Research Journal of Recent Sciences ISSN 2277-2502
Vol. **1(9),** 41-48, September **(2012)** *Res.J.Recent Sci.*

Attenuation Coefficient of Soil Samples by Gamma ray Energy

Chaudhari Laxman[1] and Raje Dayanand[2]*
[1]Nuclear Research Laboratory, Department of Physics, Nowrosjee Wadia College, Pune-411001, MS, INDIA
*[2]Department of Physics, Rajarshi Shahu Mahavidyalaya, Latur-413512, MS, INDIA

Available online at: www.isca.in
Received 3rd June 2012, revised 12th June 2012, accepted 13th June 2012

Abstract

The variation of absorption coefficient with different soil samples of various chemical compositions and physical properties has been investigated, using gamma radiation method. For this work, soil Samples were collected from different locations of Nanded and Latur district from Maharastra and Bidar district from Karnataka states of India and Photon absorption coefficients of soils were determined by performing experiment of gamma irradiation on soil samples. The ratio of transmission intensity (I_o/I) is found to increase as the thickness of soil increases. The linear and mass attenuation coefficients due to soil density are as shown graphically. Graphs of energy in keV v/s mass attenuation coefficient due in cm^2/gm to various soil densities are plotted, exponential decay observed. Mass attenuation coefficient depends on soil compositions and its physical properties.

Key words:

Introduction

The Photon attenuation coefficient is an important parameter characterizing the penetration and diffusion of gamma rays in composite materials such as soil[1], Soil has chemical properties as on its compositions like C, K, S, P, Ca, Mg, Na, etc. physical Properties: i. Sand, Loam, Clay, ii. Moistness, iii. Water holding capacity, iv. Particle density, v. Appearance density, vi. Porosity etc. in variable concentrations. The effects of different parameters on the attenuation coefficients of soils were discussed in several studies. An extensive data on mass attenuation coefficients of gamma rays in compound and mixtures of dosimetric interest have been studied by Hubbel[1] in the energy range of 1 kev to 20 Mev. An updated version of attenuation coefficients for elements having atomic number from 1-92 and for 48 additional substances have been compiled by Hubbell and Sheltzer[2]. Other scientists such as Bradley[3], Cunningham[4], Carlsson[5], Jahagirdar[6], Singh[7], The reports on attenuation coefficients measured by researchers reported [8-24] for different energies for various samples in solid as well as liquid.

The purpose of this paper is to determine linear and mass attenuation coefficients due to absorption of soil samples of various chemical compositions and physical properties on photon attenuation coefficient by using gamma irradiation technique.

Attenuation coefficient is a basic quantity used in calculation of penetration of materials by quantum particles or energy beams. The linear attenuation coefficient, also called the narrow beam attenuation coefficient, is a quantity, which describes the extent to which the intensity of a beam is reduced as it passes through the material due to absorption of soil samples. We determined the linear and mass attenuation coefficients due to soil samples using gamma ray. The absorption of radiation is characterized by the equation.

The attenuation of gamma rays expressed as:

$$I = I_o \exp(-\mu \rho L) \quad (1)$$

Where I_o is the number of particles of radiation counted during certain time without any absorber, I is the number counted during the same time with a thickness *L* of absorber between the source of radiation and the detector, ρ is density of the material and μ is the linear absorption coefficient. This equation may be cast into the linear form,

$$\mu = (1/\rho L) \log (I_o/I) \quad (2)$$

also ,

$$\mu = m \rho_s + c \quad (3)$$

where m is slope and c is intercept on Y-axis of each linear graphs of Thickness Vs Intensity ratio (I_o/I).

The mass absorption coefficient μ_m is defined as,

$$\mu_m = \mu/\rho \quad (4)$$

Where, μ is measured in cm^{-1}, μ_m is measured in cm^2/gm and ρ is particle density of soil sample in gm/cc. The unit of μ is cm^{-1} and that of μ_s is cm^2/gm.

Material and Methods

The experimental arrangement is as shown in fig. (i).The gamma ray source having nominal activity 1 μCi, of energy 662 keV. A Na (Tl) detector is in conjunction with counter circuits. The whole system was enclosed in lead castle. The detector absorbs a narrow beam of gamma rays after passing through the test column. A multichannel analyzer was used to count the signal magnitude of the transmitted gamma ray. A soil sample was used in a plastic cylinder of internal diameter

For this work, soil samples were collected from different locations of Latur and Osmanabad districts from Maharashtra state.

A cylindrical plastic container of internal diameter 3.8 cm and height 8 cm was placed in between detector and source as shown in figure 1. The distance between detector, soil sample container and source is 3 cm each. By keeping empty container in between source and detector firstly, the number of counts I_o of gamma particles for 1000 sec was measured to remove error due to the random nature of radioactivity. Then by inserting the soil sample in container 1 cm, 2cm, etc, the number of counts I of gamma particles for 1000 sec was measured for each path length. This procedure repeated for different sources of various energies: 122, 360, 511, 662, 840, 1170, 1280 and1330 keV. For this experiment MCB1 (U 1-2) software was used.

