Attenuation and Exposure Build up Studies in some Oxide based glasses

Dissertation -2 report Submitted

By

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ANJALI THAKUR

CONTENTS

1. INTRODUCTION

1.1 Radiation:

Radiation is the energy in the form electromagnetic wave which travellers in the air such as X ray, gamma ray, neutron ray, infrared ray etc.

1. Heat, visible light, gamma and X ray, radio waves all are included in electromagnetic radiation.
2. Beta radiation, alpha radiation and neutron radiation all are included in particle radiation.

Two type of radiation are:

1. Ionizing radiation
2. Non- ionizing radiation

1.2 Ionizing radiation: The energy of ionizing radiation is higher. It has enough energy to produced ion. These radiations are associated with the higher energy like, X ray, gamma ray, neutron ray. Further these radiations have worse effected on human health.[1]

Different types of ionizing radiations can be summarized as below:

1. α-radiations
2. β- radiations
3. x rays
4. □- radiations

1.2 α- radiations : α particle made up of two proton and two neutron they have large mass and charge .alpha particle are internal hazards it damage the human tissue when it inhaled by the human when alpha particle emitted substance. It loses energy and become He ion

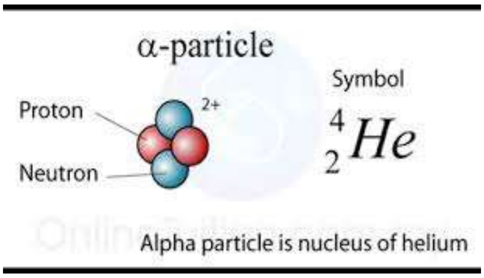


Fig .1 α- particles [8]

1.3 β- radiations: Electron ejected from nucleus which consist of negative charge particle it has small mass and can penetrate more it is also harmful for human during beta radiation emitting substance. Its damage outer layer of skin. Example of beta decay is titanium.

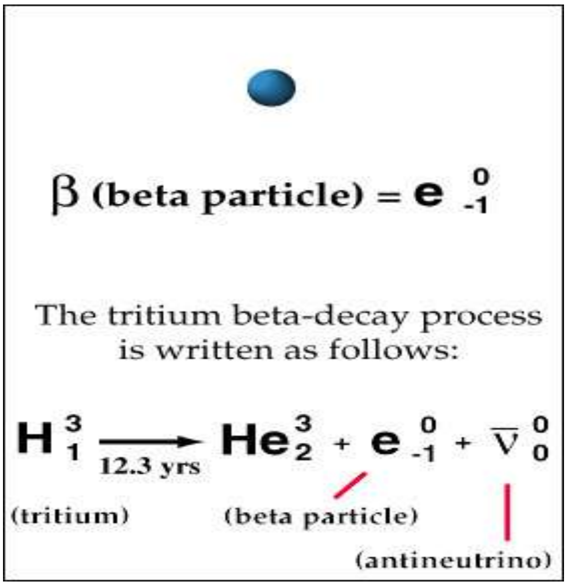


Fig 2. Beta decay

1.4 Gamma ray and x ray: They are photon radiation gamma radiation emitted photon within the nucleus and x ray emitted photon outside the nucleus .x ray has lower energy than the gamma ray . X ray and gamma ray travel with more distance than the beta and alpha radiation. Both are also more dangerous for the human tissue example of photon radiation is cobalt -60 which decay in form of nickel -60.

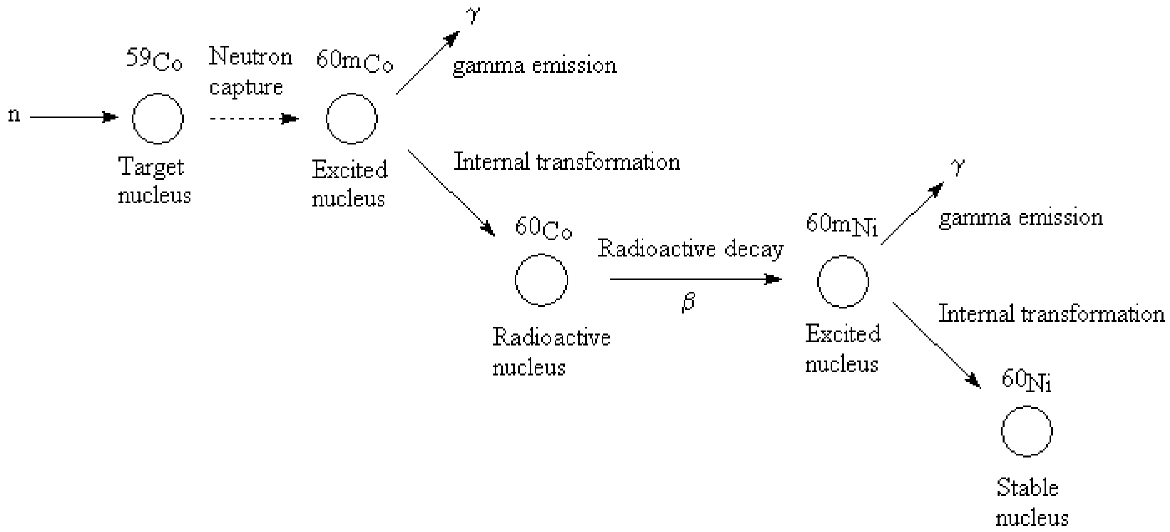


Fig 3. Photon emission of cobalt-60

1.5 Non ionizing radiation: The energy of non ionizing radiation is quiet low, thereby possesses very low ability to produce ions. Non ionizing energy generally deals with the lower frequency region, like infrared, visible, radio wave, sunlight. Radiations can be categorized on the basis of wavelength also like shortwave and long wave radiations. [2]

Electromagnetic radiations: William Rontgen discovered x rays while experimenting with high voltage applied to a evaluated tube. Alpha ray and beta ray were differentiated by Ernest Rutherford through simple experiment ion in 1899. Rutherford used a genetic radioactive source and determine that the ray produced by the some had differing penetration in material one type had short penetration and positive charge is called x ray. The other was more penetrating and negative charge called beta rays.

1.6 Use of Radiation:

Radiation is utilized as a part of prescription, scholastics, and industry, and also to generate power. What's more, radiation has valuable applications in such regions as farming, palaeontology (cell based dating), space investigation, law authorization, topography (counting mining), and numerous others.

