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STUDIES ON MASS ATTENUATION COEFFICIENT, MOLAR EXTINCTION COEFFICIENT AND EFFECTIVE ATOMIC NUMBER OF SOME OXIDES IN THE ENERGY RANGE OF 122-1330KEV

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ABSTRACT

In the present investigation we have measured here the mass attenuation coefficients (μ_m) of six oxides such as aluminum, manganese, copper, nickel magnesium for 122 -1330 keV . Photons are measured using the radioactive sources Co^{57}, Ba^{133}, Cs^{137}, Na^{22}, Mn^{54} and Co^{60}. To detect gamma rays NaI(Tl) scintillation detection system was used. The investigated attenuation coefficient values were then used to determine the other important parameters like linear attenuation coefficient (μ), total atomic cross sections (σ_t), molar extinction coefficients (ε), electronic cross sections (σ_e), effective atomic numbers (Z_{eff}) and effective electron densities (N_{eff}) of these oxide. Graphically it is observed that the variations of μ_m, σ_t, ε, σ_e, Z_{eff}, and N_{eff} with energy The values of μ_m, μ, σ_t, ε, σ_e are higher at lower energies and they decrease sharply as energy increases. The XCOM data is used to calculate Theoretical values. We were observed that the Theoretical and experimental values are found to be in a good agreement (error < 4%).

KEYWORDS: Mass attenuation coefficient; linear attenuation coefficient; total atomic and electronic cross sections; effective atomic number; effective electron density; molar extinction coefficient

The mass attenuation coefficient values of partial photon interaction processes such as photoelectric effect, Compton scattering, pair production and all these are available in the form of software package XCOM from Berger and Hubbell (1987) by substituting the chemical composition of compound or mixture the mass attenuation coefficient of the In recent years the study of photon atom interaction with different materials has gained more importance because of extensive use of radioactive sources in different field like medicine, industrial, biological, chemical and other field. The proper characterization is needed for scientific study of interaction of radiation with matter and also the penetration and diffusion of gamma radiation in external medium is necessary. The nature of the material is also important because from many studies it is observed that the Mass attenuation coefficient (μ_m) usually depends upon the energy of radiations and nature of the material.

The Oxide covers a wide range of applications almost in every field. The study on the interaction of gamma rays with oxide materials are of great interest from theoretical and experimental point of view. It is found that the values of mass attenuation coefficients, total atomic and electronic cross sections, molar extinction coefficients, effective atomic numbers and electron densities of some metal oxides in the energy range of 122-1330 keV are calculated. These measured values are compared with theoretical values calculated using XCOM program (Berger M.J. and Hubbell J.H., 1987,1999).are found to be good agreement between each other.

Mass attenuation coefficient (μ_m) is a most important and measure factor of the average number of interactions between incident photons and substance that occur in a given mass per unit area thickness of the material under investigation (Hubbell, 1999). Because of their diverse applications in industrial, chemical, biological, medical, shielding, agricultural applications also in food technology, biosensor, photovoltaic cell and solar cells ultra sound are more recent applications. The useful parameters, like total atomic and electronic cross sections, molar extinction coefficients, effective atomic numbers and effective electron densities are critical parameters in applied field as well as fundamental science are obtained by using mass attenuation coefficient.

The Shielding materials will be generated in the energy range 1 keV - 100 GeV. Hubble (1982) are published tables of mass attenuation coefficients and the mass energy absorption coefficients for 40 elements and 45 mixtures and compounds for 1 keV to 20 MeV . Hubbell and Seltzer (1995) replaced these tables in form of tabulation for all elements having $1 \leq Z \leq 92$ and for 48

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additional substances for dissymmetric interest. XCOM program converted to windows version is now called as

Oxides and biological material) plays an important The knowledge of Interaction of photons with different substances (i.e. alloy, plastic, soil, role in radiation biology, nuclear technology, and space research as radioactive sources such as Co^{57} (122 keV), Ba^{133} (356 keV), Na^{22} (511 and 1275 keV), Cs^{137} (662 keV), Mn^{54} (840 keV) and Co^{60} (1170 and 1330 keV) are more useful in biological studies, radiation sterilization, industry (Hall, 1978). Photons in the mega-electron-volt range are vital for radiography and medical imaging, where the cross-sectional anatomy is generated by computer-aided tomography (CAT) and photons in the giga-electron-volt energy range are important in astrophysics and cosmology (Manohara et al. 2008).There have been several experimental and theoretical investigations for the determination of mass attenuation coefficient (μ_m) of different materials can be used to determine other related parameters like linear attenuation coefficient (μ), total atomic cross (Z_{eff}) and effective electron densities (N_{eff}) of the chosen sample (El-Kateb and Abdual-Hamid, 1991; Gowda et al., 2005; Manjunathaguru and Umesh, 2006; Pawar P.P. and Bichile sections (σ_t), molar extinction

CALCULATION METHODS

Mass Attenuation Coefficient

The inverse exponential power law that in the present work we study some theoretical parameters of some oxide that have been used to determine the mass attenuation coefficient μ_m . And other related parameters which are based on it. A parallel beam of the measured intensity *I* of the transmitted mono-energetic X-ray or γ-photons passing through matter is related to the incident intensity I_0 is is usually referred to as Beer-Lambert law is given by the relation.

$$I = I_0 e^{-\mu_m X}$$

(1)

Where, I_0 and I are incident and transmitted photon intensities respectively,

X is mass per unit area (g/cm^2), μ_m is mass attenuation coefficient (cm^2/g) given by the following equation for a compound or mixture of elements (Jackson D. F. and Hawkes D.J., 1981; Hubbell and Seltzer, 1995):

Win XCOM Gerward et al.(2001,2004).

coefficients (ε), electronic cross sections (σ_e), effective atomic numbers G.K., 2013; Sandhu et al., 2002).