Firstly, the graphs of Thickness V/s (Io/I) for each soil sample and various energies are plotted. Straight lines obtained for each soil sample and for all energies, but slopes and intercepts for each are different. Slope (m) and intercept on Y-axis (c) are noted for each straight line for the calculation of linear and mass attenuation coefficients. Finally, the energy V/s mass attenuation coefficient for each soil sample is plotted for results.

For this work, soil samples were collected from different locations of Latur and Nanded districts from Maharashtra state and Bidar from Karnataka state of India.

The chemical compositions and physical properties of each soil sample are given in table- 1 and table-2.

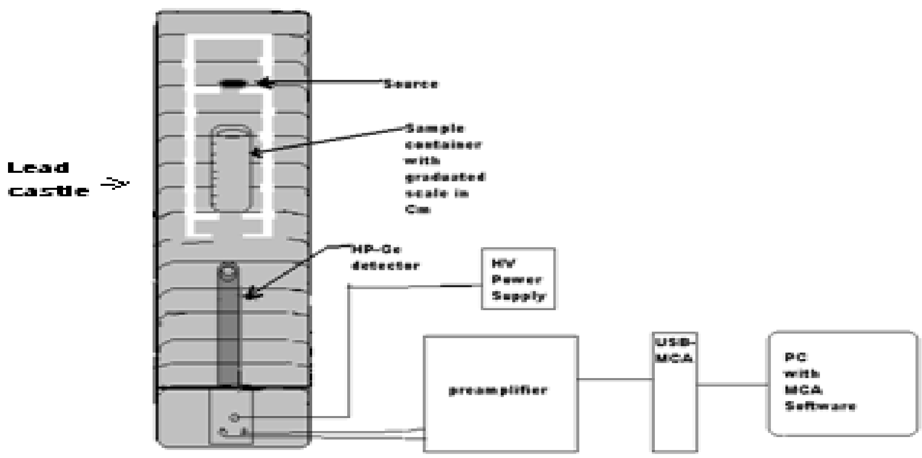

Figure- 1

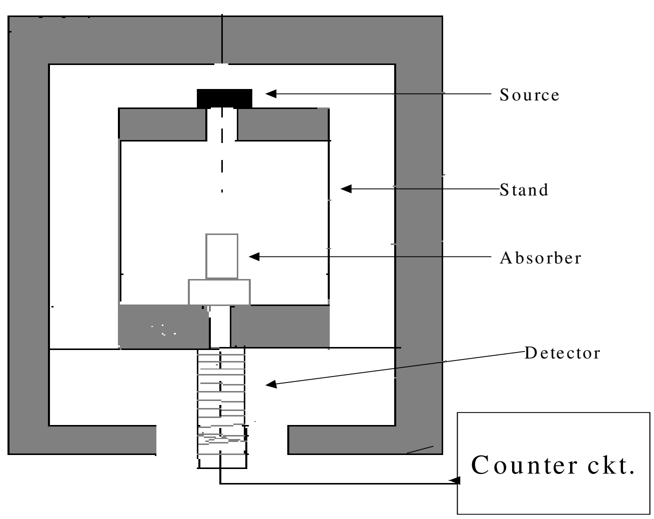

Figure -2

Results and Discussion

Observation tables for linear absorption coefficients μ using Thickness (cm) of soil samples V/s transmission intensity ratio (I_o/I) of gamma rays and mass attenuation coefficient μ/ρ_s, as well as variation in mass attenuation coefficient with soil density are shown graphically as follows:

Table-1
Chemical Components

S. No.	Constituents Soil Sample	Carbon (C) %	Phosphorus (P) Kg/hect	Potash (K) Kg/hect	Calcium (Ca) %	Magne-sium (Mg) %	Sodium Na %	Calcium-Carbonate $CaCo_3$ %
1	NANDED1	1.39	28.38	310.04	37.50	49.16	12.71	5.25
2	NANDED2	1.04	23.93	1518.72	37.76	56.15	4.23	7.88
3	NANDED3	1.67	22.82	197.57	51.62	43.84	4.29	11.63
4	BIDAR 1	1.22	33.39	698.88	51.74	44.78	2.03	2.5
5	BIDAR 2	1.28	311.67	653.18	82.82	13.93	1.96	2.50
6	BIDAR 3	0.99	32.28	447.55	76.84	19.87	1.88	1.63
7	LATUR 1	1.25	31.17	721.79	63.82	33.61	1.51	5.88
8	LATUR 2	1.41	30.05	936.77	63.49	33.69	1.55	4.63
9	LATUR 3	0.77	28.94	912.58	49.64	46.65	2.07	6.63