1.61 Medicine

The most widely recognized of these restorative techniques include the utilization of x-beams — a kind of radiation that can go through our skin. At the point when x-rayed, our bones and different structures cast shadows since they are denser than our skin, and those shadows can be distinguished on photographic film.

1.62 Academic and Scientific Applications

Colleges, universities, secondary schools, and other scholarly and logical foundations utilize atomic materials in course work, lab showings, exploratory research, and an assortment of wellbeing physical science applications. For instance, similarly as specialists can name substances inside individuals' bodies, researchers can name substances that go through plants, creatures, or our reality. This enables analysts to concentrate such things as the ways that diverse sorts of air and water contamination take through nature.

1.7 Shielding material

Radiation shielding materials are used for the environments having high exposure of energetic radiations. Generally shielding materials find their application for gamma radiations.

1.8 Radiation shielding material: Radiation shielding material is generally concretes, lead composite and leads free radiation shielding. Lead composite shielding is a good standard in radiation shielding because it is cheap and easy to process it is very effective shielding which attenuate the higher energetic rays.[3] Lead composite and lead free composite has same protection level. Lead free effective protection against the x ray .it is recyclable and for the non hazardous disposal. Concrete has additionally been utilized as a protecting material against γ-beam radiation. It experiences weaknesses like substantial thickness prerequisite to fill the need and erosion because of drained uranium. It expanded mindfulness for the natural wellbeing has required the requirement for the advancement of non harmful, i.e. lead free and eco-accommodating radiation protecting materials.[4]

1.9 Material used currently for the purpose: The transparent property of glassmaker it useful for optical window in nuclear reactor and isotope technology centres. Lead and lead glass are easily available for shielding of the gamma ray and neutrons because according to the electromagnetic spectrum the wavelength of gamma ray is very high no. Offer lathe gamma ray interaction cross – section for gamma ray play important role. Now day, bismuth (Bi) and (Be) are playing an important role in radiation shielding by replacing lead. The glass contending low Z element (H, Li, B, C etc.) Are another group of the glass required for neutron radiation shielding produced specially in nuclear reactors and accelerators. Interaction of energetic radiation X and gamma ray and neutron with the material is essential in radiation technologies, medical nuclear engineering and other shielding application. Transparent radiation shielding materials have been an interesting area in nuclear engineering to provide the adequate radiation protection as well as visibility through it. Glass are found to perform the double functions of being transparent to visible light and absorbing the radiation thus providing radiation shielding to the observer.

In our project work glass will be used for the purpose of shielding materials

1.10 Glass

Glass is amorphous solid which is often transparent and has widespread practical to visible light and absorbing the radiation, glass are used in window planes, tableware the silicate glass are found to most commonly commercial glass the primary consistent of sand. In term glass is often used to refer to this type of material which is familiar us as window glass many silica based glasses the exits ordinary glazing and container glass is formed from specific type called silica lime glass.

1.11 Formation of glass

The main consistent of glass is silica (SiO_2), B_2O_3 silica melts at very high temperature i.e. 1713^0C. Secondly, it's rapidly crystallized on solidification and form a regular structure. The limitation of high melting temperature is overcome by addition of impurities to silica. This causes a depression in melting point. Secondly if the melt is cooled very rapidly, the melt thickness the concept is used in the manufacture of glass e.g. 25%soda (Na_2O) lower the liquid temperature of silica from to 1713^oC to 793^0C. [5]

1.12 Thermodynamics of glass formation:

There are two main types of pathways that a liquid may follow on cooling to the solid state: Either it may crystalline at or below melting temperature or it may under cool sufficiently to form a glass with crystalline. A glass is genially obtaining a liquid below its freezing point. The classical explanation of glass formation, when a liquid is cooled if fluidity which is reciprocal of viscosity decreases at a certain temperature below the freezing point it became zero. The liquid becomes rigid. When a liquid is cooled to form a solid the resulting cooling curve show differences from those the crystalline and amorphous. When liquid solidifies into a crystalline state there is discontinues in the temperature is called melting point (tm) the volume of liquid is decrease melting point also decrease in the expansion coefficients in range of temperature called glass transformation range . Change of slop at temperature called glass transition temperature. (T_g)

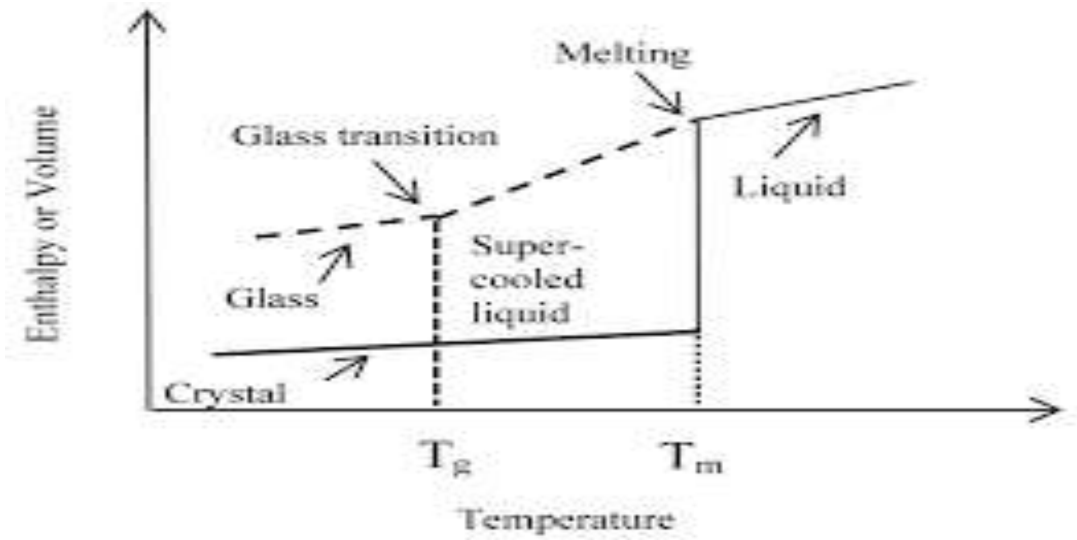


Fig 3. Thermodynamic of glass formation

1.13 Glass formation theory

Various theories are given to explain the glass forming tendency of the oxide.

1. Goldschmidt's creation gives a correlation between the ability to form a glass and the relative size of oxygen anion and cation.
2. One of the most important theories infused glass science was given by Zacharias. According to him Goldschmidt’s creation was not satisfactory even as an

empirical rule. Zacharias considered the relative glass forming ability of simple oxide and concluded that the ideal condition for glass formation is that the material should be capable of forming an extended 3D network without long rang order.