Effective atomic number (Z_{eff}) plays an important role in the determination of a substitute material for an element associated with the required energy (Hine, 1952). The energy absorption in a given medium can be calculated if certain constants are known. These necessary constants are Z_{eff} and electron density N_{eff} of the medium. As effective atomic numbers and electron densities are useful in many technological applications (Pravina P Pawar and Govind K Bichile, K.S.R. Sastry, S. Jnanananda, G.S. Mudahar, M. Singh, G. Singh). Many researcher are interested in the determination of mass attenuation and different parameters of complex molecules in the energy range 5-1500 keV as the photons in this energy range are widely used in medical and biological applications (Hubbell, 1999) via different methods (Murut Kurudirek, 2013, 2014a, 2014b, 2014c, 2015; Midgley, 2004, 2005; Manohara and Hanagodimath, 2007; Demir et al., 2012; Murat Kurudirek and Tayfur Onaran, 2015; Danial Salehi et al., 2015).

$$(\mu/\rho)_i = \sum_i W_i (\mu/\rho)_i$$

(2)

Where W_i is the weight fraction and $(\mu/\rho)_i$ is the mass attenuation coefficient of the i^{th} constituent element.

Weight fraction is given by

$$W_i = n_i A_i / \sum_j n_i A_j \ ,$$

(3)

Where A_j is the atomic weight of i^{th} element and n_i is the number of formula units.

Total Atomic Cross Section

Total attenuation cross section (σ_t) is a fundamental parameter to describe the photon interaction with matter. The value of mass attenuation coefficient (μ_m) is used to determine Total atomic cross section (σ_t) by using the following relation.

$$\sigma_t = \frac{A}{N_A X} \ln(I_o / I)$$

(4)

Where, A is molecular weight and N_A is Avogadro's number (6.02486×10^{23}).

Molar Extinction Coefficient

Molar Extinction coefficient (ε) is a measure of how strongly a chemical species attenuates light at a given wavelength, the value of Molar Extinction coefficient (ε) is determined by using the following equation.

$$\varepsilon = 0.4343\, N_A \sigma_t \quad (5)$$

Electronic Cross Section

The electronic cross section (σ_e) is for an element is expressed by following relation

$$\sigma_e = \frac{\sigma_t}{\overline{Z}} \quad (6)$$

Where $\overline{Z}$ is mean atomic number.

Effective Atomic Number

Effective atomic number (Z_{eff}) is also a important parameter and it is given by the equation as,

$$Z_{eff} = \frac{\sum_i W_i f_i A_i (\mu/\rho)_i}{\sum_i f_i (A_j / Z_j)(\mu/\rho)_j} \quad (7)$$

Where f_i is the mole fraction of each constituent element (provided $\sum_i f_i = 1$) and A_i is the atomic weight. In this study all the quantities are directly used (Manohara et al., 2008).

Effective Electron Density

The value of effective atomic number (Z_{eff}) and A_{eff} is used to determine the Effective electron density expressed in the number of electrons per unit mass is closely related to the effective atomic number and is given by

$$N_{eff} = \left(\frac{N_A}{A_{eff}}\right) * Z_{eff} \quad (8)$$

Where $$A_{eff} = \frac{A}{\text{total number of atoms}} \quad (9)$$

EXPERIMENTAL DETAILS

In the presented studies we measured incident and transmitted photon energies by using a narrow-beam good geometry set up. Fig. 1 shows the schematic view of experimental set up. The six radioactive sources, Co^{57} (122 keV), Ba^{133} (356 keV), Na^{22} (511 and 1275 keV), Cs^{137} (662 keV), Mn^{54} (840 keV) and Co^{60} (1170 and 1330 keV) used in this investigation were obtained from Bhabha Atomic Research Centre, Mumbai, India. Gamma rays emitted by these radioactive sources were collimated and detected by a NaI(Tl) scintillation detector. The Signals from the detector (2"×2") NaI (Tl) crystal having energy resolution of 8.2% at 0.662 MeV gamma rays from the decay of Cs^{137} after suitable amplification were recorded in an EG&G ORTEC 13-bit plug-in-card coupled with a PC/AT. Stability and reproducibility of the arrangement were checked before and after each set of runs. In order to minimize the effects of small-angle scattering and multiple scattering events on the measured intensity, the transmitted intensity was measured by setting the channels at the full-width half-maximum position of the photo-peak.

Pellet shaped uniform thickness of chosen oxides such as aluminum oxide(Al_2O_3), manganese oxide(MnO_2), copper oxide(CuO) ,nickel oxide (NiO) ,magnesium oxide(MgO) and beryllium oxide (BeO) under investigation were confined in a cylindrical plastic container with diameter similar to that of the sample pellet. The diameters of the sample pellets were determined using a traveling microscope. The attenuation of photons in the empty containers was negligible. Each sample pellet was weighted in a sensitive digital balance with an accuracy of 0.001 mg several times to obtain the average value of the mass. The mass per unit area was determined in each case using the diameter of the pellet and mean value of the mass of the pellet. The sample thickness was selected in order to satisfy the following ideal condition as far as possible (Creagh D.C., 1987):

$$2 \le \ln\left(\frac{I_o}{I}\right) \le 4.$$

The Mass attenuation coefficients (μ/ρ) of all the samples of oxides were determined from the measured values of incident photon intensity I_0 (without sample) and transmitted photon intensity I (with sample) Eq. (2). The experiments were conducted in an air-conditioned room to avoid possible shifts of the photo-peaks. Room temperature of 23 ± 1°C was maintained throughout the experimental period. Other sources of error, excluding multiple scattering and counting statistics, are small-angle scattering, sample impurity, nonuniformity of the sample, photo built-up effects, dead time of the counting instrument, and pulse pile effect which were evaluated and reduced.

The maximum angle of scattering was maintained <30 min by properly adjusting the distance between the detector and source (30cm $\leq$ d $\leq$ 50 cm), as the contribution of coherent and incoherent scattering at such angles in the measured cross sections at intermediate energies is negligible (Hubbell, 1999). Hence, no small-angle scattering corrections were applied to the measured data. All the oxides samples used in this study were of high quality sigma Aldrich and of high purity (99.9 %) without high-Z impurities. Hence, sample impurity corrections were not applied to the measured data.

