absorption. In this process, the photon transfers all of its energy to the electron and its own existence terminates. The electron will escape its orbit with a kinetic energy equal to the difference between the photon energy and its own binding energy. Photoelectric absorption is most important for photons below 0.1 MeV if the absorbing medium is water or biological tissue. However, in high Z (atomic mass number) materials such as lead, this process is relatively important for photons up to about 1 MeV(Dendy,P.P 1999).



Photoelectric effect in a metal



Photoelectric effect in a metal energy level diagram

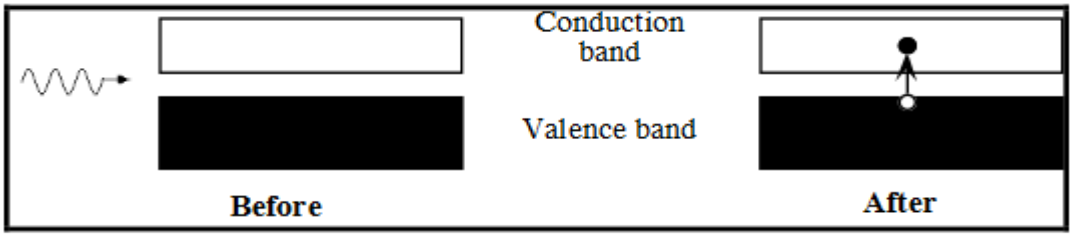


Fig.2.4 :Photoelectric effect in a metal semi conductor energy level diagram (ECTS,2012)

As with ionization produced by any process, secondary radiation are initiated, in this case, by the photoelectron which may have sufficient energy to produce additional ionization and excitation of orbital electrons. Also, filling of the electron vacancy left by the photoelectron results in characteristic X-rays(ECTS, 2012).

Pair Production

Photons with energy greater than 1.024 MeV, under the influence of the electromagnetic field of a nucleus, may be converted into electron and positron. At least 1.024 MeV of photons energy are required for pair production, because the energy equivalent of the rest mass of the electron and positron is 0.51 MeV each. Pair production

is not very probable, however, until the photon energy exceeds about 5 MeV. The available kinetic energy to be shared by the electron and the positron is the photon energy minus 1.02 MeV, or that energy needed to create the pair. The probability of pair production increases with Z of the absorber and with the photon energy (ECTS, 2012)



Fig.2.5 :Pair production(ECTS,2012)

Relative Importance of Photon Attenuation Processes

The various processes of photon attenuation can now be considered by examining the effects of photon energy and atomic mass number of the absorber on their relative importance (Figure 1). The lines in the figure indicate the values of the photon energy and Z where the probabilities of occurrence of two major processes are equal.

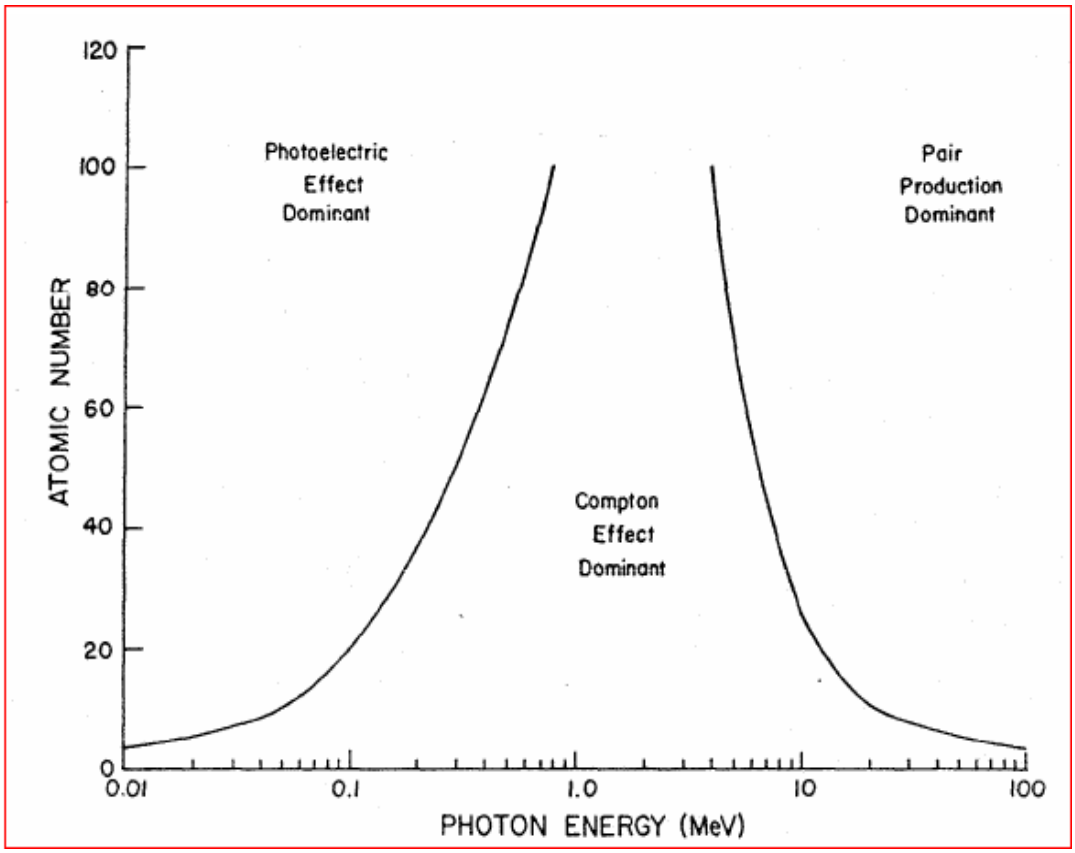


Figure 2.6. Effects of photon energy and atomic mass number of absorbing medium on dominant type of photon attenuation processes.

Neutrons

The neutrons interact with atoms due to electromagnetic and nuclear forces. The neutrons affect living matter by the process of moderation. A high-energy neutron encountering biological material is apt to collide with a proton with sufficient force to dislodge the proton from the molecule, which held it. The proton (normally called the "recoil proton") may then have sufficient energy to travel some distance in the tissue causing secondary damage through ionization and excitation of molecules along its path(ECTS, 2012).

2.2.13 Regulation on Radioactive Contamination in Drinking Water.

The regulations on the contamination level of radioactivity in water as set by the 1976 National Interim Regulation of the USEPA (Milvy and Cothern, 1990) is as follows:

Gross alpha	550Bq/m^3
Radium-226 and Radium-228	185Bq/m^3
Gross Beta	1850Bq/m^3

The maximum regulatory equivalent dose from man-made radionuclides was set at 0.04mSv. It is believed that no interim maximum contamination level standard for uranium in drinking water exists (Milvy and Cothern, 1990). Many experts have suggested that maximum contamination level be set in the range of 0.74 x 10^{-3}Bq/m^3 to 3.7 x $l0^{-3}$Bq/m^3, based on both chemo toxic and radiological risk of uranium. Data from the United States national inorganic radionuclide survey (NIRS) shows that less than 4% of the nation's 60,000 public water supplies exceed the lower regulatory level. Also less than 0.5% exceeds the higher value level (Longtin, 1988).

2.2.14. Quantification of the Effects of Radioactivity in Drinking water

The calculation of the absorbed dose from internally deposited radioisotopes has to be done with the assumptions that as radioisotopes get into the body, they are accumulated in one or more organs in the body. After its deposition, these radioisotopes are eliminated from the organ at the rate determined by its half-life. The retention of the radioisotopes in the body is given (Cember, 1996) as

$$Q = Q_o e^{-\lambda_E T} \qquad 2.8$$

Where Q_0 is the initial activity of the radioisotopes at time t = 0, Q is the activity remaining after a time T andλ_E is the effective elimination constantand.If the intake continues, then the accumulation of the isotopes is given by

$$Q = \frac{K}{\lambda_E}(1 - e^{\lambda_E T}) \qquad 2.9$$

Where k is the intake of activity per unit time (Bq/day).And $\lambda_E$is effective elimination constant, as t increases, λ_E decreases and the body burden Q approaches the limiting point (Cember, 1996) as

$$Q = \frac{K}{\lambda_E} \qquad 2.10$$

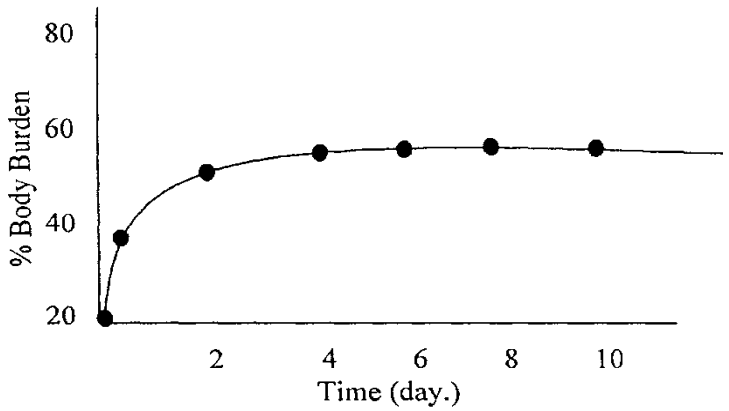


Fig. 2.7: Build-up of a Radioisotope in the Body Resulting from Continuous Intake.

(United Nation Scientific Committee 1982)

The limiting value, for practical purposes is reached after about six-effective half lives. At this time a steady state is reached, in which the amount of activity deposited is equal to the amount of activity eliminated (Cember, 1996).

For estimation of maximum permissible concentration (MPC) of radioisotope in drinking water, some physical and biological data must be known. These include the type of radiation (α, $\beta$and γ), the energy of the radiation, and the radiological half-life (physical data). The biological data include identification of the critical organ, biological clearance rate from the critical organ and the fraction of the ingested activity that is systematically deposited. For example, ICRP publication 2 shows that ^{131}I a beta-emitter, with activity of 5.4 x l0^{3}Bq had the maximum permissible body burden of 2.7 x 10^{4}Bq. The quantity of a radioisotope when uniformly distributed throughout an organ delivers the maximum recommended dose rate to the organ (Cember, 1996) This dose rate is given by:

$$q = \frac{A_O E_O}{m} \qquad 2.11$$

Where q is the dose rate in Gy/s, A_0 is the activity in Bq, E_0 is the effective energy in MeV and m is the mass in kg.

To estimate the maximum concentration in drinking water for any radionuclide in a steady state conditions it is assumed that The activity deposited is equal to the activity eliminated therefore,

$$C(Bq/ml) x 2.2 x 10^{3}(ml/day) \times F = \lambda_E(day^{-1}) \times A_0(Bq) \qquad 2.l2$$

Where C is the maximum permissible concentration of isotope in water, F is the fraction of intake that is deposited in critical organ,λ_E is the effective elimination constant and A_0 is the steady state activity in critical organ. ICRP publication 2 lists the MPC in water for continuous ingestion as 0.74 x 10^{-6}Bq/m^{3}. For forty hour per week of occupational exposure the MPC in water for ^{131}I is 2.22 x 10^{-6}Bq/m^{3} (Cember, 1996).

Table 2.4 below shows the equivalent dose rate to some organs due to intake of radionuclide

Table 2.3: Equivalent Dose rates of Different Organs

Daily Equivalent dose rate (104μSv)	Critical Organ
1.4	Whole body, hemopoetic system, gonads
8.6	Throid
4.3	Other organs or tissues

(Cember, 1996)

Figure 2.8 below gives the overall screening and guidance level for gross alpha and beta radioactivity in ground water (ICRP, 1991).

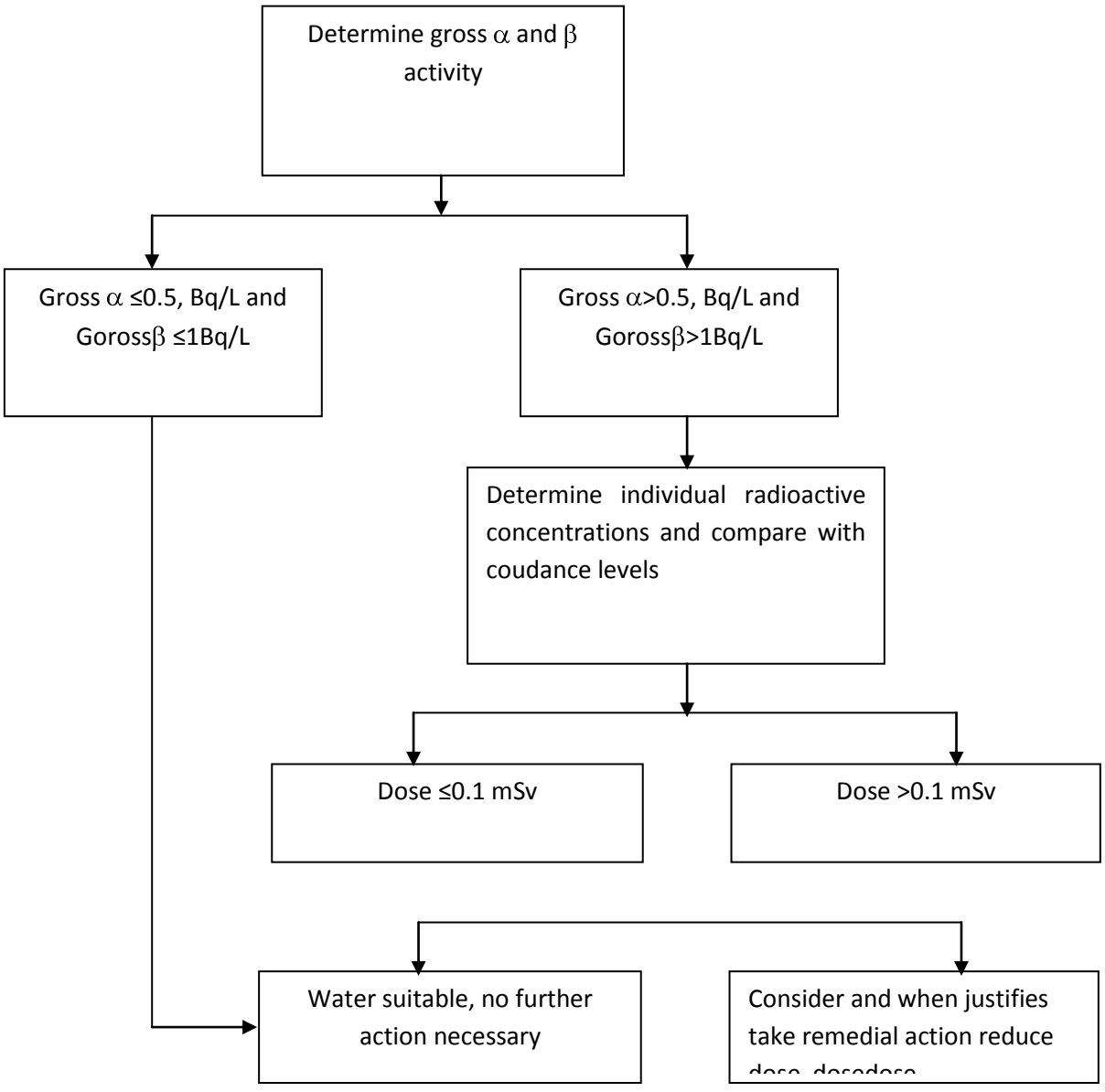


Figure 2.8Flow chart for deciding guidance level for radioactivity in water

Sources :(ICRP, 1991)

2.3 Maximum Acceptable Values [MAV] Of Radioactivity In Drinking Water

All life on earth is exposed to radiation from material sources including cosmic radiation; external radiation from natural radionuclides presence in soils, rocks and building materials; and internal radiation due to uranium-238, potassium-40 and inhaled radionuclides, particularly as the compositions of solid and rocks change, and increase with altitude as cosmic radiation intensity increases. Radon is a radioactive gas, which emanates from the ground and can accumulate in buildings. Use of water can increase the indoor radon concentration and if radon is present in the radionuclides in drinking –water is an increase in cancer rate. This prompts for the need to set limits for radiological determinants, so that the radiation exposure resulting from the presence of radionuclides in water presents only a small part of the total radiation exposure from natural sources.