1.14 Zachariasen's rule:

- An oxygen atom is linked to at most two other atom.
- The coordination no. of the other atom is small.
- The coordination polyhedral, formed by oxygen around the other atom.[6]

Glass component: glass component are mainly divided into three components:

1. glass former
2. modifier
3. intermediate

Former:

1. Glass former generally have cation oxygen bond strength greater than 80kcal/mole.
2. Glass former SiO_2, B_2O_3, and GeO_2.
3. The no. of intermediate neighbour or coordinate no. one for B2O3.
4. B_2O_3 which is having triangular structure.

Modifier:

1. In multi component system, oxide with lower bond strength don't became part of the network are called modifiers.
2. Modifiers are Na_2O, MgO, and HgO etc.
3. Bond strength of the modifier is usually in the range between 10 to 40 cal/mol
4. Coordination no. varies from 4 to 10.
5. It is used in optoelectronic device, solid state ionic conductor.

Intermediate:

1 Intermediate occupy a position between former and modifier

2 Intermediate are TiO_2, ZnO and PbO.

3 Oxide with energies about 335kj/mole may not became part of network

1.15Interactions of photon with matter:

Photons are electromagnetic radiation with zero mass, zero charge and a velocity that is always c, the speed of light. When photon interact with matter it can be scattered, absorbed and disappear. Photons are more penetrating than charged particles of same energy. Penetration distance depends on photon energy and interacting particles.

Generally there are four type of interaction of photon:

1. Rayleigh scattering
2. Compton scattering
3. Photoelectric absorption
4. Pair production

1.16Interaction probability:

1.161 Linear attenuation coefficient,μ

1. Proportional constant μ is called linear attenuation coefficient.
2. The probability of an interaction per unit distance travelled.
3. Then **μ=(n/N)/dx**
4. μ depends on photon energy and on the density of the material.

1.162Mass attenuation coefficient: mass attenuation coefficient is defined for other electromagnetic radiation such as x- ray, gamma or any other beam that attenuate.

SI unit of mass attenuation coefficient is the square meter kilogram.

Mass attenuation coefficient is **μ/ρ**

μ = attenuation coefficient

ρ=mass density

In solution:

In chemistry, mass attenuation is used for a chemical dissolve in a solution

μ= (μ/ρ2) ρ1+ (μ/ρ1) ρ2+...

Sum is the mass attenuation coefficient and density of a different component of the solution.

1.163.Coherent scattering:

1. If the energy of photon is less than the binding energy of electron of atom photon may deflect its path with no loss in energy.
2. It is also called classical or Rayleigh scattering.
3. Coherent scattering varies with the atomic no of absorber and incident photon Z2/E.

1.164. Photoelectric effect:

1. In the photoelectric absorption process a photon is an interacting with an absorber atom in which photon is completely absorbed.
2. Vacancy created by k-shell which will be filled by electron from l-shell.
3. It can take place only if photon energy is equal to or greater than binding energy.
4. Photoelectron appear with energy
   a. **E =hν-E**
5. The probability of photoelectric absorption is proportional to the cube of photon energy.
   a. **τ= k Zn/E3**

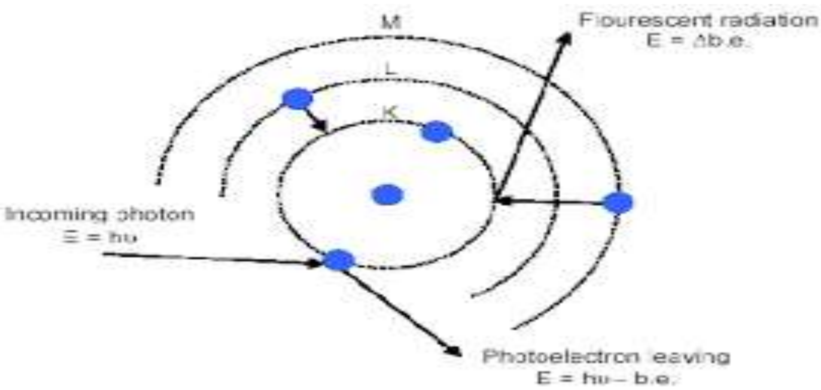


Fig4. Photoelectric absorption

1.165 Compton scattering:

1. Compton scattering take place between the incident gamma ray photon and electron in the absorption
2. If photon energy is higher than binding energy, electron is considered as free electron.
3. Interaction between free electron and photon is called Compton scattering.
4. Photon may be scattered in any direction.
5. In Compton process for energy absorption is soft tissue in the range for 100 keV to 10 Mev.
6. The Compton scattering probability σ independent of atom no. Z