In the presented investigation, uncertainty in the mass per unit area and the error due to nonuniformity of the sample are <0.05% for all energies of interest. . Optimum values of count rate and counting time were chosen to reduce the effects of photon built-up and pulse piles. The photon built-up effect, which is a consequence of the multiple scattering inside the sample, depends on the atomic number and sample thickness, as well as the incident photon energy. A built-in provision for dead time correction was present in the MCA used during this investigation.

RESULTS AND DISCUSION

In the present work, the values of mean atomic number, molar mass and mean atomic weight calculated using the chemical formulae of investigated oxides such as aluminum oxide, manganese oxide, copper oxide, nickel oxide, magnesium oxide and beryllium oxide in Table 1. The variation between experimental and theoretical values of μ_m (cm^2/g) for all sample studied at 122, 360, 511, 662, 840, 1170, 1275- and 1330-keV photon energies are shown in Table 2, and those for all oxide samples are plotted in Figure 2. It can be observed from the figure and table that μ_m decreases with increasing photon energy. It is observed that he experimental values of μ_m agree with the theoretical values calculated using the XCOM program

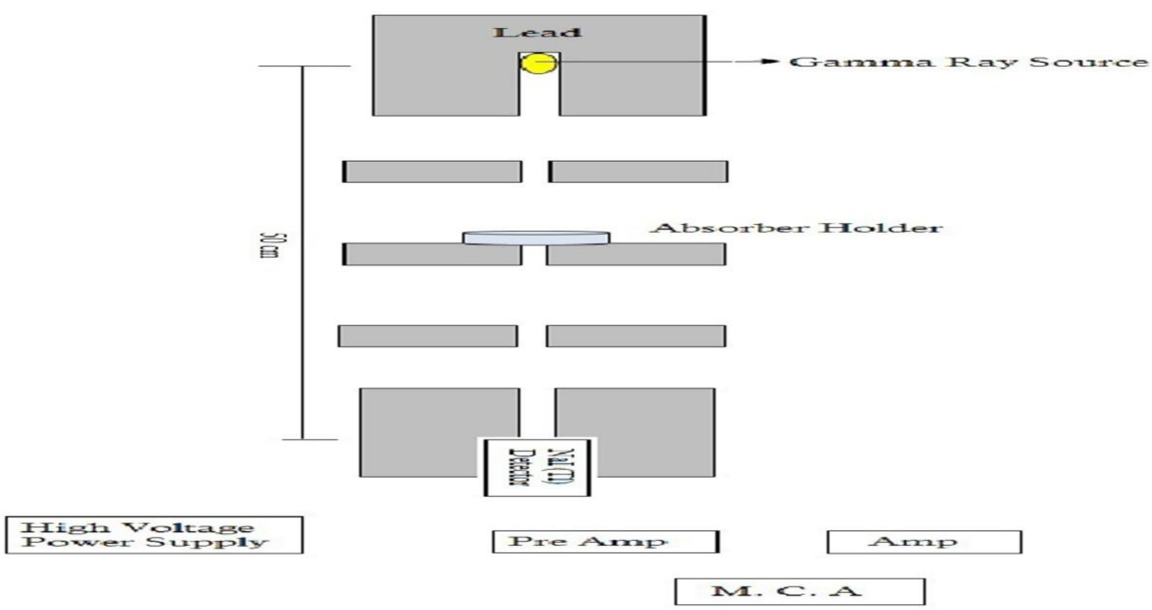

Fig.1 :Narrow Beam Good Geometry Set Up

Oxides	Molar mass (g/mol)	Chemical Formula	Mean atomic number, $\bar{Z}$	A_{eff}
Aluminum	101.960	Al_2O_3	10	20.39
Mangnese	86.936	MnO_2	11	28.97
Copper	79.545	CuO	18.5	39.77
Nickel	74.692	NiO	18	37.34
Magnesium	40.304	MgO	10	20.15
Beryllium	25.010	BeO	06	12.00