The MAVs for radiological determinants are:

Total Alpha Concentration: 500 Bqm^{-3}, excluding Rn-222

Total Beta Concentration: 1,000 Bqm^{-3}, excluding K-40

Radon -222 Concentration: 100,000 Bqm^{-3}

In the radiological context, the MAV is intended to indicate a level above which the radioactive content of the water should be investigated further and an assessment of all relevant radiological issues undertaken. The MAV is thus more of a guideline than necessarily an absolute maximum. It is also intended to be clear however, that at levels below the MAV, there is no need for further assessment.

2.3.1Alpha activity in natural Radioactivity series

Three isotopes of uranium are known to occur naturally, they are^{234}U, ^{235}U, ^{238}U. The relative abundances of ^{234}U, ^{235}U, ^{238}U are 0.0054%, 0.7110%, 99.230%, respectively. Although the abundance of $^{234}U$is much less than the abundance of ^{238}U on a grametric basis, $^{234}U$is in secular equilibrium with ^{238}U, so that when all of the media containing these isotopes in taken into account, the activity of ^{234}U must equal the

activity of ^{238}U,and it is known that groundwater samples are often enriched in ^{234}U relative to ^{238}U.

The alpha activity A of a particular uranium isotope is just

$$A=\lambda N \qquad (2.1.1)$$

Where λ is the decay constant of the uranium isotope and N is the Number of atoms of the uranium isotope.

And

$$N=m\frac{No}{W} \qquad (2.1.2)$$

Where m is the mass of the uranium isotope, N_0 is Avagodro's number, and W is the atomic weight of the uranium isotope.

If m is the mass of the isotope, m_T is the total uranium mass, and f is the fractional abundance of the uranium isotope, then the total uranium A_T is just the sum of three such terms, one from each uranium isotope.

$$A_T = \left(\frac{\gamma_{U234}}{W_{U234}} f_{U234} + \frac{\gamma_{U235}}{M_{U235}} f_{U235} + \frac{\gamma_{U238}}{M_{U238}} f_{U238}\right) N_{0M1} \qquad (2.1.3)$$

2.3.2 Radon in Water

Radon gas is responsible for a large percentage of natural radiation exposure; it comes mainly due to decay of radium contained in rocks and soil as part of the uranium radionuclide. Radon is present virtually everywhere on earth, but particularly in air over land and in buildings. Underground rock containing natural uranium continuously releases radon. Radon is readily released from surface water; consequently, groundwater normally has much higher concentrations of radon than surface water.

2.3.3 Transport of radionuclide's in ground water Source of Contamination

Radioactivity in groundwater comes from two sources; natural and artificial. Artificial radioactivity is usually found in surface water due to human activities while naturally occurring radioactivity comes from the bedrock. The natural radioactivity is mainly due to contamination as a result of leaching of materials in the earth crust while the artificial enter the subsurface environment through waste disposal practices, spills, and land application iof chemicals. Among the most health-relevant naturallyoccurring groundwater constituents are arsenic, fluoride, selenium, radon and uranium. (Rivett, et al.2002)

The establishment of effective disposal and isolation procedures for chemical-wastes, the protection of public health, and the understanding of the nature and distribution pattern of radioactivity in groundwater rely on the ability to predict the velocity at which contaminants move through the vadose (unsaturated) and saturated zones. For the transport nature of contaminants to be well understood, a valid conceptual model of the contaminant migration needs to be developed. A classical contaminant conceptual model of a near surface "leaching source zone" where chemical contaminant is leached, that is dissolved or solubilise, into water infiltrating through the source , a dissolved phase chemical solute plume subsequently emerges in water draining from the base of the contaminant source zone and moves vertically downward through any unsaturated zone present the dissolved solute plume ultimately penetrates below the water table to subsequently migrate laterally in the following groundwater. Many sources such as a landfill, chemical waste lagoon, contaminated industrial site soils, pesticide residues in field soils, may have sufficient chemical mass to enable them to act as long-term generators of dissolved phase contaminant plumest; potentially such sources can last decades. This will lead to continuous dissolved-phase plumes extending from these sources through the groundwater pathway that grow with time and may ultimately reach distant eceptors unless attention processes operate. This near-surface leachable source-dissolved-plume conceptual model is the model mostly invoked and the one to which groundwater vulnerability and protection concepts and groundwater risk-assessment models are most easily applied.

In arid and semi-arid regions, such as the study area, evapotranspiration rates are much higher. Recharge is less, flow paths longer and residence times much greater and hence much higher leves of natural mineralization. Thus the major ion contents and Total Desolve Solid (TDS) are often high. In some desert regions, even if groundwater can be found it may be so salty (extremely high TDS) as to

beundrinkable, and the difficult of meeting even the most basic domestic requirements can have serious impacts on health and livelihood. (Rivett., et al 2002)

2.3.4 Methods Of Gross Alpha And Beta Radioactivity

To analyse drinking-water for gross alpha and gross beta activities, the dryness and measure the activity of the residue using a gas free single channel proportional counter. As alpha radiation is easily within a thin layer of solid material, the reliability and sensitivity of the method for alpha determination may be reduced in samples with high TDS content. Counting efficiency of alpha particles by this method is 35% to 40% at best (≡0 mg residue) and declines to less than 10%when 100mg of solids are left on the counting planchet. The counting time in excess. Of 1000 minutes are typically require to reach a detection limit of 100 mBq/L. samples containing extremely high level of dissolved solid may require even long counting time to achieve the desired detection limit since an even smaller samples size must be used. (Thakkar.et al 2002). An alternative method is the used for liquid scintillation counter. The inherent counter efficiency for alpha particles by this method is in excess of 90%. Since it does not suffer from self absorption problems, this method can equally handle higher level dissolved solid. However, the samples size is limited by what can be put into a liquid scintillation counter vial, and so for samples larger than 10ml, some form of sample concentration must be performed. Another new approach to the measurement of gross alpha in liquid samples, which involves using extraction chromatography and liquid scintillation counting has also been proposed. The method is fast and simple. As many as 20 samples can be processed in 24 hours, requiring only one to two of hands on time. Using $0.001m^3$ samples, a detection limit of 75mBq/L can be reached only 60 minutes counting time (Thakkar, et al. 2002).

2.4 Radioactivity Measurement

Radioactivity in water was determined by gas-filled detectors, scintillation and semi-conductor detectors. Alpha and beta activities was then detected by the proportional counters such as gas free,gas filled detector. Gamma activity was also detected by scintillation detectors and semiconductor detector like Ge (Li), HpGc detectors.

2.4.1 Detection Based On Ionization

The two types of detector used for radiation monitoring,whose mode of operation is based on ionization are

1. Gas filled detectors
2. Solid state conductivity detectors

2.4.2 GAS FILLED DETECTORS

The Gas filled detector Consist a chamber filled with a gas and two electrodes,The positive electrode is called the anode and it is often at the centre of the chamber. It is electrically insulated from the outer casing. The outer casing of the chamber is often the negative electrode or cathode.(Nicholas T. 2010)

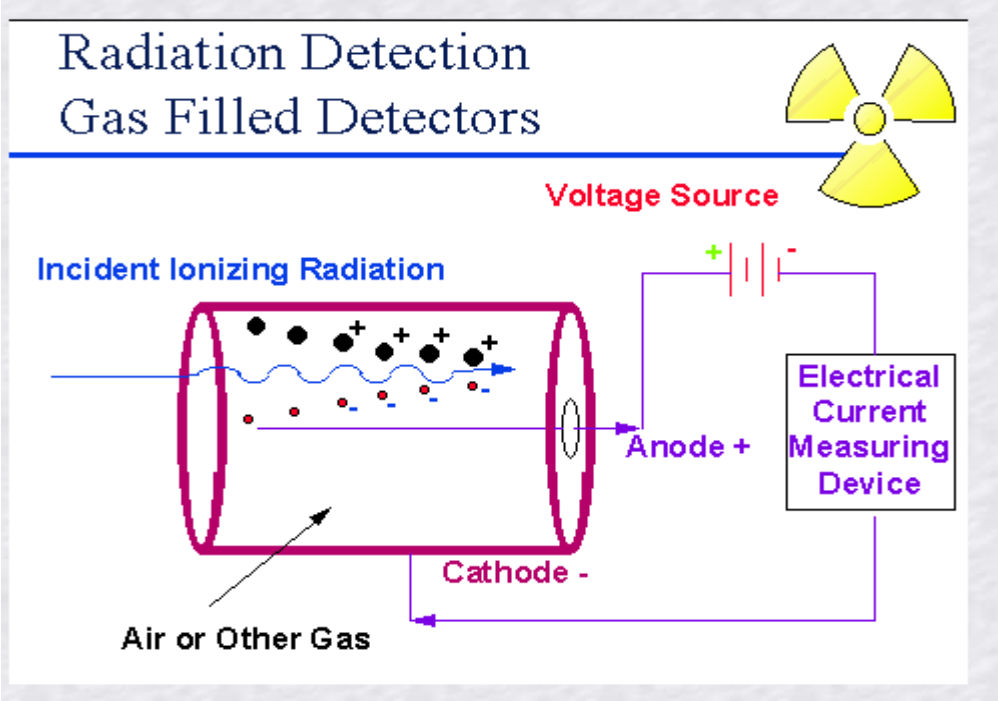


Fig 2.9 simple diagram of gas filled detector

Mode of operation of the gas filled Detector

Incoming radiation interact with the wall of the chamber or the gas particles and produce ion pair. When voltage is applied between the electrode positive ions are attracted towards the positive charged electrode anode. A charge lose on the anode causing a change in voltage. This change in voltage is referred to as DV=pulse and the presence of the pulse cause the current to flow in the external circuit. By detecting the pulse or current we can detect the passage of ionizing radiation. The size of pulse depends on the number of electrons collected by the anode and this can defend on the amount of ionizing radiation entering the chamber in addition, the size of the pulse is often function of voltage applied between the cathode & anode figure show how pulse size varies as the applied voltage is increase.

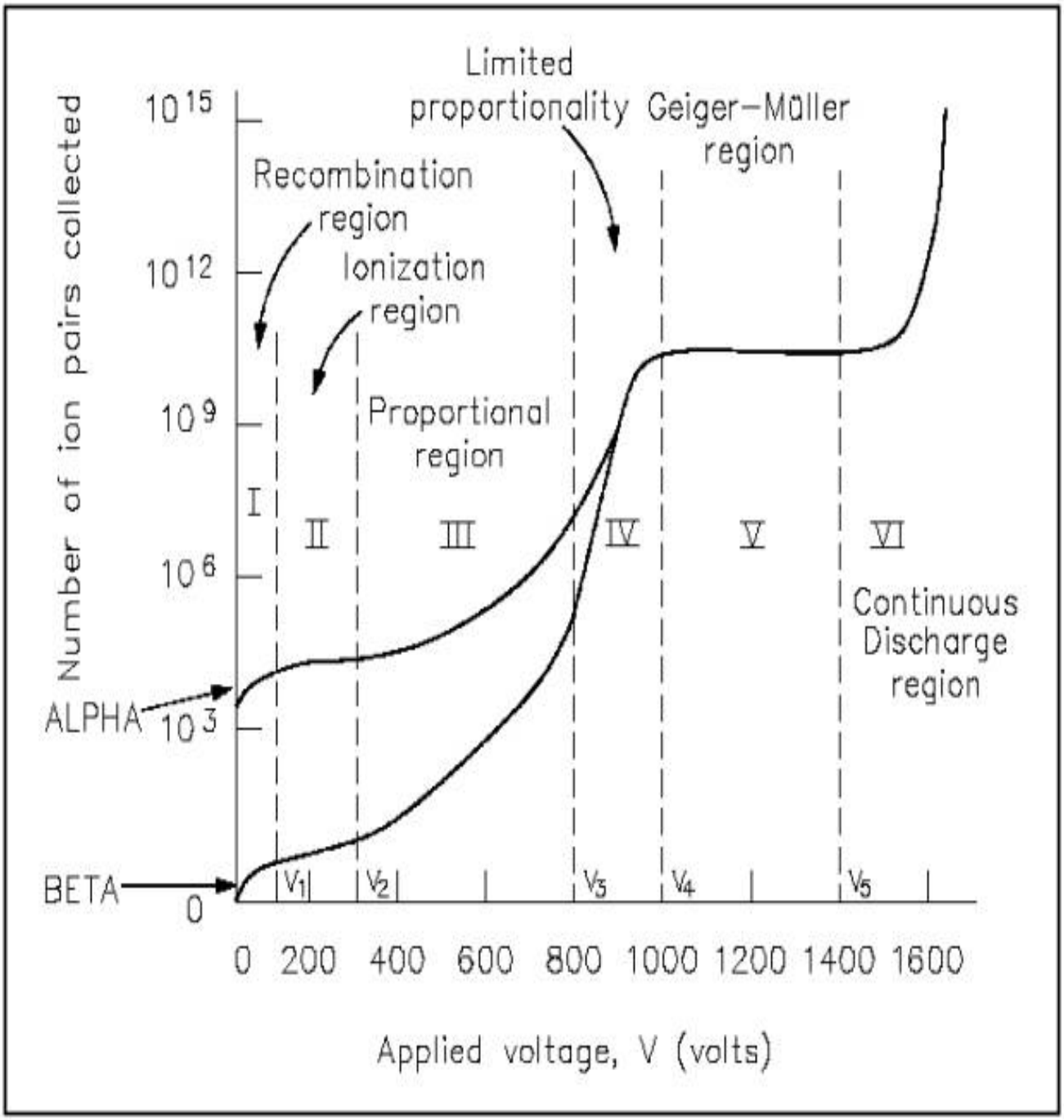


Fig 2.10 (Nicholas T. 2010)

I Recombination region

II Ion chamber region

III Proportional region limited

IV Limited proportionality

V Geiger miller region

Discharge region

There is limited proportional region in some recombination region when the voltage on the chamber is quite known, the forces is also quite low in this situation, there are two processes which are computing for the ionize.