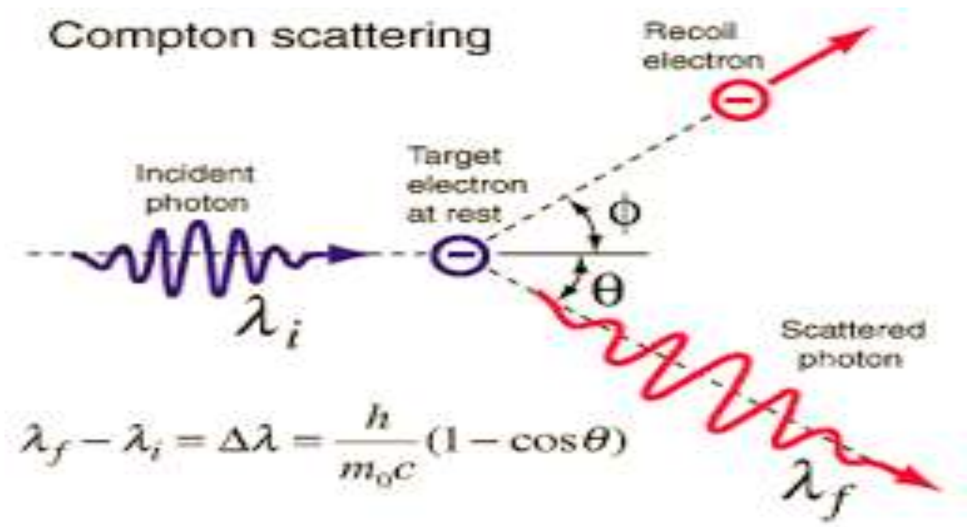
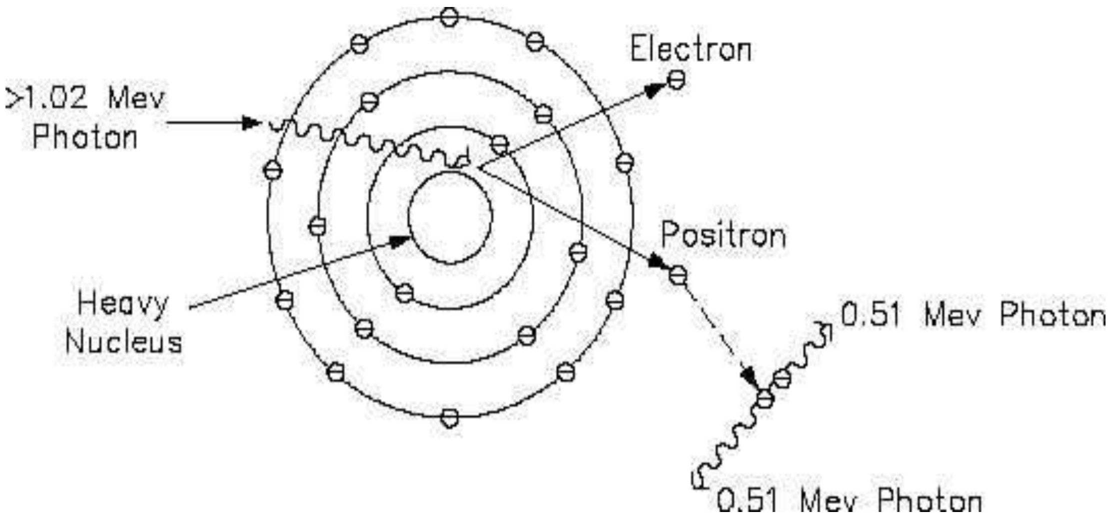


FIG5. COMPTON EFFECT

1.166.Pair production:

1. Pair production enters matter with an energy in excess of **1.022 MeV, it** may interact by a process called pair production.
2. The photon, passing near the nucleus of an atom due to strong field effect it will disappear as a photon and reappear as a negative and a positive electron pair.



3.Pair production probability

a. Increases with increasing photon energy
b. Increases with atomic no as Z2[7]

1.167. Build up factor:

When beam of monoenergetic gamma ray interact with matter with the same energy then the scattered of electromagnetic energy but only some beam reach to the detector. It is necessary to modify computational method for shield is thick enough only considered scattered beam of the gamma photon. Buildup factor is the shielding parameter it depend on geometry parameter which correct the simple attenuation calculation and included only scattered part. Equation of build up factor is

$$\mathbf{I=BI_0e^{-ux}}$$

Build up factor is always greater than 1 with the increase of build up factor penetration depth increase.

1.168 Classification of build up factor

1. **Exposure build up factor:** It is define exposure and absorption in air by detector after penetration through shielding material is called EBF.
2. **Energy Absorption Build up Factor:** It is define energy deposition in the medium and dose build up factor in medium is called EABF.

2. REVIEW OF LITERATURE

2.1 K. Singh et al.(1995)[1]: had studied in the range 10^{-2} to 10^{-5} MeV the effective atomic no and mass attenuation coefficient for total and partial photon interaction of some compound has been calculated .they have been determine experimentally in the energy range of 122-1131 kev by transmission method both the theoretical and experimental in agreement with change in composition of compound and energy the value of these parameter have been found be identical at all energies are to variation in determination of different energy different mass attenuation coefficient value was observed.

2.2 N.S et al. (2006)[2]: had using gamma ray at 511,652 and 1273 KeV energies PbO-BaO-B2O3 glass system investigation is been done. in term of molar mass ,HVL, mass attenuation has been calculated by using computer program NISTXCOM . gamma ray attenuation of prepared glass sample are compared with tabulation between the theoretical value of tabulation and experimental value good agreement has been observed uncerternity less than 3% are resulted property such as radiation shielding of glass have been compared with the value of concrete thus concluded that the glass are better radiation shielding .

2.3 M.EI-Hof et al.(2007)[3]: had studied the transformation of thermal energy into mechanical energy is required where there is releasing constrain of the chemical bond in glass an equation can be obtained to calculate transition of glass i.e. the glass transition temperature tg by equating the both energy i.e. mechanical and thermal therefore obtained equation is applied haloborate and halomolybdate glasses successfully which thus show that the ratio of chemical component the length of bond and the stretching force are crucial parameter to determine value of tg.

2.4 Dariush sardai , Ali abbaspour et al. (2009)[4]: X-ray and gamma ray build up factor in soft tissue and water in the energy range 0.2-2Mev is calculated by using Monte Carlo method. Data of soft tissue compare with pure water existing build up factor data .The composition of soft is $H_{63}C_6O_{28}N$.It is observed that the medical application of gamma and x-ray water is usually approximately by soft tissue. It has been concluded that difference between soft tissue and water built up factor is more than 10%.Build up factor compare with experimental data and also observed 10% error as well as.

2.5 B.oto et al. (2012)[5]: had measured the mass attenuation for concrete which contain tinical concentrate waste in energies range 59.54 and 8099 kev by using NISTXCOM program. had concluded that sample TCW absorbed more photon than the ordinary concrete the mass attenuation energy decrease with increase in energy t5(25%) concrete had best gamma radiation shielding.

2.6 Abbas J.Al Saddi (2012)[6]:had studied that gamma ray build up factor for two layer shield consist of water lead and lead water are calculated at the energy range 1.2 and 6 Mev but using kalo's formula this program use for calculated atomic number of the attenuation medium ,thickness of slab and arrangement of materials. And concluded that build-up factor for lead water were high at energy range (1-2Mev) while at energy 6Mev build up factor were lower.

2.7 Sandeep Gupta and G.S Sidhu(2012)[7]:had studied of gamma ray energy absorption build up factor of some oxide glasses such as Cao-Al_2O_3, Na_2O-Al_2O_3-SiO_2 and Na_2O-SiO_2 and calculated build up factor, effective atomic mass in energy range 0.015to 15 Mev up to penetration depth 40 Mfp using ANSI/ANS-6.43 and G.P fitting method .they reported that the value of EABF remain constant and low for penetration at 0.015Mev but for energy 0.2and 0.5 Mev the value of EABF is high and penetration is increase with increase of energy and also concluded that at energy 0.2Mev EABF will increase for oxide glasses where Compton scattering predominant.