Table 1: Mean Atomic Numbers Calculated from the Chemical Formula for Oxides

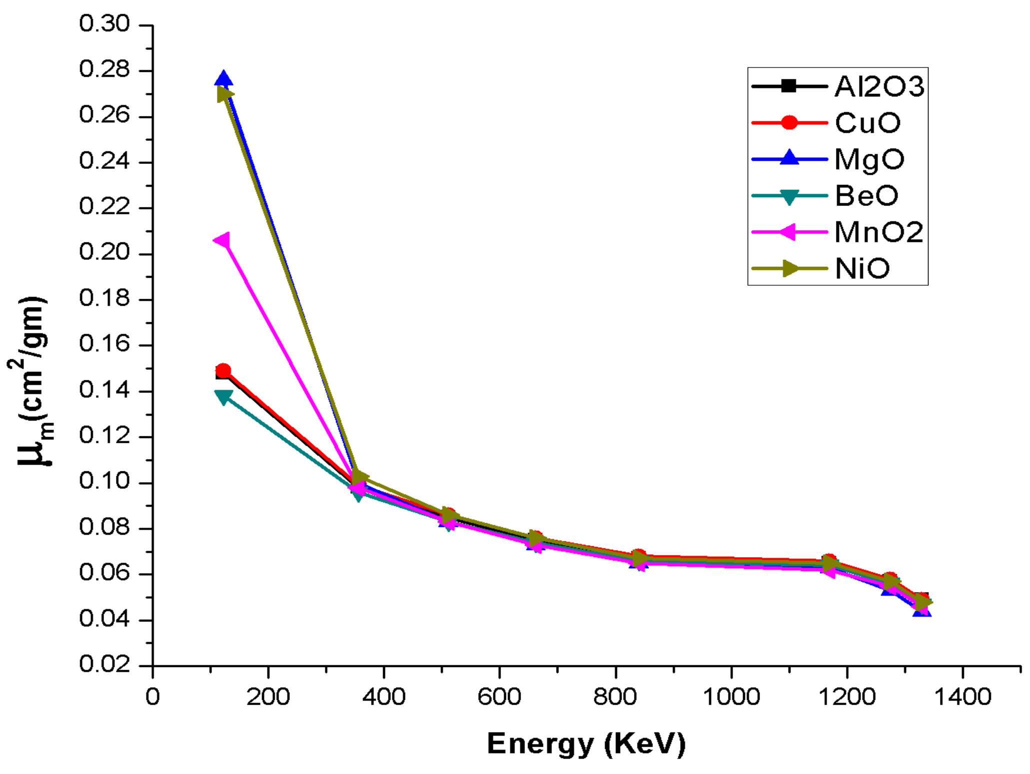

Fig. 2 :Typical Plot of μ_m versus energy for Oxides

Energy	Al_2O_3		MnO_2		CuO		NiO		MgO		BeO	
Kev	Expt.	Theo.	Expt.	Theo.	Expt.	Theo.	Exp.	Theo.	Exp	Theo.	Exp.	Theo.
122	0.146	0.148	0.203	0.206	0.272	0.276	0.268	0.27	0.145	0.149	0.135	0.138
356	0.095	0.098	0.095	0.098	0.103	0.1	0.105	0.103	0.097	0.099	0.098	0.096
511	0.083	0.085	0.085	0.083	0.085	0.083	0.083	0.086	0.087	0.086	0.085	0.083
662	0.073	0.075	0.075	0.073	0.071	0.073	0.077	0.076	0.078	0.076	0.071	0.074
840	0.065	0.067	0.063	0.065	0.067	0.065	0.064	0.067	0.069	0.068	0.063	0.066
1170	0.063	0.065	0.06	0.062	0.061	0.063	0.062	0.065	0.064	0.066	0.062	0.064
1275	0.059	0.057	0.052	0.055	0.055	0.053	0.059	0.057	0.06	0.058	0.058	0.056
1330	0.051	0.049	0.048	0.046	0.041	0.044	0.051	0.048	0.047	0.049	0.045	0.047