1. Ion collection
2. Ion recombination

This means that, after an ion has been found it may recombine to become mention again before it can be collected by the electrode. Hence, the pulse in the external circuit depend on the outcome between the two processes. As the voltage across the electrode is increase more of the ions which the electrode and pulse size increases. How ever, recombination of ions is still significant and so this region is known as recombination region, gas filled detection are not operated in this region.

Ion chamber region: When voltage is large enope almost all the ions generated will teach the electrode and the lost of ions through recombination is negligible in this region realy all ions are been collected and the pulse size no longer increase with the apply

voltage instead is level out to the platoon known as ion chamber region. The current I flowing in the circuit also reach a maximum value known as the saturated current the saturated current is proportional to the amount of radiation entering the chamber and if the amount of radiation is increase the saturated current increase.(Nicholas T. 2010)

Proportional region: As the voltage increase passed the ion chamber region the pulse height has lead to increase again we can explain why the pulse size as the applied voltage increase the ion not get enough energy to reach. But also gain enough energy to acceleration. This act causing more ions pairs to through secondary ionization or the particles of the gas the process is known as the gas multiplication and it result in collection of more ions pair and therefore enlarge pulse the increase in the number of ions collected is function of the applied voltage however, the total pulse size that result is also proportional to the initial number of ions produce in the gas. For these reactions the region of the gas filled detectors where this occurs is known as proportional region.(Nicholas T. 2010)

Geiger muller region: If the voltage is increased still further the gas multiplication ion is so strong that produce multiple avalanches along the length of the anode resulting in a very large pulse.

This region where this occurs is Geiger Muller region and in this region the size of the pulse is the same regardless of the quality of energy originally deposited, the pulse size is control more by the external circuit and the pulse light has shown a very small rise as the voltage increase. Continues discharge if the volume increase beyong the Geiger Muller platoo then the voltage is height enough to ionize the gas molecules directly and the large

signal generated even when radiation fill is remove. This is called the continuos discharge region as the readings can be misleading, the radiation detectors can not be operated in this region.

(a) IONIZATION CHAMBER (IONS CHAMBERS)

Are design to operate at saturation current in the ion chamber as shown in Fig. 2.4 the average current output is measure and is proportional to the amount of radiation to which the chamber has been expose since the output does not defend on the voltage there is no need for a highly stable power supply. However, it is important that the voltage is steady anope to ensure saturation current.

(Nicholas, 2010)

(b) Internal Proportional Counter

Proportional counters as gas filled detectors operate on the principle of ionization of the counting gas by the incident radiation, and subsequent charge collection at the electrodes. These collected charges give the measure of the energy of the incident radiation.

Internal proportional counters are suitable for determining alpha activity, at the alpha operating plateau and alpha plus beta activity at the beta-operating plateau The alpha or beta activity, or both, can emanate from a single or several radionuclides. The internal proportional counter accepts counting pans within the counting chambers and at the beta operating voltage records all alpha, all beta and some gamma radiations emitted into the counting gas (Arnold, et a!., 1992). Theoretically half of the radiation is emitted

in the direction of the counting pan. Some of the beta radiation, but only 1% to 2% of the alpha radiation, is backscattered into the counting gas by sample solids, the counting pans or walls of the counting chamber. The percentage of beta radiation detected may be around 60% while that of the alpha radiation is 50% for substantially weightless samples (Arnold, et al., 1992).

(V) **Geiger Muller Counters**

This operate in a Geiger Muller as shown in fig 2.4 above and used as gas filing such as the p-10 use in proportional counter the height of output pulse is independent of the energy of ionizing particles this means that is not possible to distinguish electronically between α & β particles radiation now it is possible to measure or discriminate between the energy of the incoming radiation in the Geiger Muller region a discharge take place along the anode this discharge must be quente to prevent it continues by itself and to prevent multiple pulse form use an appropriate gas such as organic gases or halogen in addition to filling gas will provide punches.

Table 2.4 Summary of gas filled detectors

Detector	Type of radiation	Efficiency	Comments
Ionization chambers	Alpha	High (with suitable thin end window	Use for counting &spectrocopy
	Beta	Moderate (with a suitable thin end window	Used in portable radiation monitoring instrument
	Gamma	<0	" "
	X-ray	Depends on window thickness	Useful most energies encountered in radiation protection

The international standard organization (ISO 9696 and ISO 9697:1992E) procedure for the measurement of gross alpha and beta activity in water was employed in this anlysis.This procedure provided a screening technique to determine the gross alpha and beta radioactivity in water samples.The procedure is highlighted below.

Table 2.4: Summary of gas filled detector

Proportional counter	Alpha	High (with sutaible thin end window	Use for counting& spectroscopy
	Beta	Moderate (with suitability thin and window	Use for counting all energies &spectroscopy
	Gamma	<1%	-
	x-ray	Depends on window thickness	-
G.m. counter	Alpha	Moderate CT suitably thin end window	Cannot discriminate between energies
	Beta	Moderate (with suitably thin end windows	-Cannot discriminate between energies
	Gamma	<1%	But used inpotable radiation monitoring
	x-rays	Depend on window thickness	

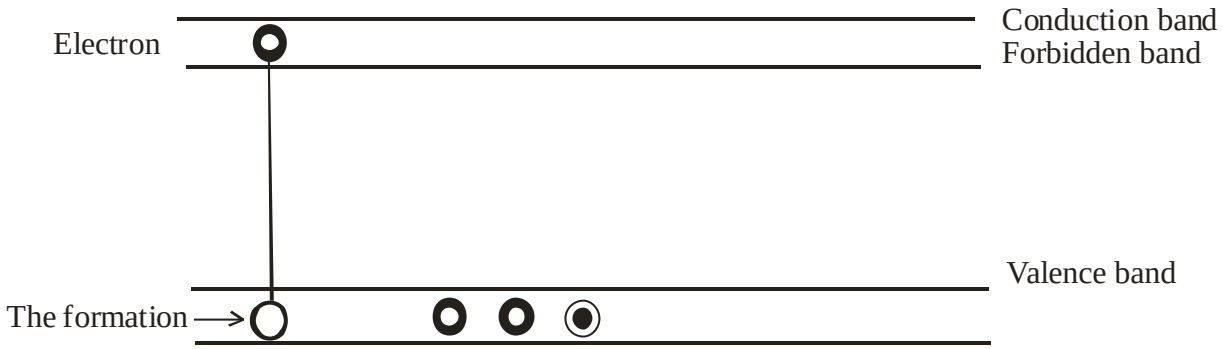
(Arnold, et al., 1992).

2.4.3 Solid State Conductivity Detectors

Solid state conductivity detectors conductivity refers to ability of a material to conduct electric current. Materials that have good conductivity are known as conductors e.g. metals. Materials that have poor conductivity are known as insulators e.g. (wood). A semi conductor is a material with properties some where in between these two extremes and although the are a number of substances with semi Conductor properties. The one commonly use for radiation detection are the crysteline.Solid of silicon & germanium solid state conductivity detectors are so named because they consist of semi conductor crystalline solid. When ionizing radiation interacts with this solid the overall conductivity of the material is increased. This increase if measured, can be related to the amount of incident radiation.(Knoll F.G 1989)

Mode of operation

To understand how solid state conductivity detectors work,we need to consider interaction of ionizing radiation with semiconductor material on a microscopic scale. In the structure of matter, electrons can only exist in definite energy levels,usually referred to as energy bands.These energy bands are separated by an area known as forbidden bands and the highest energy band in which electrons usually exist is known as valence bands.



The formation of electron-hole pair by ionizing rad.

Fig 2.11The formation of electron – hole pair by ionizing radiation.

Ionizing radiation can give enough energy to an electron in a semi conductor crystalline solid to move it from itsnormal energy level (valence band) through normally forbidden levels into a higher energy level (conduction band) as this happens itcreatesa vacancy (hole) as seen in fig-2.5.The raising of the electrons to the conduction band is known as ionization and the resulting electron hole pairs can be compared with ion pairs in the same ways as positive & negative ions move between electrode in a gas filled detectors & the ion pairs will move in a solid state detectors when a voltage is applied. Note that in reality the positive charge materials can not move in a crystalline solid materials, what actually happen, is that holes are filled by neibouring electrons which move across and leave another hole(Knoll F.G 1989).

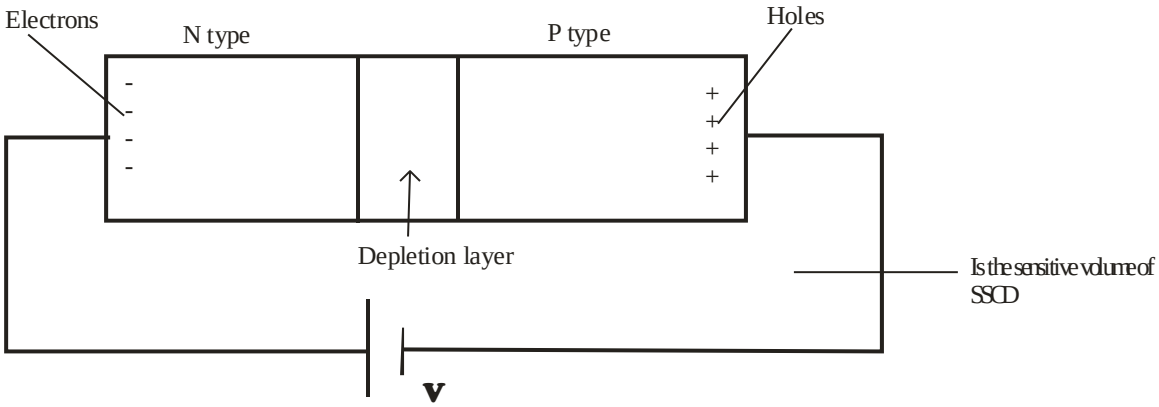


fig 2.12Simple diagram of solid state conductivity detector

TYPES OF Solid State Conductivity Detector (SSCD)

There are many different types of SSCD. Available for detecting ionizing radiation. The types of SSCD consider are as follows.

(a) Surface barrier detectors

(b) Ion implantation detectors

(c) Lithium drifted detectors

(d) Lithium Drifted Silicon

(e)High purity germanium detectors

(a)The Basic Surface Barrier Detector

As well as exteremely efficient at detecting charge particles, surface detectors are also very good in separating out the different energy of the incoming radiation (i.e. there good energy resolution). Separate family of α-particles from Am-241 with energy of 5.486, 5.443 & 5.389MeV. One of the main problem with crystal barrier must be kept very clean

and free from oil or other foring material. They are also very sensitive to light because light photons can reach the sensitive volume and electrons holes pairs.(Nicholas T. 2010)

(b) ION INPLANTATION DETECTORS

In alternative method of introducing impurities. Is to expose the suface a beam of ions to produce by an accelerators e.g. A silicon crystal expose to boron ions will have a layer of β-type materials forms close to the surface.

This methods of dapping is called ion implantation and it give a much more stable crystal which is less likely to be effected by environmental condition. In fact, this type of detectors are very roget and the can be manufactures with thin end windows for alpha and Beta detectors ion implantation detectors have a wide variety of application include α-spectroscopy, low energy β-detector, and heavy ion detectors(Knoll F.G 1989).

(c) LITHIUM DRIPTED DIODE

Surface barrier & ion implantation detectors are very good for spectroscopy of charges particles in the semiconductors crystal that do not have a large anope sensitive volume for photons/gammarays& x-rays spectroscopy). To counteract the effect due to this impurities, semiconductors can have lithium added to them to create a digger sensitive volume.The area between the p-type and n-type is known as lithiumdripted or intristic region and the size of this intristic region determine the sensitive volume of the detectors.

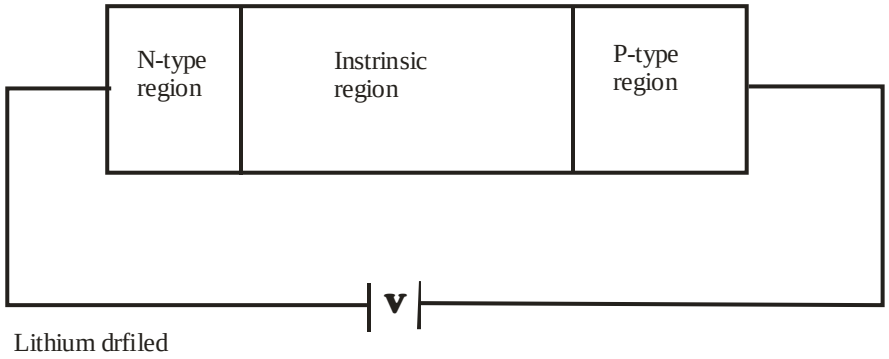


Fig 2.13 LitiumDripted

When lithium is added to a germanium crystal the detectors is called a lithium dripted germanium detectors. At room temperature the lithium atom will continues to move through the germanium.

Changing the nature of the intrinsic region it is important Geli detectors is always kept at a very low temperature using liquid nitrogen even when not been used lithium dripted germanium detectors are efficient detectors for gamma radiation and have excellent energy resolution(Knoll F.G 1989).

(d) LITHIUM DRIPTED SILICON

This consist of lithium dripted silicon crystal.These lithium silicon (Si(Li)) detectors are very similar to Ge(Li) detectors but have the advantage that can be stored at room temperature without any damage to the crystal.They can be operated at room temperature but their performance is greatly improved if they are cool by little liquid nitrogen.

(e) HIGH PURITY GERMANIUM DETECTORS

Pure germanium has high efficiency for the detector of gamma radiation

If the impurities in a germanium crystals is kept low, it is possible to obtain depletion layers that are comparable with those in Ge(li) detectors. This type of detector is called a high purity germanium detectorHp (Ge) detectors.Like the Ge(li) detectors the Hp (Ge) detectors act as an efficiency gamma detectors with excellent energy resolution. Similarly both detectors require cooling with liquid nitrogen for high efficiency. One advantage of Hp(Ge) is that it may be stored at room temperature when not used(Knoll F.G 1989).