2.8 J.S Dillon B.singh et al. (2012)[8]: had studied that gamma ray photon energy absorption build up factor study in some soil. Mostly mercury and lead are used as shielding material but these are difficult to use because high cost soil can be use as a gamma shielding material and the parameter are used to calculate energy absorption build up factor (EABF) and exposure build up factor in range 0.005-15Mev up to penetration depth of 40mpf and concluded that EABF value of soil is maximum around 0.2Mev .Soil as potential radiation shielding material.

2.9 Tejbir singh et al. (2013)[9]: had studied of gamma ray exposure building for some ceramic like silicon carbide ,boron nitride , Fe3O4 and measure the photon energy , penetration depth had concluded that the ferrite is the better gamma ray shielding because in the higher energies for more penetration depth then the exposure building factor will be directly proportional to Z_{eff}.

2.10 Balwinder singh et al.(2013)[10]:had studied that gamma ray shielding for low Z shielding material like Bakelite ,concrete, red sand and white sand shield .some parameter have been calculated mass attenuation coefficient, equivalent total no and energy no. in the range 0.15-15 Mev. It have been observed that effective atomic no. Is related to effectiveness of shielding and concluded that the white sand and red sand are good shielding material due to its high mass attenuation and lest value of the build up .

2.11 Harpreet Singh ishar, Sandeep Gupta et al.(2014)[11]: Dana's material are usedsuchasAnalcime(M1),Chabanite(M2),Heulandites(M3),Pyropylite(M4),Scapolite(M5),Stilbite(M6),Serpertive(M7) as gamma ray shielding material. Some parameter are calculated such as mass attenuation coefficient , equivalent atomic no and exposure build up factor in energy range 15Kev-15 Mev penetration depth up to 40mpf it has been concluded that M2 and M5 are the good shielding material because of its lower exposure build up factor and higher value of mass attenuation.[11]

2.12 D.B Thombre et al.(2014)[12]: had studied that by the using melt quench technique the glass sample of lithium borosilicate were prepared ,in order to studied their structure density and molar volume were determine . As mole % of SiO2 increase the molar volume linearly decrease the various properties are studied which are physical parameters like oxygen packing density, dielectric constant, reflective index, was also studied. The concentration of SiO2 is increasing with decreasing the oxygen packing density. And linearly ionic concentrations are also studied.

2.13 V.P. Singh N.M Badiger et al. (2014)[13]: had worked on the mass attenuation coffieicent , HVL, TVL, effective atomic number and effective electron densities of borate glass containing NiO and PbO with gamma ray and neutron. the gamma parameter mass attenuation , HVL,TVL were deal for photon in the range 1kev-100gev.the value of mass attenuation very large which decrease sharply at the value of mass attenuation and concluded that PbO had better shielding property than the NiO .so, borate glass are good radiation shielding material.

2.14 Danial saleni, darush sardai et al. (2015)[14]: had studied that interaction of photon with soft tissue examine the radiation shielding parameter like mass attenuation coefficient, effective atom, build up factor in the range 0.01 to 1000 MeV and 40 mf penetration depth and calculated mass energy absorption coff and concluded that the mass energy absorption is most important parameter for radiation exposure when flux of x ray .

2.15 J.M Sharaf H.saleh(2015)[15]: shielding properties of building material and three construction style used in jorden were evacuated using parameter such as equivalent atomic no , attenuation coff., energy build up factor and penetration depth .G.P(geometrical progression) approach are used to calculated build up factor of concrete, limestone, cement plaster ,bricks for energy range 0.05-3Mevand penetration depth up to 40 mpf. it has been concluded that building material limestone has high value of equivalent atomic no. . The value of penetration depth and energy build up factor is low also observe that any nuclear accident, large building with five layer could effectively attenuation radiation more than the small building.

2.16 M.I Sayyed (2016) [16]: Mean free path and half value layer of tellurite glass forming with different oxide (ZnO, BaO, Nb_2O_5, Ag_2O and PbO) has been calculated by using WinxCom. G.P(geometrical progression) method are used to calculate the build up factor in the energy range 0.015 -15Mev up to penetration depth 40Mpf.It has been observed that TeO_2-PbO glass has minimum mean free path and half layer value. Concluded that it has been good shielding properties against gamma radiation and also when glass compare with concrete it has been found glass is better radiation shielding than concrete.

3. SCOPE OF THIS STUDY

Our work finds its application in the fields of nuclear reactors and the fields which are exposed to radiation environment. The aim of this work is to identify oxide glasses as the shielding materials which are cheap, can be moulded to any design, transparent and easily available. Most dangerous radiations to humans and animals are gamma rays because they are highly energetic and can penetrate a larger distance in the materials exposed to these radiations. Generally concrete is used for shielding applications but due to its opaque nature, large mass and hygroscopic nature a lot of research work is going on to look for its alternate. The present work is aimed to identify such alternating material by analysing their radiation shielding parameters. .Different radiation shielding parameters like mass attenuation coefficient, HVL, total atomic cross-section, effective atomic number and build up factor are useful in the identification of such alternate materials It is observed that these alternate material are useful as they are cheaper, easily available and can be moulded to any desired shape.

4. OBJECTIVE OF STUDIES

- Estimation of gamma ray attenuation properties in terms of mass attenuation coefficients and energy build up factors by using XCOM
- To find HVL, TVL, MFP, Effective atomic number from mass attenuation coefficients and to study their variation as a function of glass composition and gamma ray photon energy
- To study energy and composition dependence of molecular cross section, atomic cross section and electronic cross section for selected glass systems
- To compare the attenuation properties of the studied glass system with standard concrete material.

5. COMUPUTATIONAL TECHNIQUE AND THEORETICAL CALCULATION

5.1 Mass Attenuation Coefficients

The linear attenuation coefficient of the glass samples is calculated by using mass attenuation coefficient and density values. The values of linear attenuation coefficients are given by mixture rule

$(\mu/\rho)_{glass} = \Sigma_i (\mu/\rho)_i w_i$ (1)

$w_i = (n_i A_i)/(\Sigma_j n_j A_j)$ (2)

$\Sigma_i w_i = 1$ (3)

Where A_i is the atomic weight of the ith element, n_i is the number of formula units in the compound, w_i is the proportion by weight.