Table 2: Mass Attenuation Coefficient (cm^2/g) for the Oxides

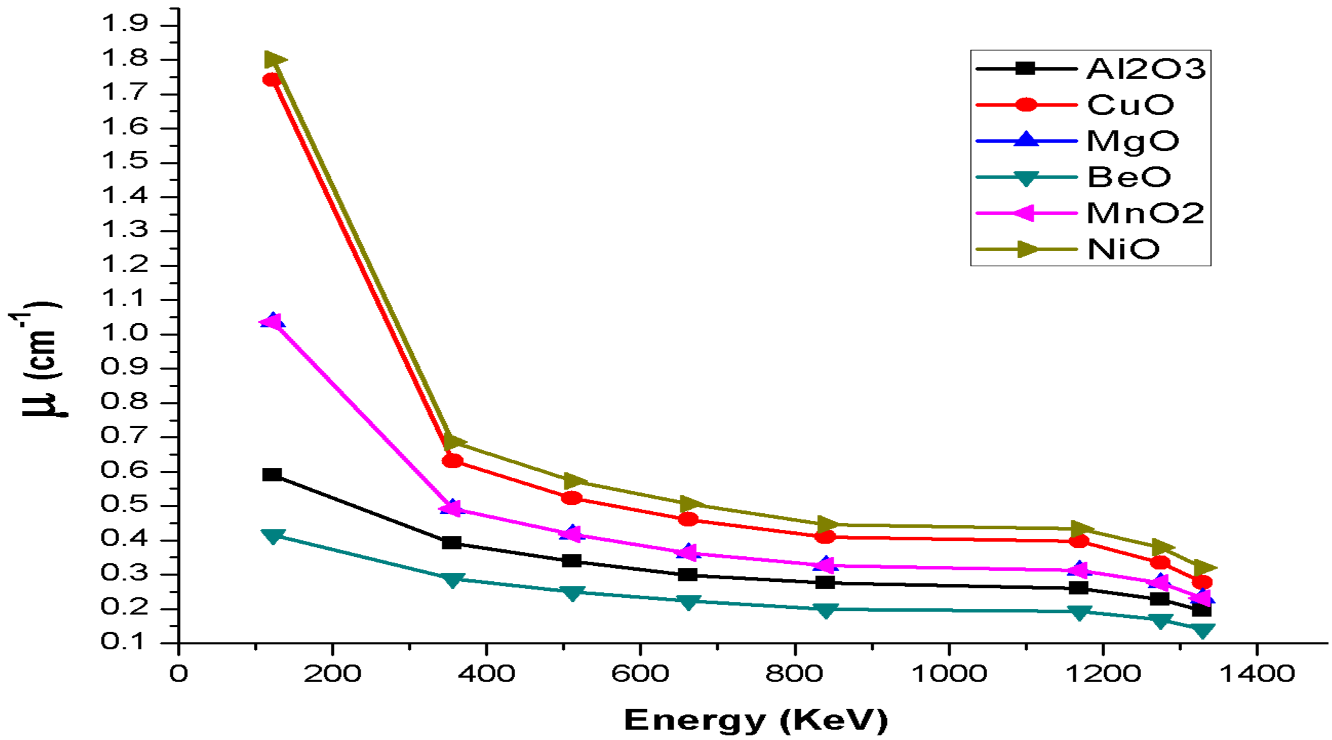

Fig. 3: Typical Plot of μ versus energy for Oxides

Energy	Al_2O_3		MnO_2		CuO		NiO		MgO		BeO	
Kev	Expt.	Theo.	Expt.	Theo.	Expt.	Theo.	Exp.	Theo.	Exp	Theo.	Exp.	Theo.
122	0.5821	0.5901	0.522	0.5364	1.7163	1.7415	1.7875	1.8009	1.0202	1.0353	0.4063	0.4153
356	0.3787	0.3907	0.3492	0.3564	0.6499	0.631	0.7003	0.687	0.4774	0.4925	0.2949	0.2889
511	0.3276	0.3388	0.3132	0.3096	0.5363	0.5232	0.5536	0.5736	0.4272	0.4171	0.2558	0.2498
662	0.291	0.299	0.2808	0.2736	0.448	0.4606	0.5202	0.5069	0.3769	0.3638	0.2137	0.2227
840	0.2751	0.2751	0.252	0.2448	0.4227	0.4101	0.4238	0.4468	0.3166	0.3266	0.1896	0.1986
1170	0.2511	0.2591	0.2304	0.2376	0.3849	0.3975	0.4135	0.4335	0.3015	0.3116	0.1866	0.1926
1275	0.2352	0.2272	0.2166	0.2038	0.347	0.3344	0.3935	0.3801	0.2613	0.2764	0.1745	0.1685
1330	0.2083	0.1953	0.1692	0.1764	0.2587	0.2776	0.3401	0.3201	0.2412	0.2311	0.1354	0.1414

Table 3:linear attenuation coefficient (μ) of oxides

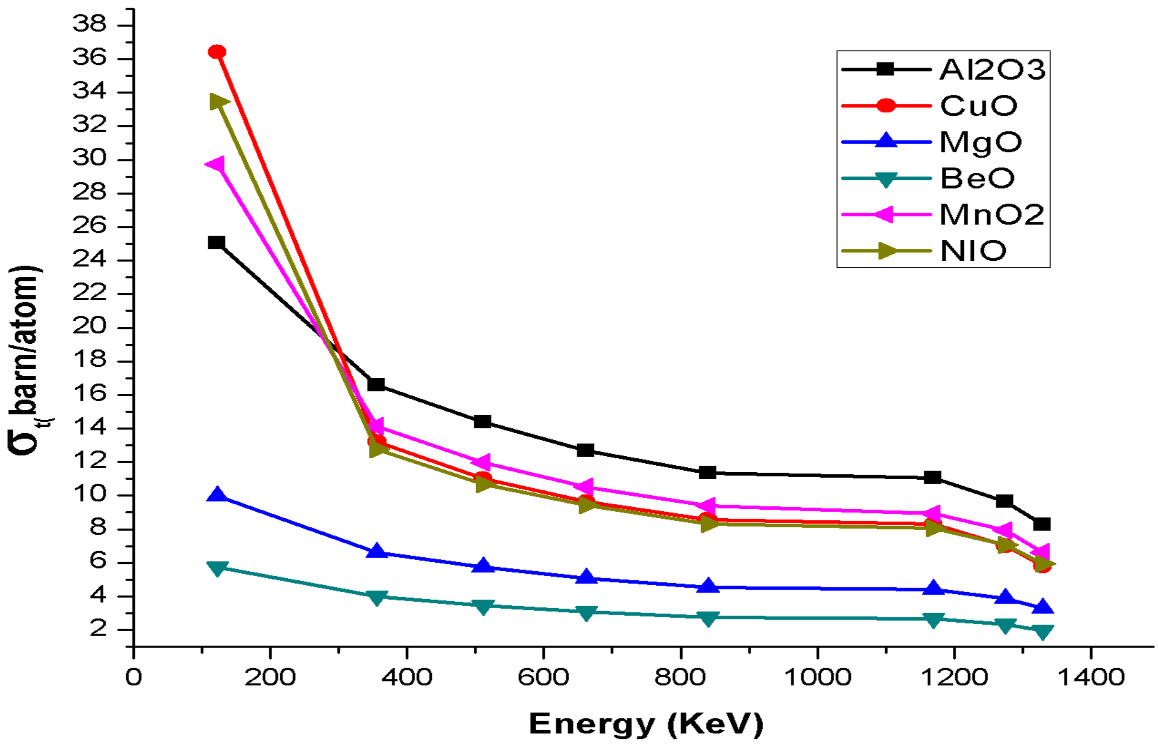

fig. 4 : Typical plot of σ_t versus energy for Oxides

Energy	Al_2O_3		MnO_2		CuO		NiO		MgO		BeO	
Kev	Expt.	Theo.	Expt.	Theo.	Expt.	Theo.	Exp.	Theo.	Exp	Theo.	Exp.	Theo.
122	24.71	25.05	29.3	29.73	35.92	36.43	33.23	33.48	9.7	9.97	5.6	5.73
356	16.08	16.58	13.71	14.14	13.6	13.21	13.02	12.77	6.49	6.62	4.06	3.98
511	13.88	14.38	12.26	11.98	11.22	11.01	10.29	10.66	5.56	5.75	3.52	3.44
662	12.35	12.69	10.82	10.53	9.37	9.64	9.54	9.42	5.21	5.08	2.94	3.07
840	11.68	11.34	9.09	9.38	8.85	8.58	7.93	8.3	4.61	4.55	2.61	2.74
1170	10.66	11.04	8.66	8.94	8.05	8.32	7.38	8.06	4.28	4.41	2.57	2.65
1275	9.98	9.65	7.5	7.93	7.26	7.01	7.31	7.06	4.01	3.88	2.4	2.32
1330	8.63	8.29	6.92	6.63	5.41	5.81	6.32	5.95	3.14	3.27	1.86	1.95
s												