Table 2.5Summary On Solid State Conducting Detectors (SSCD)

DETECTORS	MAIN USE	ADVANTAGE	DISADVANTAGE
DJD	Charged particles detectors	More rugged than surface brier	Lower energy particles not detected
SPPD	Photon detection	Light weight	
SBD	Alpha & beta spectroscopy	Efficient at detecting particles, very good energy resolution	Surface must be kept very clean Very sensitive to light
IID	Alpha spectroscopy low energy beta monitoring	Less likely to be affected by environmental conditions Very rugged	
LD Gelid	Gamma spectroscopy	Efficient detectors for Gamma radiation Excellent energy resolution	Must be kept at liquid nitrogen temp. at all times
Dsu Si (li)	B,γ,x-ray spectrocity	Good detector for very low energy gamma ray (<150, kev), X-rays & β-particles can be operated at room temp	Less likely to interact with gamma radiation then Ge (li) detectors
Ged	Gamma spectroscopy	Efficient detectors for gamma radiation, energy resolution may be stored	Should be cooled to liquid nitrogen dunney

(Arnold, et al., 1992).

Thin-windows Proportional Counter

This counter can detect alpha and low energy beta radioactivities. The counter is of very thin shielding, of plastic films less than 250 $mgcm^2$, and tube of about 5cm in diameter; and/or anti coincidence guard circuitry. It is about one-half as sensitive as internal proportional counter due to poor geometry; and absorbing losses (Jarrettee, 1946). The counter is less affected by contamination from loose residues, and poor electrical conductance, because the sample is outside (Jarrettee, 1946), unlike the internal proportional counter.

Low Background Beta Counter

This may be ionization for beta emitters having maximum energy of 0.3 MeV (Arnold, et al, 1992). The detector window thickness usually is less than $1.0mg/cm^2$ and alternation of high-energy radiation of moderate energy. The sample used may have a diameter less than that of the window. Instrument with a lead or steel shield and an anti-coincidence device of one or more guard detectors with an electronic is used to obtain a background counting rate of 1cpm or less.

2.4.4Instrument calibration

Calibration refers to the determination and adjustment of the instrument response in a particular radiation field of known intensity. Proper calibration procedures are an essential requisite toward providing confidence in measurements made to demonstrate compliance with cleanup criteria. Certain factors, such as energy dependence and environmental conditions, require consideration in the calibration process, depending on the conditions of use instrument in the field. Routine calibration of radiation detection instruments refers to calibration for normal use under typical field conditions. Routine calibration commonly involves the use of one or more sources of a specific radiation type

and energy of sufficient activity to provide adequatefield intensities for calibration on all ranges of concern. Ideally, detector should be calibration annually and respond cheked with a sourse following callibration (ANSI 1996). Instruments may require more frequent calibration if recommended by the manufacturer. Recalibration of instruments is also required if an instrument fails a performance check or if it has undergone repair or any that could affect its response. Recognized calibration procedures include, among others ANSI 1996b, DOE Order 5484. 1, NCRP 1978, NCRP 1985, NCRP 1991, iso 1988, HPS 1994a, HPS 1994b.

2.4.5 Counting Statistics

Two important statistical aspect of measuring radioactivity uncertainty result and negative values. For the fact that emission of radiation from an atom is a random process, a sample counted several times will yield a slightly different result each time; a single measurement is therefore, not definitive. To account for this phenomenon, the concept of uncertainty is applied to radiological data.

For a counter counting for some period T, the total count N_T will be the count due to the source N_S plus the count due to the background N_B.

$$N_T=N_S+N_b \qquad (2.4.1)$$

Or written in terms of rates,

$$R_T=R_S+R_B \qquad (2.4.2)$$

The background rate R_B can be determined simply by moving the source far away and re-measuring with the detector. The rate due to the source alone is

$$R_T=R_S-R_b \qquad (2.4.3)$$

The uncertainty in R_S, can then be obtained using the rule for propagation of errors in addition or subtraction:

$$\delta R_S=\sqrt{(\partial R_T)^2+(\partial R_B)^2} \qquad (2.4.4)$$

Similarly, it is possible for a radiological measurement to result in a negative number. Every sample which is analysed for radioactive material is compared to an instrument background, which is the number of radiation events observed in a blank sample. Since naturally-occurring radiation cannot be completely isolated in a sample measurement, the instrument background must be subtracted from the sample analysis. When measuring very low levels of radiation (such as those encountered in environmental media), where only a few radiation events are counted, it is common for the sample result to be insignificant. When the background is subtracted. A very low count results, signifying that the sample was found to contain lower radioactivity values as can be detected by the detector. Similarly, an average of several individual values in which some are positive and some are negative can result in a negative mean, indicating that the central trend of the data is a value which is not detectable.

2.4.6 Problems with Counting Instruments

The different counting instruments have different modes of operation and each has problems associated with it. A typical problem of most counters is the background or instrument counting rate, usually due to cosmic radiation contaminations in instrument parts and the counting room construction materials, and due to nearness of radioactivity source (Onoja, 2004).

The background noise is roughly proportional to the size or mass of the counting chamber of the detector, but can be reduced by metal shielding (Arnold, et al., .1992). Instrument "Noise" or false recording of radiation event, may be caused by faulty circuitry, too sensitive a gain setting, high humidity and variable line voltage or transients. These problems can be remedied by using constant voltage transformer with transient fitters, poorly adjusting gain setting as specified by the manufacturer, and air-conditioning of the counting room (Arnold, el al, 1992).

Also the coincidence and anti coincidence events arc worthy of mentioning. Coincidence unit is an electronic device that accepts pulse/events in two or more input channels. It gives an output signal only if the two input pulses arrive within a set time. On the other hand an anticoincidence unit is the one that accepts pulses/events in two input channels and provide an output signals only if the events do not arrive within a set time (Knoll, 1999). In measurement or counting of radiation there is need for background radiation and this is achieved by coincidence and anticoincidence shielding.

2.4.7 Coincidence Counting

If a radioactive sample that emits more than one distinguishable radiation in coincidence is to be counted, an effective background can greatly be reduced using coincidence technique. A suitable arrangement for this consists of separate beta particle and gamma ray detector in which the source is mounted to maximize the corresponding interaction rates in each detector. By demanding coincidence between pulses from the two detectors, many background interferences will be eliminated because they will occur in only one detector at a time (Onoja, 2004).

2.4.8Anti coincidence Shielding

Highly penetrating cosmic radiation which may interfere with the walls of a detector and cause background effect can be eliminated or reduced using anticoincidence, shielding.

A second detector surrounds the primary detector and the output of the primary detector is accepted only when coincident pulse in the outer detector does not accompany it (Onoja, 2004). The source to be counted is oriented and shielded so that it produces

interactions in the primary detector only when a coincident pulse in the outer detector does not accompany it. Therefore in the simplest case, no pulses are affected which correspond to the complete absorption of the source radiation within the primary detector.

However, the cosmic radiation will likely penetrate both detectors. Therefore, it can be eliminated from the output of the primary detector through the anti-coincidence arrangement (Onoja, 2004).

2.5 Review of related works

Juliet (2006) measured gross alpha and beta radioactivity in river kaduna. And found that the average alpha activity in the farming zone is $0.027\pm0.002x10^{3}Bqm^{-3}$ average alpha activity in the residential/commercial zone is $0.025 \pm 0.001 \times 10^{3}Bqm^{-3}$ and that in the industrial zone is $0.03\pm 0.003 \times 10^{3}Bqm^{-3}$.The average beta activity in the farming zone is $0.585\pm 0.007 \times 10^{3}Bqm^{-3}$,that in the residential/commercial zone is $0.411 \pm0.006 \times 10^{3}Bqm^{-3}$. While that of industrial zone is $0.321\pm 0.005 \times 10^{3}Bqm^{-3}$.The overall results show that both alpha activity and beta activity in the three zone are far below the practical screening level of radioactivity in drinking water of 500 Bqm^{-3} for alpha and 100 Bqm^{-3} for beta ,as recommended by CEC – FAO and WHO.

Mahesh (2001) studies the concentration of ^{222}Rn in ground waters of coasal Karnataka and kaiga of south western coast of India. It was found that the concentration of ^{222}Rn in open well water ranges from 0.14 to $25.4BqL^{-1}$. The research further estimated the water doses for the population of the region from the measure concentrations. The effective doses were found to vary from $0.09\mu Svy^{-1}$ to $204.2\mu Svy^{-1}$ for open well consumers and from $0.2\mu Svy^{-1}$ to $1586.9\mu Svy^{-1}$ for borehole consumers.

Avwiri, (2003) uses the gamma ray spectrometer to study the radionuclide concentration levels in soil and water samples in Eagle, Atlas and Rock cement companies in Port Harcourt. The average absorbed dose rates of the soil samples were found to be $49.27nGyh^{-1}$. $45.21nGyh^{-1}$, and $42.3nGyh^{-1}$ for eagle, Atlas sand Rock cement

respectively, while the water values were 22.16 $nGyh^{-1}$, 20.75$nGyh^{-1}$, and s19.37$nGyh^{-1}$for the respective companies. Mean dose rate equivalent of 0.18 $mSvy^{-1}$, and 0.39$mSvy^{-1}$ were obtained for the water and soil samples, the natural radionuclide level have been studied in surface soils in Ijen-Ekiti (Ajayi, et al. 1995), in soil and water around a cement company in Ewekoro by Jubiri, et al (1991) and in rocks in Ekiti by Ajayi, et al (1991). In all the studies a non significant t level of radioactivity was observed.

Jibiri and Agumuo, (2007) measured the radioactivity in some terrestrial food crops in Jos-Plateau. The results showed a higher concentration of potassium among the essential elements in all the crops. Calcium concentration in both maize and guinea corn was below detection level and also zinc in green beans, sweet potato and cassava. The trace elements Sc, Hf, Sm and Zn were below detection limit in all the crops expect in green beans. The activity concentration of the radionuclides in the food samples were found to vary between 83 and 129 $Bqkg^{-1}$ for ^{232}Th. They further reported that the mining activity in the area influenced the concentration levels of these elements and radionuclides in the food crops Fasasi, et al (2003) determined the presence and level of radioactivity in bituminous sand and overburden obtained from bituminous sand deposits in Ondo State Nigeria. Some radionuclides belonging to the natural decay series of ^{238}U and ^{232}Th were identified. They also found the specific activity of the identified radionuclides as ^{214}Bi, ^{208}H, and ^{226}Ra having 165.64, 150.25 and 60.97 $Bqkg^{-1}$ respectively.

Onoja, (2004) evaluated the gross alpha and beta radioactivity in well water from zaria area of Kaduna State Nigeria. The result indicated the range of alpha activity in well water to be between 0.58 to 43.19 Bqm^{-3} with a geometric mean of $6.35\pm0.45Bqm^{-3}$ and that of beta activity to be between 3.58 to 622 Bqm^{-3} with a geometric mean of 75.34 ± 1.53 Bqm^{-3}. These values were below the practical screening level of radioactivity in drinking water of 500 Bqm^{-3} for alpha and 1000 Bqm^{-3} for beta as recommended by both CEC, FAO and WHO.

Tajudeen (2006)measured the gross alpha and beta activity concentration in the well water from gwmmaja in Kano State of Nigeria. The result indicate very low alpha and

beta activity concentrations with range of 2.06 – 11.48 Bqm^{-3} for alpha and 2.00-17.75 Bqm^{-3} for beta.

Arkian et al, (2006) measured the gross alpha and beta radioactivity in the surface air of Tehran Nuclear research center in Iran. The gross alpha and beta activity concentration was found to range form 71.04-121.20 and 174.91-305.46 Bqm^{-3} respectively.

Dogru et al, (2008) measured the gross alpha and beta radioactivity in the ground water of Van in Turkey; the gross alpha and beta activity concentration was found to range from 630-782 and 21-816 Bqm^{-3} respectively.

Zainihamzah et al (2001),measurement of gross alpha, gross beta, radonand radium activity concentrations in aqueoussamples using liquid scintillation technique.The results show that grossalpha and beta can be measured using scintillation cocktail and radium and radon using extraction method. The results for gross alpha, gross beta, 222Ra and 226Ra are 0.39-6.42, 0.66-16.18, 0.40-4.65 and 0.05-0.56 Bq/L. MDA for gross alpha, gross beta and radium is 0.03, 0.08 and 0.00035 Bq/L respectively.

Bashir Gide (2006), A survey of gross alpha and beta activity concentration in ground water from katsina. It was found that the gross alpha and beta activity concentration in the water range from 80 ± 5Bqm^{-3} – 2,300 ± 41Bqm^{-3} and 120 ± 8Bqm^{-3} – 4,970± 78Bqm^{-3}respectively.Thisclealy indicate the area of elevated of alpha and beta activity concentration of 37.5% and 47.5% respectively. When compare with the ICPR (1991) maximum accepted values of 500 Bqm^{-3} and 100 Bqm^{-3} for alpha and beta respectively.

Agbalagba ,et al (2012) Determination of Gross α and β Activity Concentration and Estimation of Adults and Infants Dose Intake in Surface and Ground Water of Ten Oil Fields Environment in Western Niger Delta of Nigeria.It is fund that Gross alpha activity concentration ranged from 0.01±0.002 to 0.7±0.01 (0.15±0.003)B/L, 0.01±0.003 to 0.5±0.01 (0.1±0.003) B/Land 0.02±0.001

to 35.1±1.1 (4.1±0.1) B/L while beta activity concentration ranged from 1.1±0.04 to 13.2±0.1 (6.0±0.1) B/L, 0.7±0.1 to 54.7±1.3 (8.9±0.2) B/L and 0.7±0.03 to 151.2±1.8 (40.1±0.9) B/L for well, tap and river waters respectively. Correlation value between α and β activities in well, tap and river waters is 0.025, 0.047 and 0.512 respectively. The

obtained results showed that average natural activity concentrations of α- and β-emitting radionuclides in the water samples are slightly above the WHO recommended limit except alpha activity in tap water samples. For all samples the gross β activities were higher than the corresponding gross α activities. The mean effective equivalent dose intake per year due to alpha activity in the water samples for adults and infants
are: 76.4±1.8 and 20.9±55μSvy-1, 54.6±1.3 and 14.9±0.4 μSvy-1, and 2118±70 and 584±19.2μSvy-1 in well, tap, and river water samples respectively. The results obtained for dose intake are below the WHO recommended reference level of 0.1mSvy-1, except for Uzere river water sample.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

3.1.1 The proportional counters

The equipment used for the gross alpha and beta counting is a gas free single channel counter MPC 2000 Desktop Gross Alpha/Beta counter with 9¼" 9¼"W x 11¾" H x 16 ¾ " D. And it has light weight of less than 35 Ibs with most options with very easiest sample loading that is no rotation. Later positive drawer lock, no sample drop through and multiple. Control options (keypad/console, programmable touch panel, standard pc) the detectors are (gas free single channel counter MPC 2000) with full access maintenance (Take the top cover off-everything is accessible) also low background (w/optional shield 0.05 CPM. Alpha 38 CPM Beta) with window and windowless (i.e. highest alpha and beta efficiency field chargeable). This is the potable detector used in the counting shown in the figure below.(Detector manual)



Fig 3.1 Apotablegas free single channel counter MPC 2000 (Detector, manual)

3.2Detector Calibration

The detector is calibrated in order to obtain background counts, channel efficiency and operational voltage for the different modes of counting in the channels.