5.2The Half Value Layer and TVL values

HVL is the thickness of radiation shielding material at which the intensity of radiation reduced to half to its original intensity.

is computed by using relation

$HVL = (0.693/\mu)$ (4)

Similarly the tenth value layer is computed by the relation

$TVL = (2.303/\mu)$ (5)

5.3 Effective Atomic Number and electron Density:

Z_{eff}= (Σ_i $f_iA_i(\mu/\rho)_i$)/((Σ_i $f_i(A_i/Z_i)(\mu/\rho)_i$)) (6)

N_{eff}= (N_A (nZ_{eff}))/($\Sigma_i n_iA_i$) (7)

5.4 Gamma ray Photon Exposure Build up factor:

For the computation of gamma ray photon exposure build up factors the G.P fitting parameter are obtained from equivalent atomic number (z_{eq}) by employing ANSI/ANS6.4.3 and NIST XCOM software.

5.4.1 Equivalent atomic no.

Zeq (equivalent atomic number) the Compton mass attenuation coefficient $(\mu/\rho)_{compton}$, the total mass attenuation coefficient $(\mu/\rho)_{total}$, were obtained for oxide glasses in the energy region 0.015 to15MeV, using computer program NIST-XCOM and the following equation

$$Zeq = \frac{\mathrm{Z1(log\ R2-logR)+Z2(logR-logR1)}}{\mathrm{(logR2-logR1)}} \quad (8)$$

Where Z1 and Z2 are atomic no corresponding to ratio R1 and R2

5.4.2 Geometric progression (GP) fitting parameter:

The GP fitting parameter for element were taken from reference database ANSI/ANS6.4.3 in the energy range 0.015-15MeV up to penetration depth of 40 Mfp, GP fitting build up factor coefficient of material is calculated by formula :

$P= P_1(\log Z_2-\log Z_{eq})-P_2(\log Z_{eq}-\log Z_1)/(\log Z_2-\log Z_1)$ (9)

P is the GP fitting coefficients correspond to $Z_{eq.}$

5.4.3 Computation of the EABF:

EABF and GP fitting parameter (b,c,a,X_k and d) in the energy range 0.015 – 15MeV and penetration depth up to 40 Mfp by using formula:

$$B(E,x) = 1 + \frac{(b-1)(k^x-1)}{(k-1)} for\ k \neq 1 \quad (10)$$

B(E,x)=1+(b-1)x for K=1 (11)

where $K(E,x) = Cx^a + d\frac{\tan h(x/Xk-2)-tanh(-2)}{1-tanh(-2)}$ for (x)≤40mfp (12)

Where K is the photon dose multiplication parameter E is the incident photon energy

6. RESULT AND DISCUSSION

In this work, Mass attenuation coefficient, linear attenuation coefficient, half value layer, Effective atomic number, Equivalent atomic number, Geometric progression fitting parameter, Energy absorption build up factor for oxide based system Li2O and B2O3 in Energy range 0.015 to15 MeV Are Calculating.

Table 1.

Li2O	B2O3	Density (g/cm^3)	mol wt Li2O	mol wt B2O3	total	wt fraction Li2O	wt fraction B2O3	total
0.4	0.6	2.29	29.879	69.6182	53.72252	0.222469087	0.777530913	1

6.1Mass Attenuation Coefficient:

Form the Graph 1. Variation of Mass attenuation coefficient of the oxide based system in energy range 0.015 to 15 MeV. It is noticed that from graph between photon energy and mass attenuation for low energy range 0.015 to 0.06 Mev Mass attenuation decrease gradually with increase of energy due to photoelectric dominance, also in intermediate energy it will give almost same variation due to Compton Effect in range 0.08 to 0.2 MeV and then it again give small variation in range 1 to 100 MeV due to pair production depending on atomic no Z.

Table 2.

energy(Mev)	mass attenuation (cm^2/g)	Density	Linear mass attenuation (cm^{-1})	Half Value Layer(cm)
0.015	1.34E+00	2.29	3.07E+00	2.25E-01
0.02	6.59E-01	2.29	1.51E+00	4.59E-01
0.03	3.14E-01	2.29	7.20E-01	9.63E-01
0.04	2.29E-01	2.29	5.24E-01	1.32E+00
0.05	1.95E-01	2.29	4.47E-01	1.55E+00
0.06	1.78E-01	2.29	4.08E-01	1.70E+00
0.08	1.60E-01	2.29	3.65E-01	1.90E+00
0.1	1.49E-01	2.29	3.40E-01	2.04E+00
0.15	1.31E-01	2.29	3.00E-01	2.31E+00
0.2	1.19E-01	2.29	2.73E-01	2.53E+00
0.3	1.03E-01	2.29	2.37E-01	2.93E+00
0.4	9.25E-02	2.29	2.12E-01	3.27E+00
0.5	8.45E-02	2.29	1.93E-01	3.58E+00
0.6	7.81E-02	2.29	1.79E-01	3.88E+00
0.8	6.86E-02	2.29	1.57E-01	4.41E+00
1	6.17E-02	2.29	1.41E-01	4.91E+00
1.5	5.02E-02	2.29	1.15E-01	6.03E+00
2	4.31E-02	2.29	9.87E-02	7.02E+00
3	3.46E-02	2.29	7.93E-02	8.74E+00
4	2.97E-02	2.29	6.81E-02	1.02E+01
5	2.65E-02	2.29	6.07E-02	1.14E+01
6	2.43E-02	2.29	5.55E-02	1.25E+01
8	2.13E-02	2.29	4.88E-02	1.42E+01
10	1.95E-02	2.29	4.47E-02	1.55E+01
15	1.71E-02	2.29	3.92E-02	1.77E+01

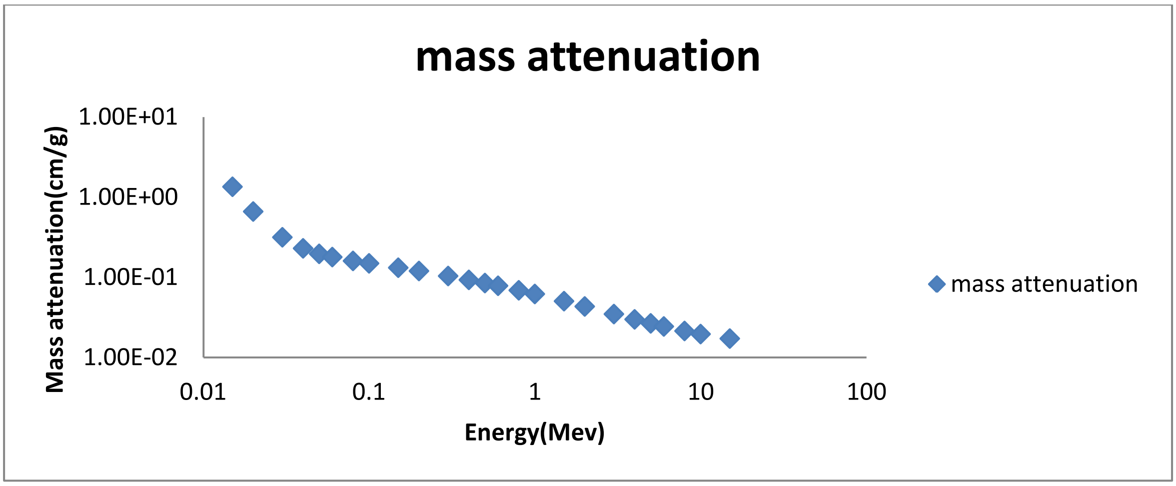


Fig.1 Variation of mass attenuation of oxide based system Li_2O and B2O3 with energy range (0.015 to 15 MeV).