Table 4: Total atomic cross sections, σ_t (barn/atom) oxides

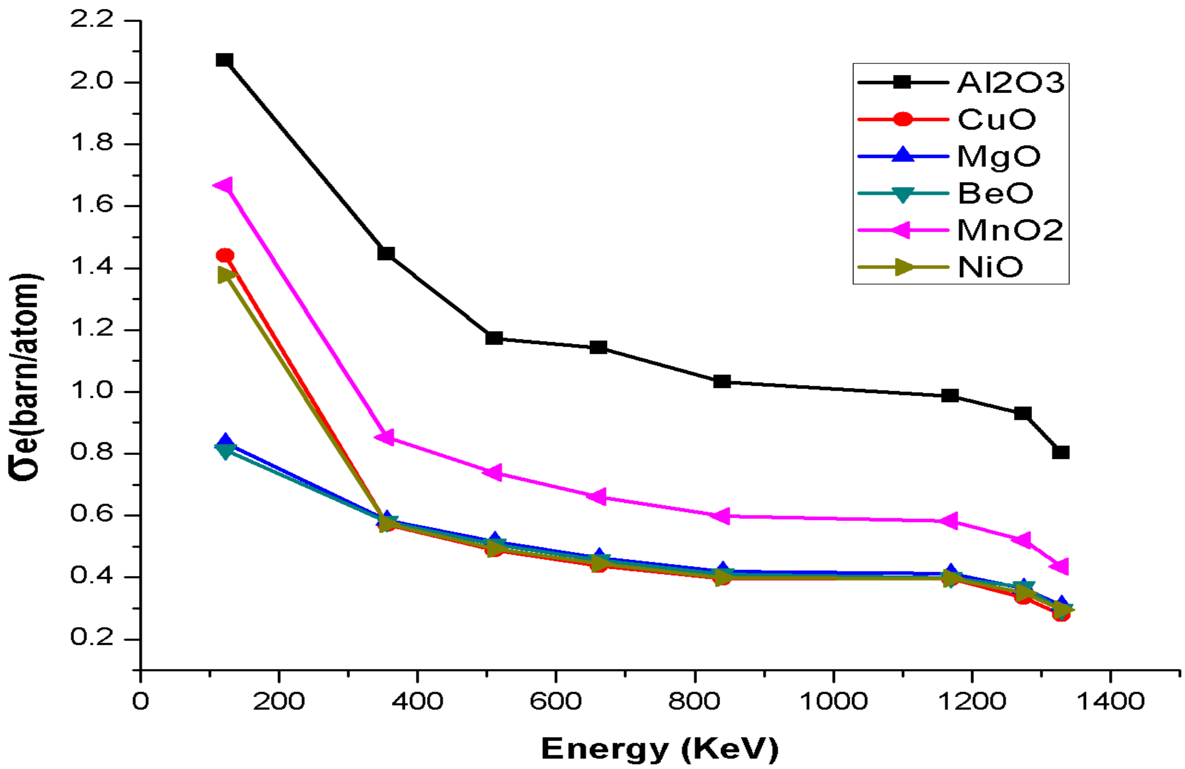

Fig. 5: Typical plot of ε versus energy for Oxides

Energy	Al_2O_3		MnO_2		CuO		NiO		MgO		BeO	
Kev	Expt.	Theo.	Expt.	Theo.	Expt.	Theo.	Exp.	Theo.	Exp	Theo.	Exp.	Theo.
122	6.463	6.552	7.664	7.776	9.395	9.528	8.691	8.757	2.537	2.606	1.469	1.498
356	4.206	4.336	3.586	3.698	3.557	3.455	3.405	3.601	1.697	1.731	1.061	1.041
511	3.63	3.761	3.206	3.1333	2.909	2.877	2.691	2.788	1.402	1.504	0.92	0.899
662	3.23	3.319	2.84	2.754	2.45	2.521	2.495	2.463	1.362	1.328	0.779	0.803
840	3.057	2.966	2.377	2.453	2.314	2.244	2.074	2.171	1.205	1.19	0.692	0.719
1170	2.788	2.878	2.265	2.338	2.105	2.176	2.068	2.108	1.119	1.153	0.672	0.693
1275	2.61	2.524	1.961	2.074	1.898	1.831	1.912	1.846	1.048	1.014	0.727	0.616
1330	2.257	2.168	1.81	1.734	1.415	1.519	1.653	1.556	0.821	0.855	0.486	0.511

Table 5 Molar extinction coefficients, ε (cm^2/mol), of oxides.

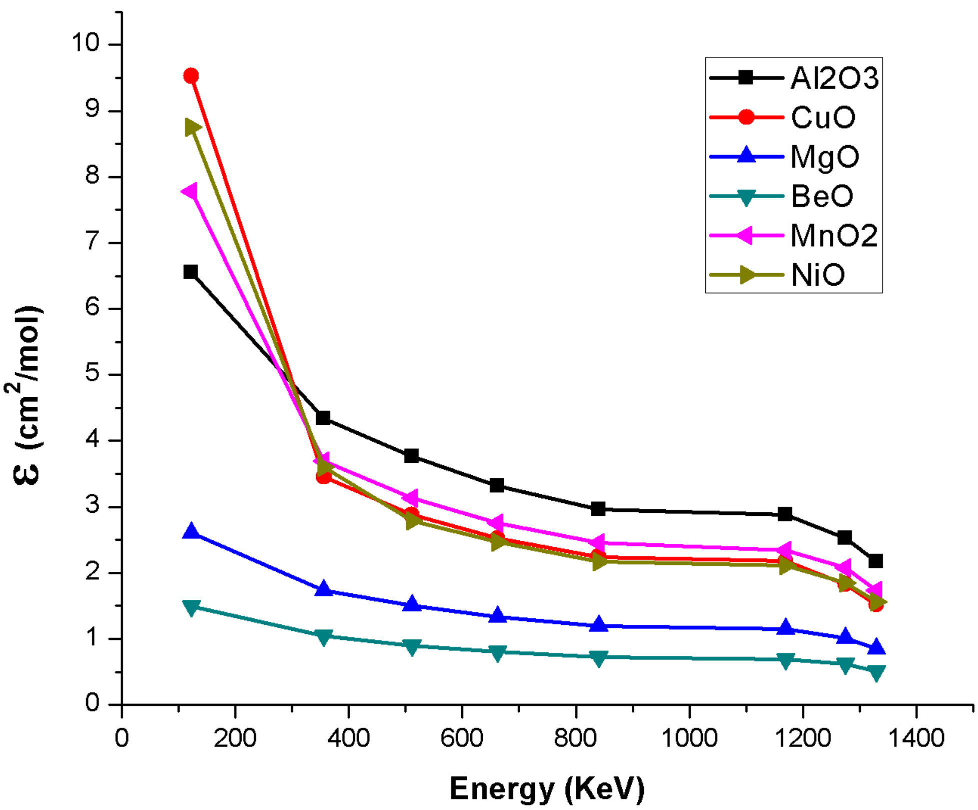

Fig. 6 Typical plot of σ_e versus energy for Oxides.