Channel Efficiency Calibration

This parameter takes account of the operational voltage and efficiency of the channel.This is achieved via plateau test measuarement in order to calculate the samples activity. Two standards were used:- Sr-90, a beta standard and Pu -239, an alpha standard which are measured on 4π solid angle (geometry) for the radiation type.Each standard has different activity strength and source number which were used for the detector efficiency calibration and hence producing the optimal operational voltage in alpha/beta simultaneously mode,alpha only mode and beta (+α) mode of counting. For a gas filled proportional counter,the detector efficiency is greater than 30% but cannot exceed 50% This is recommended for proportional counter(Eurysis measures, 1991).After several calibrations using different voltages for the different modes of counting,it was observed that the operational voltage that yielded efficiencies of 59.12% for the alpha and 44.09% for the beta which gave a calibration print out similar to that in the technical manual of the detector for the alpha only mode and beta(+α) mode of counting is 1650V and 1700V respectively.In alpha/beta simultaneous mode, the efficiencies were less than 25% and therefore can not be used in the sample analysis.Measurement where made on 2700s for 5 cycles the measument results where stored progressively during acquisition. Calculation and graph printout is perfomed at the end of acquisitions.The program searches for the best straight line and the plateau is a plot of efficiency vs Voltage over a 200V segment.

Plateau Test

Plateau test is the plot of efficiency vs voltage attach is the graph shows plateau test of a gas field detector

Plateau test was run with the manufacturers calibration standards (Pu – 239 and Sr – 90) whose activities range from 133.29 – 185.49Bq and 92.31 – 103.68Bq respectively in all the three operating modes. This test was run for 2700s for 5 cycles. The operational efficiencies of the channel of the counter indicated an efficiency of 59.12% for the Alpha counts and 44.0% for the beta counts. These are good efficiency values for this type of counting system.

3.3 Background Radioactivity

The counting system was then used to count clear empty planchets in all the counting mode to obtain the background radioactivity of the environment which is needed to be used in the subsequent measurements. The results gave background radioactivity of 92.69cpm for Alpha, and 95.65cpm for Beta. This result is quite representative of the environment and could therefore be employed in the subsequent measurement of the water samples.

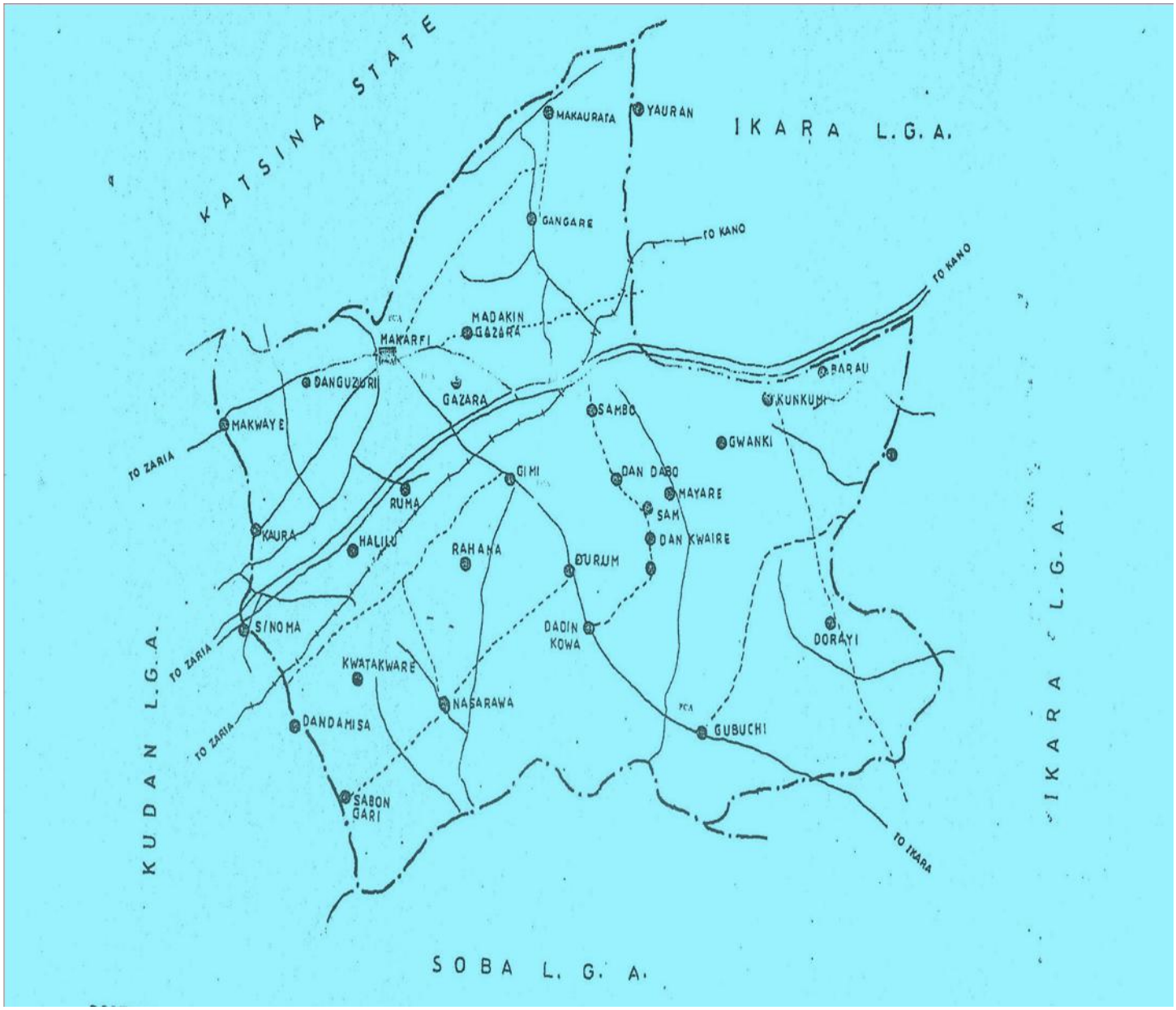
3.4Other materials

Other materials used for the various experimental stages of this work include 2 litre polythene container to collect the water sample, conductivity meter in order to know the conductivity of the water sample, geographical positioning system (GPS) for measuring the geographical co-ordinates, stainless steel planchets, glass beakers Hot plate,weighingbalance,also the following reagents were used namely Nitric acid, acetone,andVenyl acetate.

3.5 Methods

3.5.1Sampling Sites

The samples were collected at the Makarfi Local Government area, Kaduna State Nigeria. The area is situated at the northern part of Kaduna State. The geographical location will be determined by hand held GPS (Global positioning system). The area is



comprised of a settlement of large populace,and the map of the study area is shown in Fig 3.2.

Fig 3.2Map of the study area,

KEY:

sample area

KANO

(Department of works Makarfi local government)

3.5.2Sample collection/Sample Preparation

A total of 31 samples were collected using the composite sampling method in the different villages around the local government area, namely Makarfi Town, school of health technology Makarfi, TashanYari, Gazara, Gangara, Gimi, Gubuchi, Mayere, Kunkumi, Gwanki, Dorayi, Durum, NasarawaDoya, Kwatakware, Hawanmaimashi.Samples were collected in clean 2 litres. Polyethene containers with tight covers. To avoid contamination, the boreholes was allowed to run so as to evacuate the existing water in the pipe before collection. The containers were also rinsed thoroughly with water. The specific conductivity of the water was measured on collection,The water sample was preservedwith 20ml of concentrated HNO_3 per litre of water, in order to minimize the loss of radioactivity material from solutiondue to absorption. The acid would dissolve the radioactive materials already expected on the particulate materials in the sample. The sample was analyzed ten days after collection.

3.5.3Determination of total solid

The total solid concentration in the samples, was determined in order to know the appropriate volume of water to evaporate for each sample so as to avoid unnecessary sample thickness which may lead to self absorption. The volume of water required is such that it can produce a mass of solid residue slightly in excess of 0.1A mg (where A is the area of the planchet in mm^2) The volume of the sample that can give a solid residue slightly in excess of 71mg the sample was prepared in accordance with the ISO 9696. Appropriate volumes of the samples that can produce a mass of solid residue slightly in excess of 71mg were evaporated to near dryness using hot plates. The aliquotsweretransferred in planchets and a small quantity of acetone was added in order

to reduce moisture also small amount of venyl acetate was added to dry the sample in the planchets. The residues weretaken for counting of gross alpha and beta activity using gas free single channel counter MPC 2000.

3.5.4 Counting procedure

3.5.4.1 Plateau Test

The Plateau test together with the manufacturers standard sources was used to verify the suitable voltages to be used for the different modes of counting and also to determine the efficiencies and detection limits of the detector .

3.5.4.2 Background Counting

In compliance with the ISO 9696 standard, clean emptyplanchets will be counted in order to determine the background radioactivity of the environment. We set the operational high voltage and allowed detector to run for 1800s- cycles. For five cycles by usingthe alpha only (1,550V), beta only (1,650V) and alpha and beta simultaneously (1,750V) modes. The background count rates were determined in counts per minute.

3.5.4.3 Counting

The counting equipment is automated.The procedure involve entering the present time,number of cycles and the counting (operational) voltage. Also the counter characteristics (efficiency and background count rate) volume of sample used and sample efficiency were entered. The sample efficiency was determined using equation shown below;

$$\text{Sample efficiency} = M_T/0.1A \qquad 3.1$$

Where M_T is the mass of residue in planchete got from sample preparation and 0.1Amg is the expected mass of the residue in the planchete.Where unit co-efficient is the

multiplication coefficient making it possible to obtain the results expressed in the units used by the operator (e.g. in pc efficiency in %).

3.5.5 Expression of Results

a) Gross alpha counting

The high voltage for gross alpha counting was set at 1600V and s

amples were counted for 45 minutes in alpha only mode. Then the results were displayed as row counts;count rate (count/minutes) The count rate and the activity were calculated using the formula:

$$\text{Activity} = \frac{Netcount}{D.E \times samplevolume \times 60} \qquad 3.1$$

Where D.E is the detector efficient

Net count = Raw count – Background counting.

b) Gross Beta counting

The high voltage for gross beta counting was set at 1700V and samples were counted for 45 minutes in beta only mode. The count rate and the activity were calculated using the formula:

$$\text{Activity } \square = \frac{Netcount}{D.E \times samplevolume \times 60} \qquad 3.2$$

Where D.E is the detector efficient

Net count = Raw count – Background counting.

Contour distribution

The specific activities of radionuclide as well as the gross alpha and gross beta activity concentration were shown in contour distributions. This is aimed at finding out the areas of high distribution.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the results of all the experimental procedures carried out in order to achieve the stated objectives of the research. The gas free single channel counter MPC 2000 used was initially calibrated using the manufacturers standard Alpha and Beta sources (Pu – 239 and Sr – 90) The calibration is aimed at obtaining the operational efficiency of the channel of the counter. After the calibration, the counter was then used to count the background radioactivity of the environment. The gross Alpha and Beta radioactivity counting modes applicable to the counter, whose respective voltages are 1,550 and 1650 volts were then employed to count the prepared water samples collected from 31 different locations in Makarfi Local Government Area of Kaduna State.

4.2 Gross Alpha and Beta Radioactivity in Groundwater

Table 4.1 shows the gross alpha and beta activity concentration of the ground water of the selected locations obtained using alpha only and beta only measurement modes.

The result from the table 4.1 below indicates an alpha activity concentration range of $2.70x10^{-4} \pm 0.40x10^{-4} – 60.4x10^{-4} \pm 4.20 \times 10^{-4} BqL^{-1}$similarly the range of Beta activity concentration spanned from $3.87x10^{-4} \pm 1.05x10^{-4} – 51.8x10^{-4} \pm 3.27x10^{-4}$The overall results show the elevated areas of Alpha are $60.4 \times 10^{-4} \pm 4.20 \times 10^{-4} BqL^{-1}$of T/Yari B, $35.7x\ 10^{-4} \pm 2.64x\ 10^{-4} BqL^{-1}$of MayereW,and that of Beta are $51.8 \times 10^{-4} \pm 3.27 \times 10^{-4} BqL^{-1}$of Mayere W,$36.4x\ 10^{-4} \pm 3.37x\ 10^{-4} BqL^{-1}$of Gimi W, $34.8 \times 10^{-4} \pm 3.43 \times 10^{-4} BqL^{-1}$of D/Damisa though both alpha activity and beta activity in the study area are far

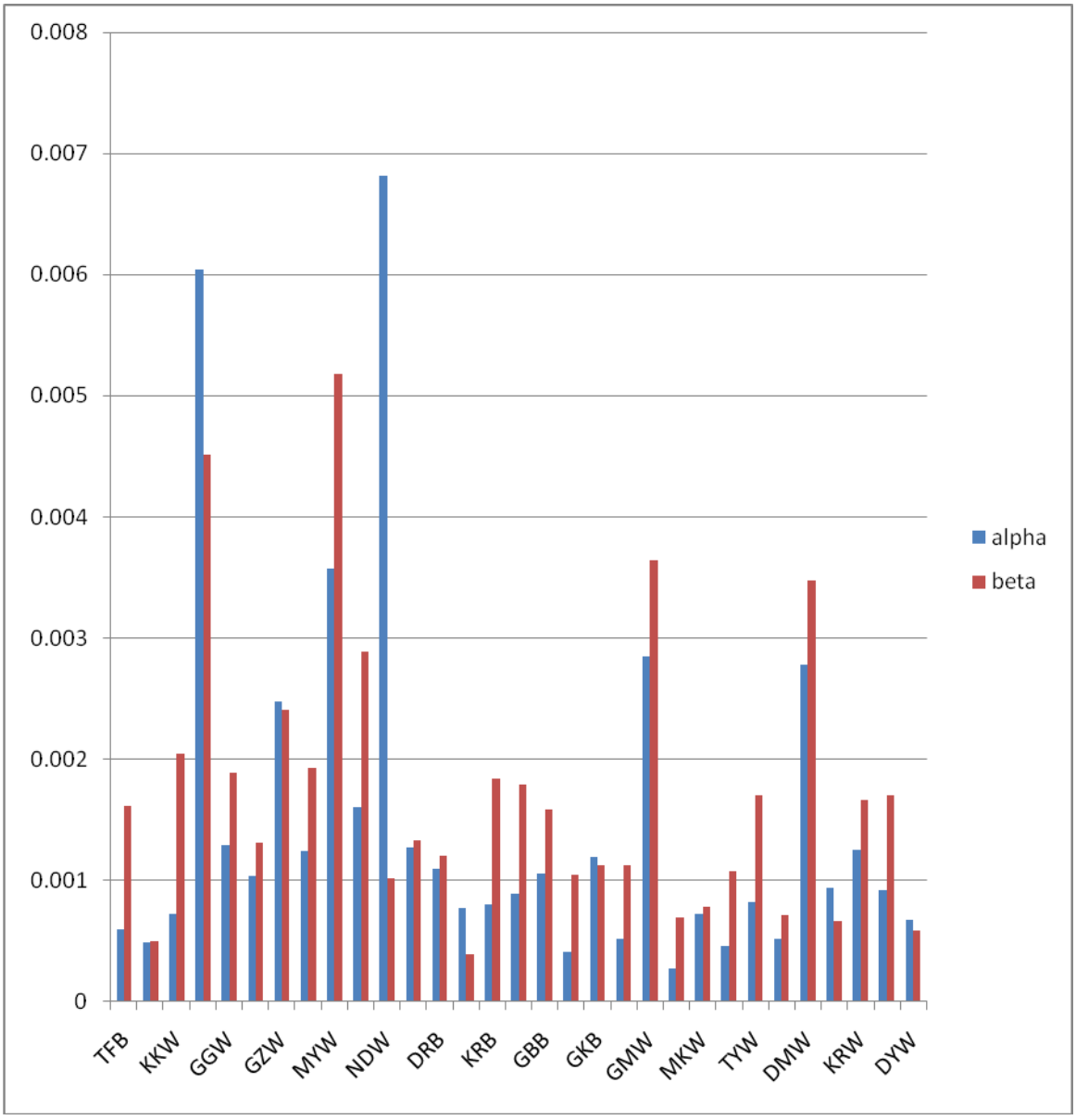
below the practical screening level of radioactivity in drinking water of 0.5 Bq/L for alpha and 1Bq/L for beta, as recommended by CEC – FAO and WHO.