6.2 Half Value Layer:

Variation of oxide based system Li_2O and B_2O_3 with energy range 0.015 to 15 MeV. Which is shown in Fig2, it is observed that the variation is opposite to mass attenuation in this graph for lower energy it will increase with increase in energy due to photoelectric effect in energy range 0.015 to 0.06 MeV, then it will show constant variation in range 0.06 to 0.8 due to Compton effect and In last it further give the increasing variation in range 1.2 to 15 MeV due to pair production.

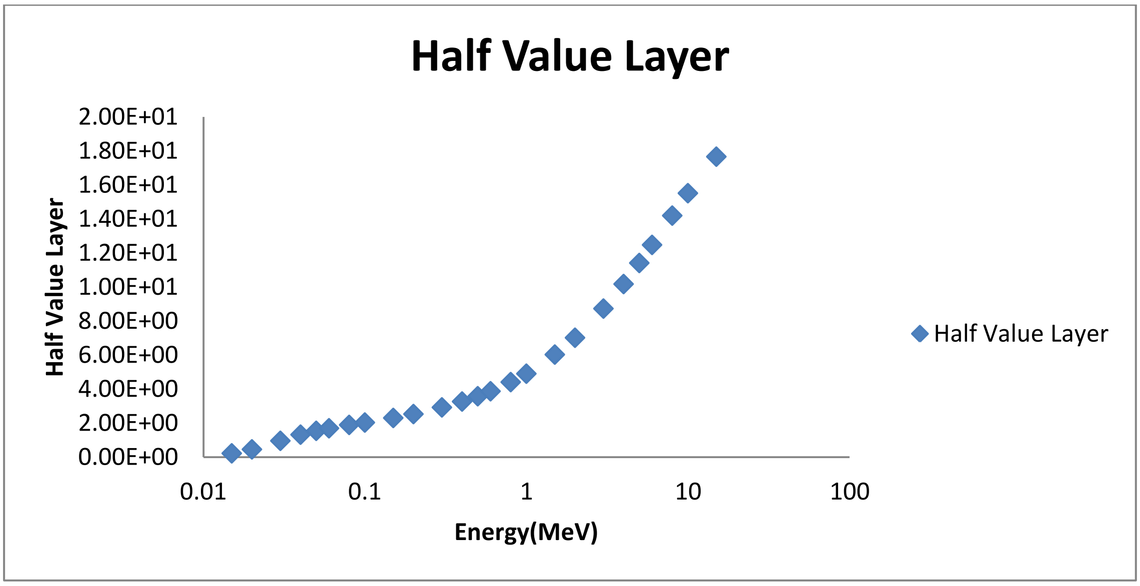


Fig 2. Variation of HVL for oxide based system Li2O and B2O3 with energy range 0.015 to 15 MeV.

6.3 Linear attenuation coefficient:

Variation of oxide based system Li2O and B2O3 with energy range 0.015 to 15 MeV. Is shown in Fig3. It is observed that the variation of graph of linear attenuation is slightly same as mass attenuation for the low energy it is decrease gradually in range 0.015 to 0.06 MeV due to photoelectric effect, then it will give the same variation in energy range 0.08 to 0.4 MeV due to Compton effect and finaly for high enegy range its futher give the variation in range 1 to 15 MeV. Due to pair production because its depend on atomic no. Z.

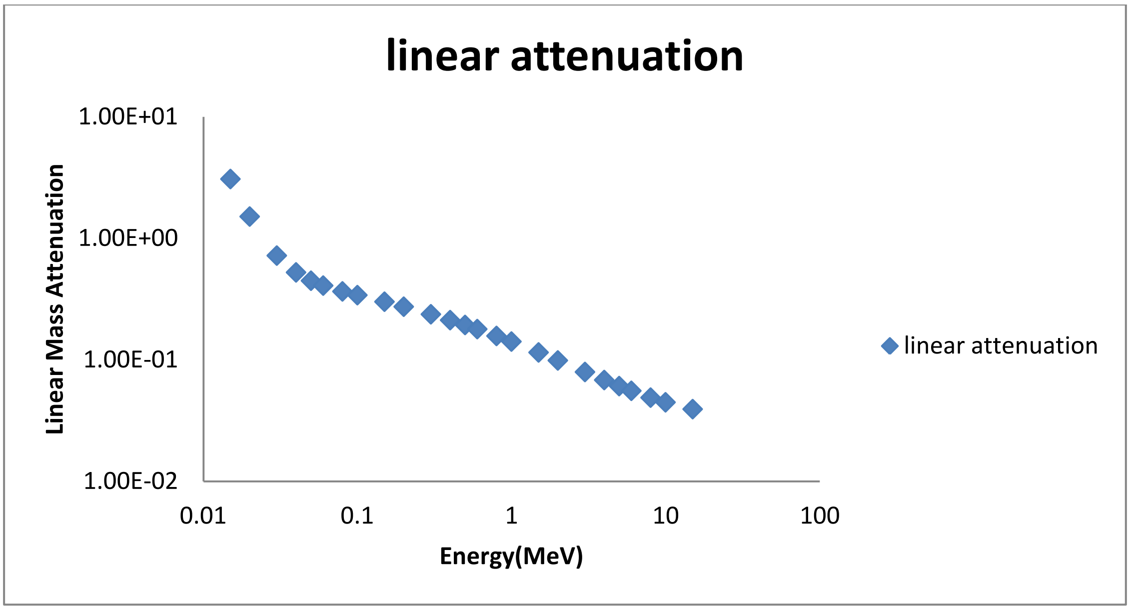


Fig 3.Variation of linear attenuation for oxide based system Li2O and B2O3 with energy range 0.015 to 15 MeV.