Energy	Al_2O_3		MnO_2		CuO		NiO		MgO		BeO	
Kev	Expt.	Theo.	Expt.	Theo.	Expt.	Theo.	Exp.	Theo.	Exp	Theo.	Exp.	Theo.
122	2.0507	2.0702	1.6479	1.6674	1.4248	1.4404	1.3714	1.3783	0.8158	0.8351	0.8011	0.8116
356	1.4117	1.4455	0.8283	0.8518	0.5889	0.5701	0.5854	0.5726	0.5743	0.5842	0.5961	0.5801
511	1.2115	1.1719	0.7591	0.7391	0.4997	0.4886	0.4761	0.4921	0.5018	0.5166	0.5238	0.5066
662	1.1016	1.1411	0.6809	0.6611	0.4247	0.4375	0.4508	0.4439	0.4771	0.4622	0.4401	0.4554
840	1.0705	1.0318	0.5823	0.5982	0.4108	0.3971	0.3819	0.3986	0.4264	0.4189	0.4066	0.4104
1170	0.9797	0.9861	0.5663	0.5827	0.3821	0.3956	0.3798	0.3974	0.4033	0.4129	0.3905	0.3989
1275	0.9318	0.9275	0.4918	0.5201	0.3488	0.3351	0.3641	0.3505	0.3791	0.3646	0.3652	0.3682
1330	0.8081	0.8021	0.4543	0.4358	0.2608	0.2791	0.3156	0.2964	0.2959	0.3099	0.2809	0.2945

Table 6 electronic cross sections (σ_e) of Oxides.

The total uncertainties in experimental values of the μ_m depend on the uncertainties of I_0 (without attenuation), I (after attenuation) measurements of mass thickness values, and counting statistics. The estimated total uncertainty in the measured experimental values of μ_m was found to be in the range of 2-3%. The another important parameter linear attenuation coefficient (μ) for six oxides are calculated for 122 KeV – 1330 KeV photon energies are shown in Table 3, and the variation of μ with energy is shown in fig.3. The measured total atomic cross section (σ_t) and electronic cross sections (σ_e) for all the six oxides are studied and displayed in Tables 4 and 6, respectively. The typical plots show the variation of σ_t versus E and σ_e versus E for all samples in Figures 4 and 6 respectively. It is observed that the behavior of σ_t and σ_e with photon energies is almost similar to that of μ_m. Molar extinction coefficients of chosen oxides are calculated using Eq. (5) is presented in Table 5. The variations of ε with photon energy for all oxides are depicted in Figure 5. It can be observed from Table 5 and Figure 5 that ε initially decreases and tends to be almost constant at higher gamma ray energy and vary with the wavelength of the incident photons for all the samples.

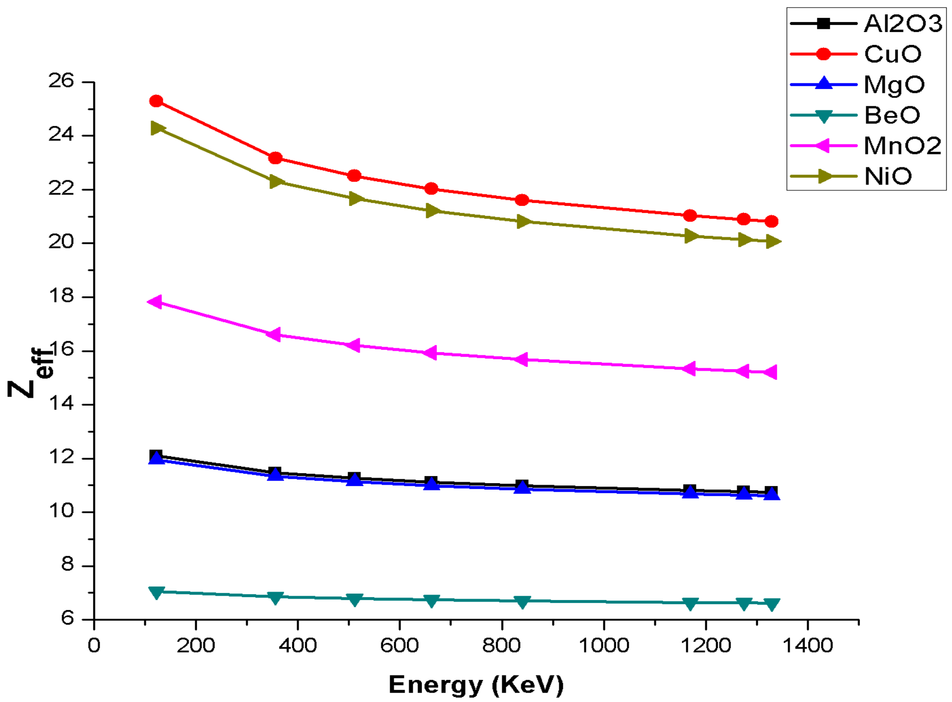

Fig. 7 Typical plot of Z_{eff} versus energy for Oxides.