Table 4.1;Gross Alpha and Beta Activity Concentration of Groundwater from various locations in Makarfi Local Government Area of Kaduna State

S/No	Location		Name	Activity Concentration	
				Alpha ($x10^{-4}$ B/L)	Beta ($x10^{-4}$ B/L)
1	$N11^{0}16^{1}46.5$”	$E008^{0}04^{1}24.6$”	Dorayi w	6.72±0.262	5.87±0.328
2	$N11^{0}18^{1}08.1$”	$E008^{0}03^{1}07.0$”	Tafida b	5.96±0.842	16.2±1.03
3	$N11^{0}14^{1}20.2$”	$E007^{0}48^{1}38.3$”	H/m-mashi w	4.94±0.589	4.97±0.736
4	$N11^{0}21^{1}32.7$”	$E008^{0}01^{1}44.4$”	Kunkumi W	7.21±1.42	20.5±1.74
5	$N11^{0}20^{1}37.9$”	$E007^{0}54^{1}38.5$”	T/yari B	60.4±4.20	45.1±5.30
6	$N11^{0}25^{1}13.5$”	$E007^{0}56^{1}31.5$”	Gangara w	12.9±1.86	18.9±2.31
7	$N11^{0}14^{1}20.2$”	$E007^{0}48^{1}38.3$”	H/m-mashi b	10.4±1.06	13.1±1.31
8	$N11^{0}21^{1}51.8$”	$E007^{0}54^{1}35.4$”	Gazara w	24.8±1.36	24.1±1.72
9	$N11^{0}14^{1}31.1$”	$E008^{0}01^{1}18.5$”	Gubuchi w	12.4±1.55	19.3±1.92
10	$N11^{0}19^{1}23.0$”	$E008^{0}00^{1}22.7$”	Mayere w	35.7±2.64	51.8±3.27
11	$N11^{0}17^{1}48.2$”	$E007^{0}57^{1}30.7$”	Durum w	16.1±1.35	28.9±1.66
12	$N11^{0}15^{1}00.3$”	$E007^{0}54^{1}16.2$”	N/doya w	6.82±1.04	10.2±1.28

13	N11^{0}21^{1}32.7”	E008^{0}01^{1}44.4”	Kunkumi b	12.7±0.95	13.3±1.20
14	N11^{0}17^{1}48.2”	E007^{0}57^{1}30.7”	Durum b	11.0±1.09	12.0±1.36
15	N11^{0}21^{1}24.8”	E007^{0}53^{1}23.6”	H/tech w	7.72±0.83	3.87±1.05
16	N11^{0}15^{1}13.5”	E007^{0}51^{1}47.2”	K/kware b	8.07±1.27	18.4±1.56
17	N11^{0}19^{1}23.0”	E008^{0}00^{1}22.7”	Mayere b	8.95±1.40	17.9±1.73
18	N11^{0}14^{1}31.1”	E008^{0}01^{1}18.5”	Gubuchi b	10.6±1.17	15.9±1.45
19	N11^{0}15^{1}00.3”	E007^{0}54^{1}16.2”	N/doya b	4.16±0.75	10.5±0.92
20	N11^{0}20^{1}26.1”	E008^{0}01^{1}38.4”	Gwanki	11.9±1.52	11.3±1.89
21	N11^{0}17^{1}14.0”	E007^{0}51^{1}43.9”	T/musa w	5.21±0.69	11.3±0.85
22	N11^{0}19^{1}38.7”	E007^{0}56^{1}02.3”	Gimi w	28.5±2.71	36.4±3.37
23	N11^{0}18^{1}08.1”	E008^{0}03^{1}07.0”	Tafida w	2.70±0.41	6.93±0.49
24	N11^{0}22^{1}44.9”	E007^{0}52^{1}34.4”	Makarfi w	7.24±0.81	7.82±1.01
25	N11^{0}21^{1}24.8”	E007^{0}53^{1}23.6”	Healt tech b	4.59±0.93	10.8±1.15
26	N11^{0}20^{1}37.9”	E007^{0}54^{1}38.5”	T/yari	8.24±0.99	17.0±1.22
27	N11^{0}20^{1}26.1”	E008^{0}01^{1}38.4”	Gwanki w	5.16±0.47	7.14±0.58
28	N11^{0}14^{1}12.3”	E007^{0}50^{1}30.8”	D/damisa	27.8±2.76	34.8±3.43
29	N11^{0}22^{1}44.9”	E007^{0}52^{1}34.4”	Makarfi B	9.36±0.89	6.69±1.12
30	N11^{0}15^{1}13.5”	E007^{0}51^{1}47.2”	k/kware W	12.5±1.17	16.6±1.45
31	N11^{0}21^{1}51.8”	E007^{0}54^{1}35.4”	Gazara B	9.18±1.35	17.0±1.67

Figure 4.1 Gives a detailed illustration of the Alpha and Beta concentration values of the points. The values are more concentrated within the lower axis with alpha elevated areas of N/ doyaw,Gangarawandbeta elevated areas of Mayerew,Gangara w.



Locations

Figure 4.1 Gross Alpha and Beta Activity concentration of Ground water from various locations in Makarfi Local Government Area.

4.3Distribution pattern of the Gross Alpha and Beta Activity concentration in the area.

4.3.1 Alpha Activity Concentration

The histogram of the Gross Alpha Activity concentration in the area is presented in figure 4.2 below. The graph shows the pattern in which the activity concentration is distributed. Figure 4.2 The result shows the highest frequency distribution of 20 between 0.0005 to 0.0015B/L. The lowest frequency distribution of 1 between 0.0055 to 0.0065 B/L.Thedistribution is skewed towards the left. This shows a generally low alpha activity in the study area. Then the mean of the distribution is 0.001488 B/L and standard deviation is 0.001532.

The regression curve represent a log normal distribution of the form

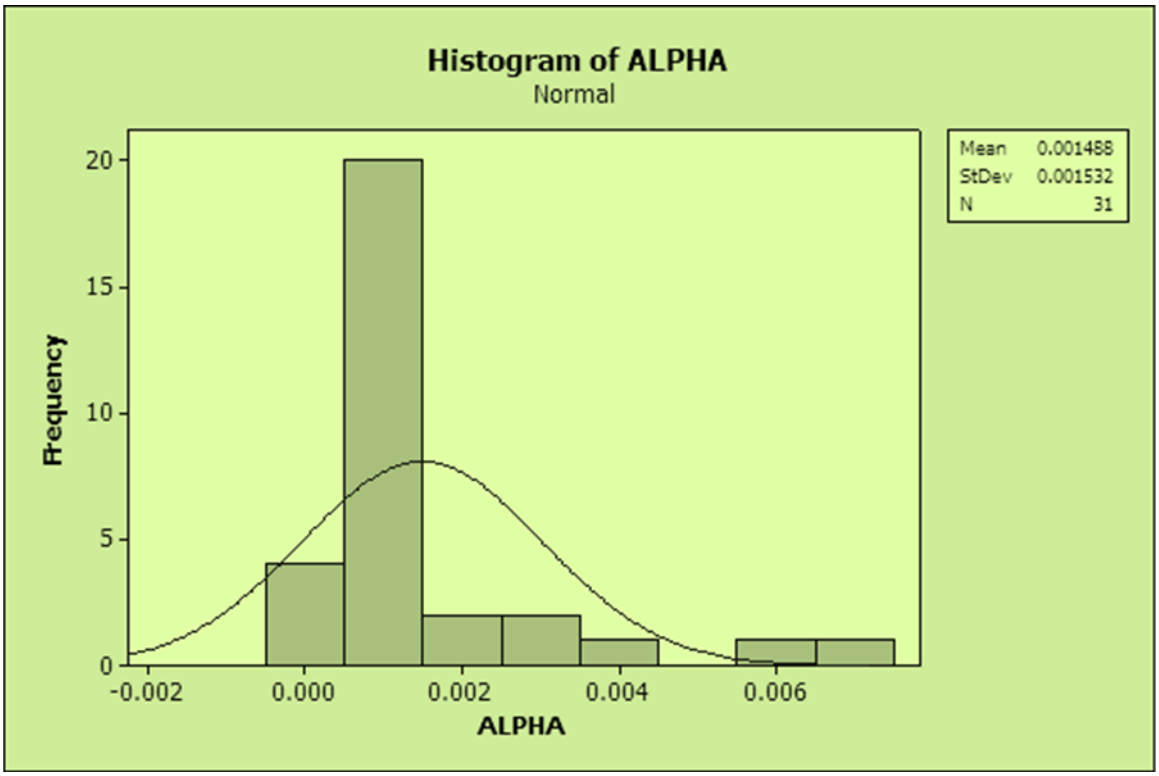
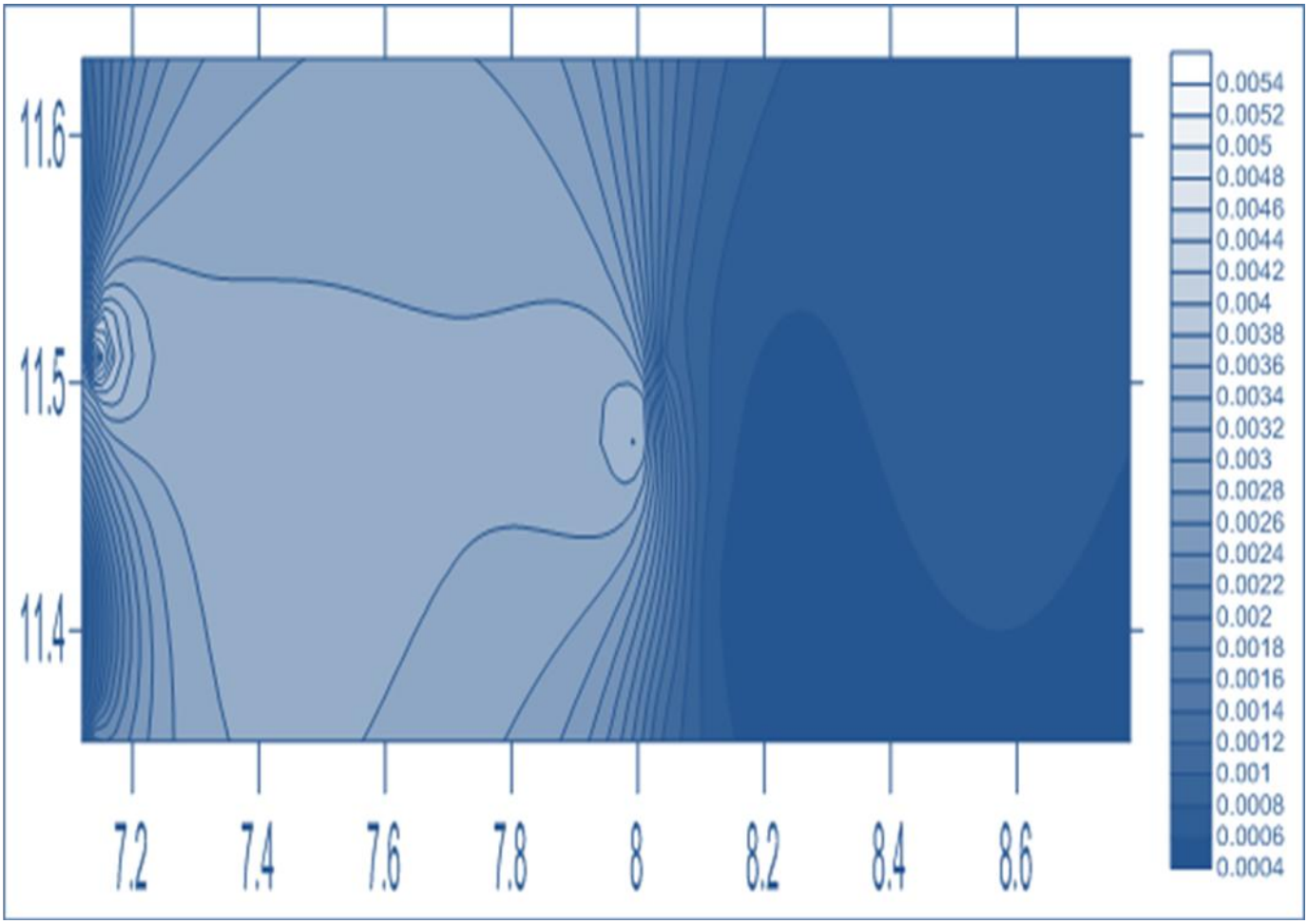


Figure 4.2 Histogram of the Alpha Activity Concentration of the Study Area.

Figure 4.3 shows high alpha activity distribution of 0.005 – 0.0054 B/L and above at a narrow area bounded by latitude 11.4^0 – 11.5^0 and longitude 7.9^0- 8.0^0. The area include Tashanyari boreholes water samples.. The areas bounded by latitude 11.0^0 – 11.6^0 and longitude 8.10^0 - 8.6^0 have low distribution of 0.0004 – 0.0008 B/L. The areas are the Nasarawandoya boreholes water and Gwanki well water samples.