6.4 Effective atomic no.(Z_{eff}) and Equivalent atomic no(Z_{equ}):

It is noticed that in table3. At the lowest energy (0.015-0.06 MeV) effective atomic no. increasing with photon energy due to photoelectric absorption, for the intermediate energy (0.08-2MeV) will give the almost constant behaviour due to the Compton Effect .In the intermediate energy attenuation properties does not effect by chemical composition, at the higher energy (1-15MeV) further it starts decreasing due to the pair production . In case of Equivalent atomic number At lower energy (0.015-0.1MeV) it will increasing and for higher energy start decreasing then give the constant behaviour and also it is depend on atomic no Z1 and Z2 corresponding to R1 and R2 ratio of $\mu/\rho_{(Compton)}$ and $\mu/\rho_{(total\ scattering)}$.

Table 3.

E(MeV)	Z1	Z2	Zeq	Zeff
0.015	6	7	7.150384	4.23E+00
0.02	7	8	7.17855	7.63E+00
0.03	7	8	7.19252	7.29E+00
0.04	7	8	7.200064	7.09E+00
0.05	7	8	7.199404	6.98E+00
0.06	7	8	7.202	6.93E+00
0.08	7	8	7.218776	6.90E+00
0.1	7	8	7.136848	6.88E+00
0.15	7	8	7.309796	6.88E+00
0.2	7	8	8.120355	6.87E+00
0.3	6	7	6	6.87E+00
0.4	7	8	7.121277	6.87E+00
0.5	7	8	8.081104	6.88E+00
0.6	6	7	5.96007	6.87E+00
0.8	7	8	8.040738	6.88E+00
1	9	10	31.76715	6.88E+00
1.5	7	8	4.315756	6.88E+00
2	6	7	6.558724	6.88E+00
3	6	7	6.620852	6.00E+00
4	6	7	6.620939	6.00E+00
5	6	7	6.599989	6.00E+00
6	6	7	6.654157	6.00E+00
8	6	7	6.626384	6.00E+00
10	6	7	6.642131	6.00E+00
15	6	7	6.632142	6.00E+00

6.5 EABF with penetration depth (1mfp, 5mfp, 10mfp) and energy:

In fig 4. Noticed that the variation of EABF with penetration depth and energy (0.015-15 MeV).At lower energy photoelectric dominant and at high energy pair production dominant

.It wiil give the maximum EABF at intermediate energy (0.05-0.8MeV) due to the Compton effect, In this process energy are reduce and photon are not remove completely only is direction is changing and give the multiple photon scattering which cause to increase build up of photon and also noticed that for the higher penetration EABF also increasing .

Table 4.

E(MeV)	B(E,x)At 1mfp	B(E,x)At 5mfp	B(E,x)At 10mfp
0.015	1.234	1.555029915	1.740692138
0.02	1.507538568	2.432419374	3.096472216
0.03	2.505794801	7.148618512	12.35546259
0.04	3.774483806	19.47183802	48.15588135
0.05	4.833699682	38.07094767	126.0917184
0.06	5.318256322	55.65676902	226.8106189
0.08	5.28242385	72.97356146	370.0495231
0.1	5.104185593	76.10796665	425.8164317
0.15	3.939839434	56.94227225	324.3419628
0.2	3.311613046	36.09436125	170.2341233
0.3	2.962	39.28793154	212.2056509
0.4	2.690866837	23.85750594	96.52635897
0.5	2.470241003	17.07016068	58.70453451
0.6	2.406	18.05968715	64.64394202
0.8	2.182869831	11.65355683	33.30423604
1.5	2.109254191	8.733636055	20.36515613
2	1.858	6.30479906	13.1681243
3	1.718	4.861070316	9.103417852
4	1.631	4.118788589	7.222041136
5	1.562	3.627507688	6.091945433
6	1.517	3.318870371	5.407595652
8	1.423	2.840672879	4.428954153
10	1.361	2.545063055	3.853197057
15	1.271	2.125304563	3.050969194

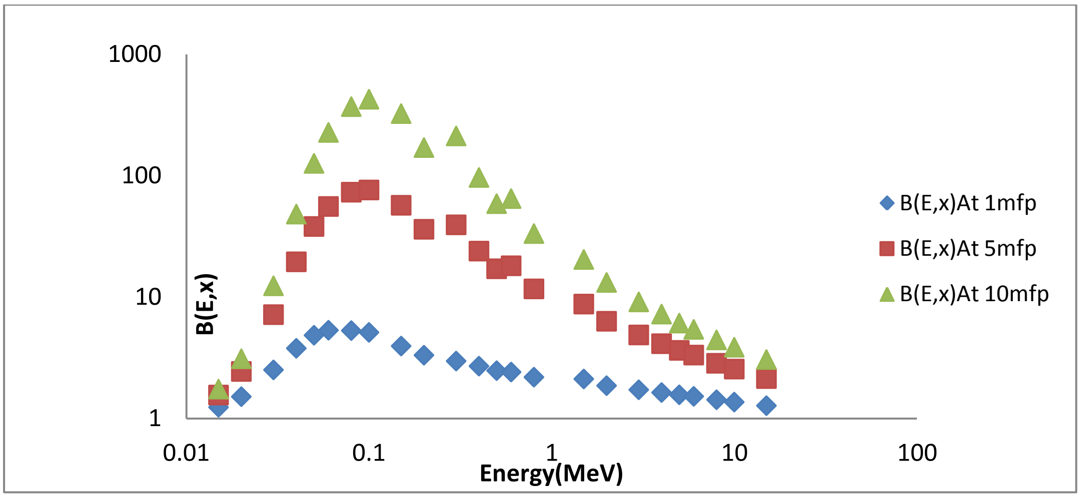


Fig3 . Variation of EABF with penetration depth (1mpf, 5mpf, 10mpf) and energy (0.015-15 MeV) for oxide based system Li_2O and B_2O_3.

7. WORK TO BE DONE

Till now only work in one sample corresponding to composition Li_2O and B_2O_3 and certain parameters of radiation shielding has been calculated, in future work all parameter like Mass attenuation coeffient , HVL, Zeff, Zequ and EABF of the remaining samples of the series will be evaluated and analysed at a function of composition as well as energy. In addition to this sample displaying best radiation shielding parameter will be compared in terms radiation shielding properties with standard concrete material.

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