Energy	Al2O3		MnO2		CuO		NiO		MgO		BeO	
Kev	Expt.	Theo.	Expt.	Theo.	Expt.	Theo.	Exp.	Theo.	Exp	Theo.	Exp.	Theo.
122	12.02	12.11	17.78	17.83	25.21	25.29	24.23	24.29	11.89	11.94	7.02	7.06
356	11.39	11.47	16.55	16.61	23.09	23.17	22.24	22.3	11.31	11.33	6.81	6.86
511	11.18	11.27	16.15	16.21	22.45	22.51	21.61	21.66	11.08	11.13	6.72	6.79
662	11.21	11.12	15.89	15.93	22.06	22.03	21.16	21.22	10.92	10.99	6.68	6.74
840	10.91	10.99	15.61	15.68	21.54	21.61	20.76	20.82	10.81	10.86	6.65	6.7
1170	10.88	10.81	15.29	15.34	21.07	21.03	20.22	20.28	10.61	10.68	6.58	6.64
1275	10.71	10.76	15.19	15.25	20.81	20.89	20.08	20.14	10.58	10.64	6.57	6.63
1330	10.68	10.74	15.14	15.21	20.74	20.81	20.02	20.07	10.55	10.61	6.55	6.62

Table 7 Effective atomic number, Z_{eff}, of metal oxides.

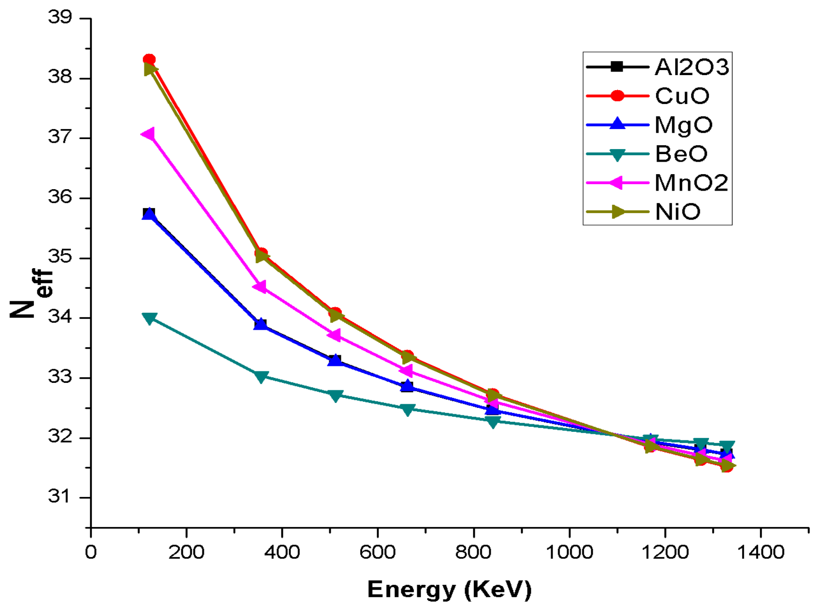

Fig. 8 Typical plot of N_{eff} versus energy for Oxides.

Energy	Al_2O_3		MnO_2		CuO		NiO		MgO		BeO	
Kev	Expt.	Theo.	Expt.	Theo.	Expt.	Theo.	Exp.	Theo.	Exp	Theo.	Exp.	Theo.
122	35.51	35.74	36.96	37.07	38.17	38.31	38.06	38.15	35.74	35.71	33.79	34.01
356	33.64	33.88	34.41	34.52	34.96	35.08	34.93	35.03	33.77	33.87	32.78	33.04
511	33.02	33.29	33.57	33.71	33.99	34.08	33.94	34.04	33.11	33.27	32.35	32.72
662	33.11	32.84	33.03	33.12	33.4	33.37	33.24	33.34	32.64	32.85	32.16	32.49
840	32.22	32.46	32.45	32.61	32.62	32.73	32.61	32.71	32.31	32.46	32.06	32.28
1170	32.13	31.93	31.78	31.89	31.91	31.85	31.76	31.86	31.71	31.94	31.67	31.98
1275	31.63	31.8	31.58	31.71	31.51	31.63	31.54	31.64	31.62	31.81	31.63	31.92
1330	31.54	31.73	31.47	31.62	31.41	31.52	31.45	31.54	31.53	31.73	31.53	31.88

Table 8: Effective electron densities, N_{eff} (10^{22} electrons/g), of metal oxides

Effective atomic numbers of composite materials, such as the oxides studied, calculated using Eq. (7) is displayed in Table 7. The relation $Z_{eff} = 0.533\, A_{eff}$ is valid in the present case. A typical plot of Z_{eff} versus energy is shown in Figure 7. The effective electron densities of all the oxides studied are shown in Table 8 and the plot of N_{eff} versus energy is shown in Figure 8. A typical plot of N_{eff} versus Z_{eff} is shown in Figure 9. It is evident from the figure Z_{eff} and N_{eff} are almost constant in the energy range studied. It is found that in this energy range, Z_{eff} is almost independent of energy because of the predominance of incoherent (Compton) scattering and dependent on relative proportion and the range of atomic numbers of the elements of the samples. The figure also shows a linear relation between Z_{eff} and N_{eff}.

CONCLUSION

The present experimental study was carried out to obtain information on mass attenuation coefficient, μ_m and related parameters (μ,σ_t, ε, σ_e, Z_{eff} and N_{eff}) for the six oxide samples. It has been found that μ_m is an extremely useful and sensitive physical quantity for the determination of these parameters for the chosen oxide samples. The total atomic and electronic cross sections of some oxide with low and medium-Z elements such as aluminum oxide(Al_2O_3), manganese oxide(MnO_2), copper oxide(CuO), nickel oxide(NiO), magnesium oxide(MgO), beryllium oxide (BeO) , are determined in the chosen energy range (122-1330 keV) which is emitted by the radioisotopes ^{60}Co, ^{57}C$_o$, ^{133}Ba, ^{54}Mn, ^{22}Na, and ^{137}Cs. For the interaction of photons with matter the values of that μ_m depend on the physical and chemical environments of the samples. These values were found to decrease with increasing photon energies. From the study it is observed that the parameters $\sigma_{t,}$ σ_e and ε change similar to μ_m and it is clear that ε depends totally on the number and nature of atoms. In the present work, it has been observed that the data on mass attenuation coefficient (μ_m) and other parameters are very useful in industrial, biological, medical, shielding and other technological applications, solar cell and recently in sensors field. The measured data were compared against Win-XCOM- based data the agreement within 3%. ss

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