Longitude^{0}

Figure 4.3Countour Plot Of Gross Alpha Activity Concentration

4.3.2 Beta Activity Concentration

The histogram of the Gross Beta Activity Concentration in the study area is presented in figure 4.4 below. The graph shows the pattern in which the activity concentration is distributed.

Figure 4.4The result shows the highest frequency distribution of 7 between 0.001 B/L and 0.0015 B/L. The lowest frequency distribution of 1 between 0.0025 to 0.003 B/L.Thedistribution is skewed towards the left. This shows a generally low beta activity

in the study area. Then the mean of the distribution is 0.001724 B/L and standard deviation is 0.001153.

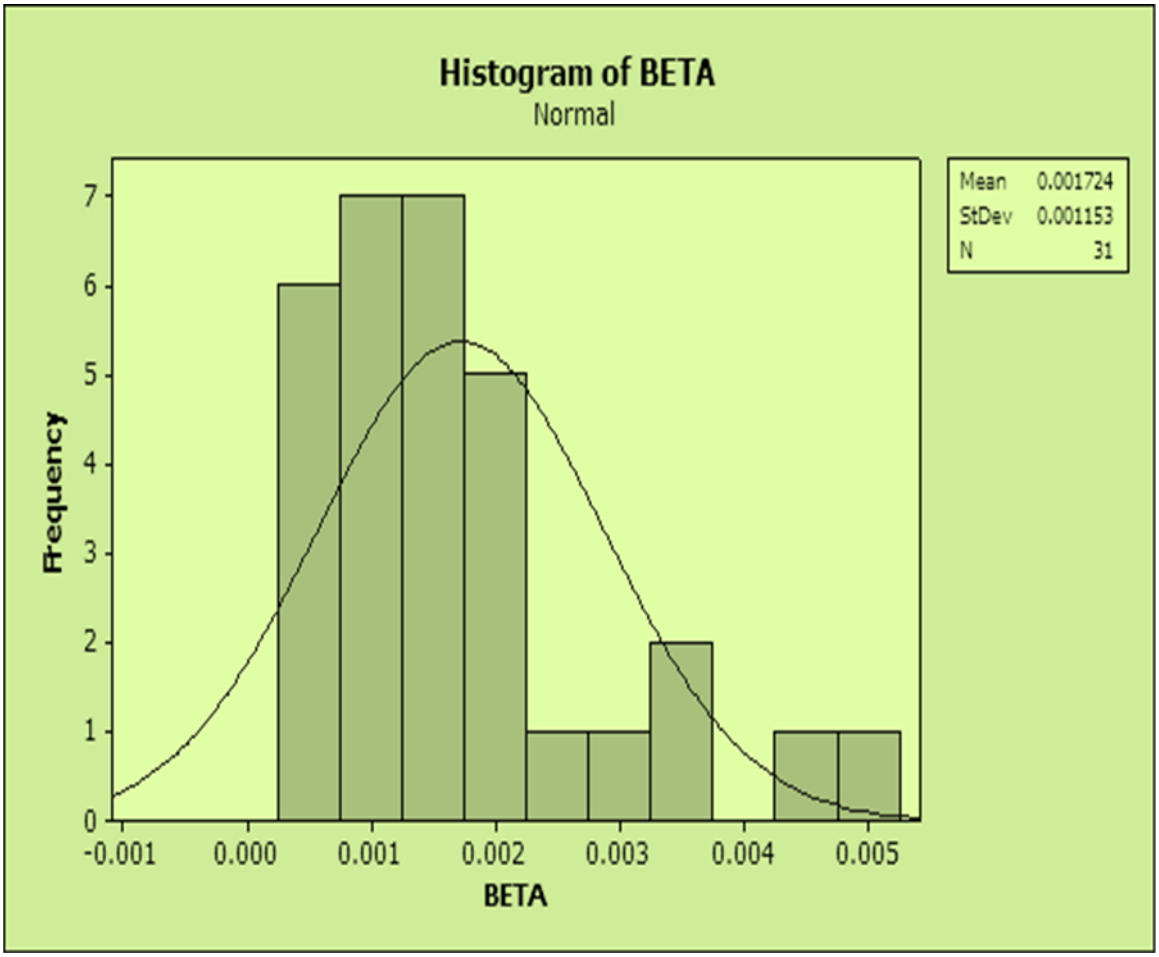


Fig. 4.4 Histogram of the beta activity concentration of the study area.

Figure 4.5 shows high beta activity distribution of 0.0052 B/L and aboveat a narrow area bounded by latitude $11.55^0$and longitude 8.4^0.The area includeMayere well water samples and TashanYari boreholes water samples.There is also high beta activity distribution of 0.005 B/L and above at area bounded by latitude $11.11^0$and longitude 8.05^0.Which are the areas of Gwanki boreholes. The areas bounded by latitude 11.4^0 – 11.5 and longitude 7.0^0 - 7.3^0have low distribution of 0.0006 B/L. The areas is the Makarfi well water and HawanMaimashi well water smples.

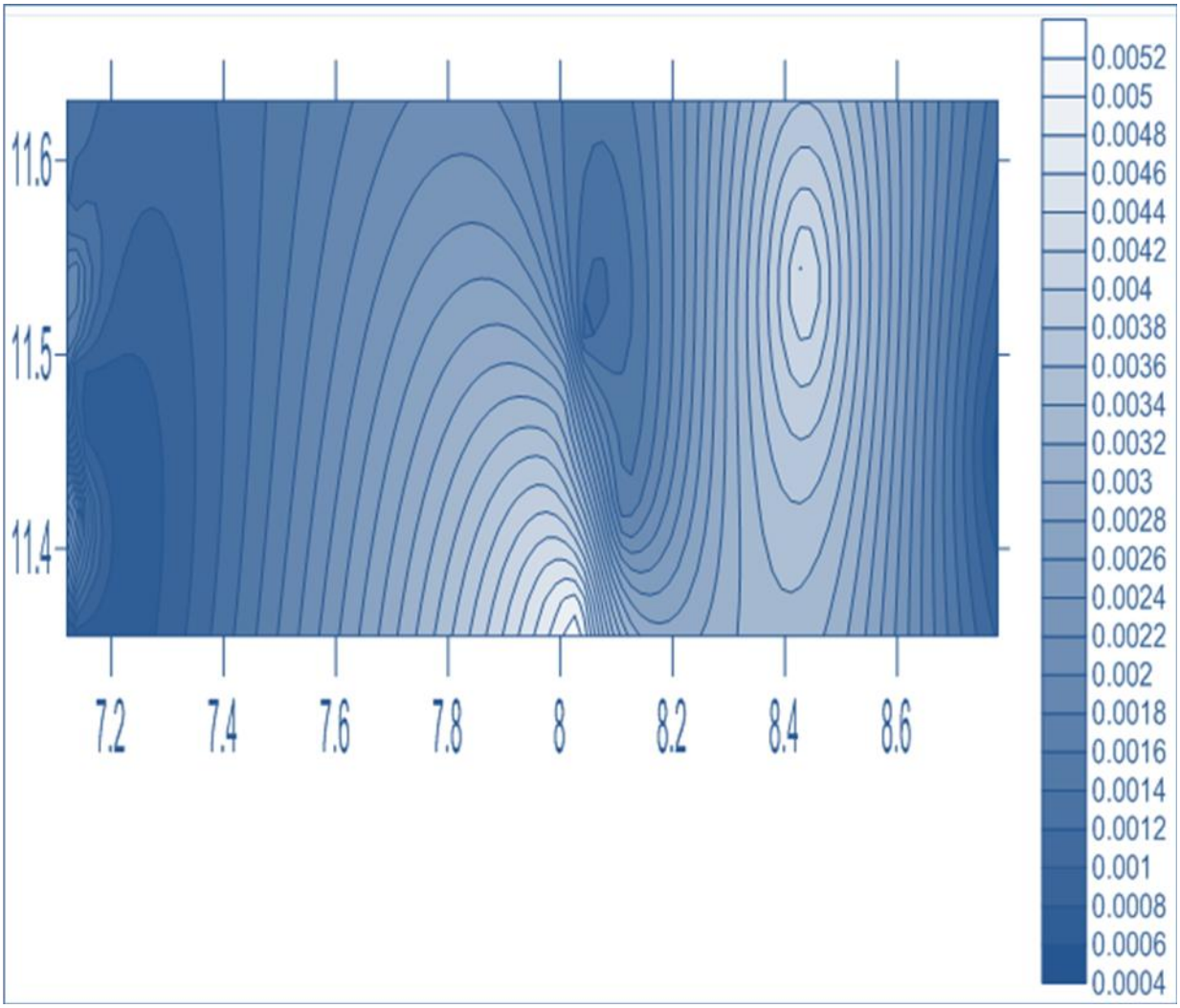


Fig 4.5Contour Plot Of Beta Activity Concentration.

4.4DISCUSSION

The gas free single channel counter MPC 2000 used for this analysis gave an average efficiency of 59.12% and 44.09% for the respective alpha and beta calibration sources. Those by mere looking are good values for this types of counter A low background activity was also observed with a 92.69cpm for Alpha and 95.65cpm for Beta. This is quite representative of the environment. Similarly the results obtained from all the

counting modes are reproducible and are hence reliable. The Gross Alpha and Beta activity concentrations in the water were found to range from $2.70x10^{-4} \pm 0.408x10^{-4}BL^{-1}$ – $60.04x10^{-4} \pm 4.20x10^{-4}BL^{-1}$ and $3.87x10^{-4} \pm 1.05x10^{-4}BL^{-1}$ – $51.80x10^{-4} \pm 3.27x10^{-4}BL^{-1}$respectively. This indicatedtheareas of elevated alpha and beta activity concentrations are of $60.4 \times 10^{-4} \pm 4.20 \times 10^{-4}$ $BqL^{-1}$of T/Yari B, $35.7x\ 10^{-4} \pm 2.64x\ 10^{-4}BqL^{-1}$of Mayere W, and that of Beta are $51.8 \times 10^{-4} \pm 3.27 \times 10^{-4}BqL^{-1}$of Mayere W,$36.4x\ 10^{-4} \pm 3.37x\ 10^{-4}BqL^{-1}$of Gimi W, $34.8 \times 10^{-4} \pm 3.43 \times 10^{-4}BqL^{-1}$of D/Damisa though both alpha activity and beta activity in the study area are far below the practical screening level of radioactivity in drinking water,when compared with ICRP (1991) maximum acceptable values of $0.5BqL^{-1}$ for alpha $1BqL^{-1}$ for beta and $100BqL^{-1}$ for Radon – 222. The Beta radioactivity show slightly higher values. They are also found to exhibit a similar distribution pattern.

4.5 Comparison of results

Table 4.2 shows the gross alpha and beta activity concentration of the boreholes water of the selected locations in Makarfi Local Government Kaduna State obtained using alpha only and beta only measurement modes.

Table 4.2 gross alpha and beta activity concentration of the boreholes water

S/No	Location		Name	Activity Concentration	
				Alpha ($x10^{-4}$ B/L)	Beta ($x10^{-4}$ B/L)
1	$N11^{0}18^{1}08.1$”	$E008^{0}03^{1}07.0$”	Tafida b	5.96±0.842	16.2±1.03
2	$N11^{0}20^{1}37.9$”	$E007^{0}54^{1}38.5$”	T/yari b	60.4±4.20	45.1±5.30
3	$N11^{0}14^{1}20.2$”	$E007^{0}48^{1}38.3$”	H/m-mashi b	10.4±1.06	13.1±1.31
4	$N11^{0}21^{1}32.7$”	$E008^{0}01^{1}44.4$”	Kunkumi b	12.7±0.95	13.3±1.20
5	$N11^{0}17^{1}48.2$”	$E007^{0}57^{1}30.7$”	Durum b	11.0±1.09	12.0±1.36
6	$N11^{0}15^{1}13.5$”	$E007^{0}51^{1}47.2$”	K/kware b	8.07±1.27	18.4±1.56
7	$N11^{0}19^{1}23.0$”	$E008^{0}00^{1}22.7$”	Mayere b	8.95±1.40	17.9±1.73
8	$N11^{0}14^{1}31.1$”	$E008^{0}01^{1}18.5$”	Gubuchi b	10.6±1.17	15.9±1.45
9	$N11^{0}15^{1}00.3$”	$E007^{0}54^{1}16.2$”	N/doya b	4.16±0.75	10.5±0.92
10	$N11^{0}20^{1}26.1$”	$E008^{0}01^{1}38.4$”	Gwanki b	11.9±1.52	11.3±1.89
11	$N11^{0}21^{1}24.8$”	$E007^{0}53^{1}23.6$”	Healt tech b	4.59±0.93	10.8±1.15
12	$N11^{0}22^{1}44.9$”	$E007^{0}52^{1}34.4$”	Makarfi b	9.36±0.89	6.69±1.12
13	$N11^{0}21^{1}51.8$”	$E007^{0}54^{1}35.4$”	Gazara b	9.18±1.35	17.0±1.67

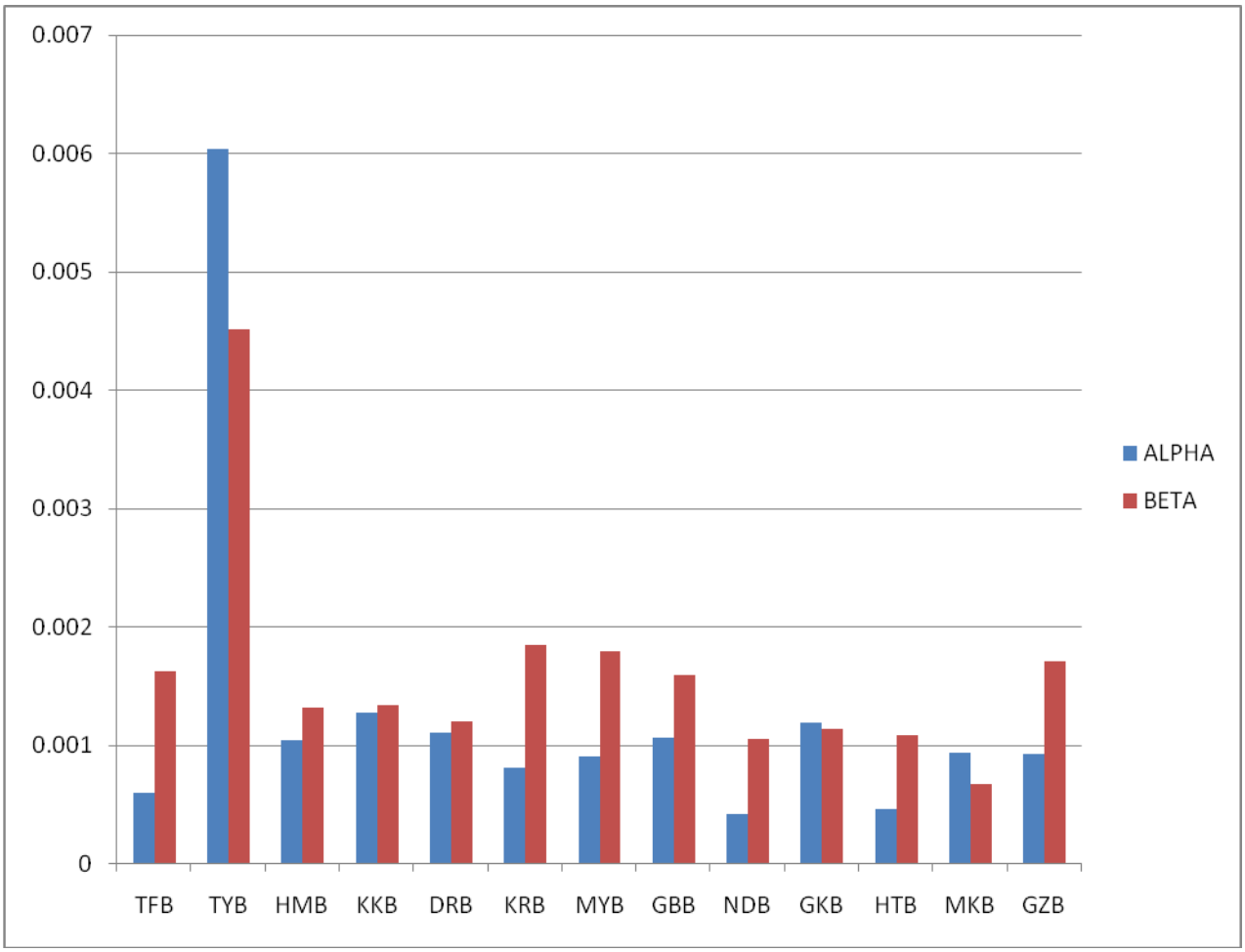


Fig 4.6 Bar chart of the alpha and beta activity concentration of boreholes water

Table 4.3 shows the gross alpha and beta activity concentration of the wells water of the selected locations in Makarfi Local Government Kaduna State obtained using alpha only and beta only measurement modes.

Table 4.3 Gross alpha and beta activity concentration of the wells water

S/No	**Location**		**Name**	**Activity Concentration**	
				Alpha	**Beta**
				($x10^{-4}$ B/L)	**($x10^{-4}$ B/L)**
1	$N11^{0}16^{1}46.5$”	$E008^{0}04^{1}24.6$”	Dorayi w	6.72±0.262	5.87±0.328
2	$N11^{0}14^{1}20.2$”	$E007^{0}48^{1}38.3$”	H/m-mashi w	4.94±0.589	4.97±0.736
3	$N11^{0}21^{1}32.7$”	$E008^{0}01^{1}44.4$”	Kunkumi w	7.21±1.42	20.5±1.74
4	$N11^{0}25^{1}13.5$”	$E007^{0}56^{1}31.5$”	Gangara w	12.9±1.86	18.9±2.31
5	$N11^{0}21^{1}51.8$”	$E007^{0}54^{1}35.4$”	Gazara w	24.8±1.36	24.1±1.72
6	$N11^{0}14^{1}31.1$”	$E008^{0}01^{1}18.5$”	Gubuchi w	12.4±1.55	19.3±1.92
7	$N11^{0}19^{1}23.0$”	$E008^{0}00^{1}22.7$”	Mayere w	35.7±2.64	51.8±3.27
8	$N11^{0}17^{1}48.2$”	$E007^{0}57^{1}30.7$”	Durum w	16.1±1.35	28.9±1.66
9	$N11^{0}15^{1}00.3$”	$E007^{0}54^{1}16.2$”	N/doya w	6.82±1.04	10.2±1.28
10	$N11^{0}21^{1}24.8$”	$E007^{0}53^{1}23.6$”	H/tech w	7.72±0.83	3.87±1.05
11	$N11^{0}20^{1}26.1$”	$E008^{0}01^{1}38.4$”	Gwanki w	11.9±1.52	11.3±1.89
12	$N11^{0}17^{1}14.0$”	$E007^{0}51^{1}43.9$”	T/musa w	5.21±0.69	11.3±0.85
13	$N11^{0}19^{1}38.7$”	$E007^{0}56^{1}02.3$”	Gimi w	28.5±2.71	36.4±3.37
14	$N11^{0}18^{1}08.1$”	$E008^{0}03^{1}07.0$”	Tafida w	2.70±0.41	6.93±0.49

15	N11^{0}22^{1}44.9”	E007^{0}52^{1}34.4”	Makarfi w	7.24±0.81	7.82±1.01
16	N11^{0}20^{1}37.9”	E007^{0}54^{1}38.5”	T/yari w	8.24±0.99	17.0±1.22
17	N11^{0}20^{1}26.1”	E008^{0}01^{1}38.4”	Gwanki w	5.16±0.47	7.14±0.58
18	N11^{0}14^{1}12.3”	E007^{0}50^{1}30.8”	D/damisa w	27.8±2.76	34.8±3.43
19	N11^{0}15^{1}13.5”	E007^{0}51^{1}47.2”	k/kware w	12.5±1.17	16.6±1.45

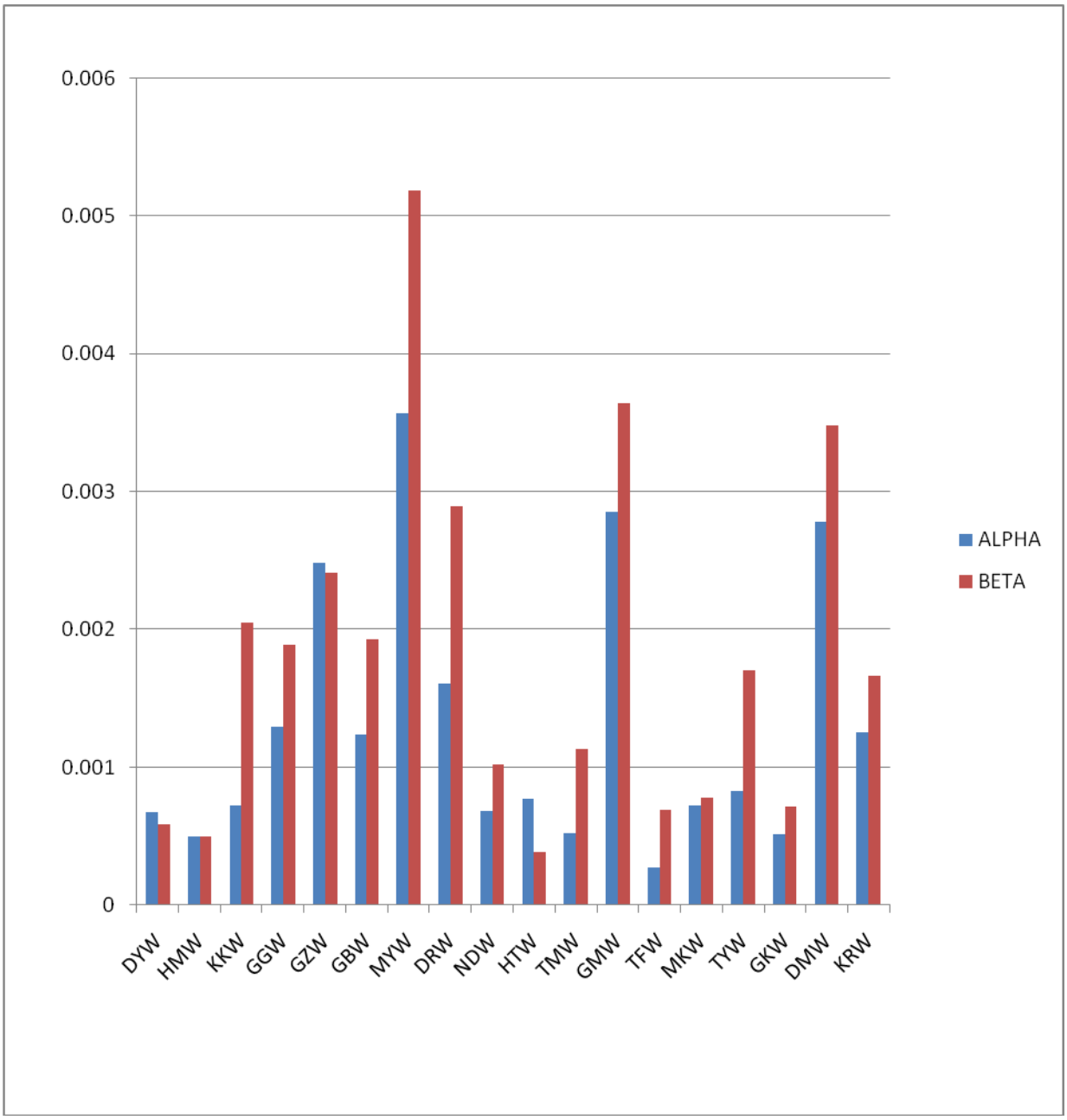


Fig 4.7 Bar chart of the alpha and beta activity concentration of wells water

4.5.1Comparison of alpha and beta activity between boreholes and wells water samples

The results of the measured alpha and beta activity concentration are shown in Table 4.2 and 4.2,the average alpha activity concentration in the boreholes water sample is 12.86 x 10^{-4}B/L, in the wells water samples is 12.87 x 10^{-4}B/L.The average beta activity concentration in the boreholes water samples is 16.04 x 10^{-4}B/L,that in the wells water sample 17.77 x 10^{-4}B/L.

In comparison of the boreholes and wells water sample,the alpha activity is highest in the wells water samples (average of 12.87 x 10^{-4}B/L) followed by that in boreholes water samples (average of 12.86 x 10^{-4}B/L). Comparing the beta activity in the wells and boreholes,the activity is highest in the wells water sample (average of 17.77 x 10^{-4}B/L) also followed by that in boreholes water samples (average 16.04 x 10^{-4}B/L).

Table 4.4 Comparison of alpha and beta activity between study area and other areas.

From the results in Table 4.4 the alpha activity in the ground water of Makarfi local government area of Kaduna State Nigeria is about 14% of that in the ground water in Zaria, also the alpha activity in the ground water of Makarfi local government area of Kaduna State Nigeria is about 12.4% of that of River water of Kaduna, the alpha activity in the ground water of Makarfi local government area of Kaduna State Nigeria is about 47% of that of ground water of Gwammaja,while the alpha activity in the ground water of Makarfi local government area of Kaduna state Nigeria is about 54% of the alpha activity of ground water in katsina, the alpha activity in the ground water of Makarfi local government area of Kaduna State Nigeria is about 0.8% of that in the oil fields environment in Niger delta.The beta activity in ground water of Makarfi local government area is about 0.89% of that of ground water Zaria,The beta activity in ground water of Makarfi local government area is about 0.68% of that of river water KadunaThe beta activity in ground water of Makarfi local government area is about 3.25% of that of ground water of Gwammaja,The beta activity in ground water of Makarfi local government area is about 0.11% of that of ground water of Katsina, also the beta activity

ground water of Makarfi local government area Kaduna state is about 0.03% of that of oil fields in Niger delta Nigeria.The results from the alpha and beta activity measurement of ground water in different places are far below the contamination limit of radioactivity in water as set by CEC-FAO and WHO that is 0.5B/L for alpha and 1B/L for beta.

Result of alpha and beta activity measurements in ground water samples from other areas; and the results of the measurements from the wells and boreholes of Makarfi local government area as well as the WHO limits of alpha and beta activity in water is shown in the table below.

Area	Alpha	Beta	Source
Ground Water of Zaria	0.021	0.312	Onoja (2004)
River Water of Kaduna	0.025	0.411	Juliet (2006)
Ground Water of Gwammaja	0.0065	0.086	Tajuddeen (2006)
Ground Water of Katsina	1.19	2.54	Bashir Gide (2006)
Oil fields environment niger Delta	0.35	7.15	Agbalagba, et al (2012)
Ground Water of Makarfi WHO limit	0.0031 1	0.00274 0.5	This Work Milvy and cothern(1990)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1CONCLUSION

The gas free single channel counter MPC 2000used for this research responded positively to the alpha and beta radioactivity. The counting modes employed gave Alpha efficiencies of 59.12% for Alpha. Similarly the beta efficiency obtained is 44.09% for beta.

The Gross Alpha and Beta Activity concentrations in the water in the study area were found to range from $2.70x10^{-4} \pm 0.408x10^{-4} - 60.04x10^{-4} \pm 4.20x10^{-4} BqL^{-1}$ and $3.87x10^{-4} \pm 1.05x10^{-4} - 51.80x10^{-4} \pm 3.27x10^{-4} BqL^{-1}$.

It can be concluded that in comparatively high alpha and beta activity in wells water sample may be as a result of relationship between the water in the wells and total desolve solid in the well due to the farming activity in the area where used of fertilizer.

This indicatesthe elevated areas of Alpha are $60.4 \times 10^{-4} \pm 4.20 \times 10^{-4} BqL^{-1}$of T/Yari B, $35.7x\ 10^{-4} \pm 2.64x\ 10^{-4} BqL^{-1}$of Mayere W, and that of Beta are $51.8 \times 10^{-4} \pm 3.27 \times 10^{-4} BqL^{-1}$of Mayere W,$36.4x\ 10^{-4} \pm 3.37x\ 10^{-4} BqL^{-1}$of Gimi W, $34.8 \times 10^{-4} \pm 3.43 \times 10^{-4} BqL^{-1}$of D/Damisa though both alpha activity and beta activity in the study area are far below the practical screening level of radioactivity in drinking water of 0.5 Bq/L for alpha and 1Bq/L for beta, set by the International Commission for Radiological Protection (ICRP, 1991).The United States Environmental Protection Agency (USEPA) and the World Health Organizsation (WHO).

5.2RECOMMENDATIONS

1. Further screening of the ground water of the area as well as the assessment of all relevant radiological issues should also be undertaken in order to safeguard the members of the settlements from unwanted radiation exposure.

2. Radon Activity Concentration in the groundwater in the area and its effect on the environment should be investigated as it may also pose a potential health threat to the settlers.
3. The another detector should be provided at least with eight (8) channels so that the gross alpha and beta analysis should be faster.
4. The counting system should be upgraded with a higher version computer system for speedy processing of radioactivity measurement.
5. There is also need to study the soils in the study area and compare it with the radioactivity of water in the area because of the correlation between water and the soil of area.
6. The work should be expanded to other sources of water in the country.
7. Survey of other sources of water like dams, should be carried out in the area.

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