Table-2
Physical Components

S. No.	Constituents Soil Sample	Silica (sand) %	Silt/Loam %	Clay %	Moistness %	Water Holding Capacity %	Soil density (gm /cc)	Porosity %
1	NANDED1	48.31	15.10	36.48	4.12	51.05	2.43	58.90
2	NANDED2	25.96	20.12	53.78	6.42	72.70	2.28	63.72
3	NANDED3	27.31	17.55	55.08	6.35	51.52	1.97	57.54
4	BIDAR 1	32.50	25.55	33.09	11.07	50.87	2.51	61.49
5	BIDAR 2	14.16	16.51	69.11	10.07	30.42	1.86	63.14
6	BIDAR 3	24.13	49.99	25.82	5.24	50.54	2.64	62.87
7	LATUR 1	41.29	24.44	34.21	11.10	58.40	2.86	66.61
8	LATUR 2	52.49	23.76	23.24	14.53	42.56	3.65	58.14
9	LATUR 3	32.54	14.38	52.95	15.01	81.67	1.52	67.00

Table-3
Attenuation coefficient of soil samples using Co-57 of energy 122 keV

S. No.	Soil density (ρ_s) gm/cc	Slope (m)	Intercept on Y-axis (c)	Linear absorption coefficient cm^{-1}	Mass attenuation coefficient (μ/ρ_s) cm^2/gm
1	1.52	0.13297	0.85274	1.0548544	0.6939832
2	1.86	0.13575	0.82665	1.079145	0.5801855
3	1.97	0.11017	0.89358	1.1106149	0.5637639
4	2.28	0.11724	0.86188	1.1291872	0.4952575
5	2.43	0.12079	0.86483	1.1583497	0.4766871
6	2.51	0.13005	0.83412	1.1605455	0.4623687
7	2.64	0.12669	0.8315	1.1659616	0.4416521
8	2.86	0.14661	0.8139	1.2332046	0.4311904
9	3.65	0.13395	0.84836	1.3372775	0.3663774

Table-4
Attenuation coefficient of soil samples using Ba-133 of energy 360 keV

S. No.	Soil density (ρ_s) gm/cc	Slope (m)	Intercept on Y-axis (c)	Linear absorption coefficient cm^{-1}	Mass attenuation coefficient (μ/ρ_s) cm^2/gm
1	1.52	0.13053	0.85658	1.0549856	0.6940695
2	1.86	0.12717	0.84624	1.0827762	0.5821377
3	1.97	0.11295	0.87327	1.0957815	0.5562343
4	2.28	0.10624	0.87747	1.1196972	0.4910953
5	2.43	0.11302	0.86664	1.1412786	0.469662
6	2.51	0.13126	0.83611	1.1655726	0.4643716
7	2.64	0.10567	0.8894	1.1683688	0.4425639
8	2.86	0.1258	0.83688	1.196668	0.4184154
9	3.65	0.12255	0.89232	1.3396275	0.3670212

Table-5
Attenuation coefficient of soil samples using Na-22 of energy 511 keV

S. No.	Soil density (ρ_s) gm/cc	Slope (m)	Intercept on Y-axis (c)	Linear absorption coefficient cm^{-1}	Mass attenuation coefficient (μ/ρ_s) cm^2/gm
1	1.52	0.10427	0.88464	1.0431304	0.68627
2	1.86	0.11059	0.93129	1.1369874	0.6112835
3	1.97	0.08699	0.92396	1.0953303	0.5560052
4	2.28	0.08211	0.92141	1.1086208	0.4862372
5	2.43	0.09317	0.9062	1.1326031	0.4660918
6	2.51	0.10943	0.93157	1.2062393	0.4805734
7	2.64	0.09684	0.93496	1.1906176	0.4509915
8	2.86	0.10424	0.88505	1.1831764	0.413698
9	3.65	0.09897	0.89611	1.2573505	0.3444796

Table-6
Attenuation coefficient of soil samples using Cs-137 of energy 662 keV :

S. No.	Soil density (ρ_s) gm/cc	Slope (m)	Intercept on Y-axis (c)	Linear absorption coefficient cm^{-1}	Mass attenuation coefficient (μ/ρ_s) cm^2/gm
1	1.52	0.10935	0.8905	1.056712	0.6952053
2	1.86	0.11132	0.8788	1.0858552	0.5837931
3	1.97	0.09085	0.91169	1.0906645	0.5536368
4	2.28	0.09349	0.89447	1.1076272	0.4858014
5	2.43	0.10387	0.88638	1.1387841	0.4686354
6	2.51	0.11134	0.88195	1.1614134	0.4627145
7	2.64	0.0965	0.90821	1.16297	0.4405189
8	2.86	0.10235	0.89673	1.189451	0.415892
9	3.65	0.10626	0.88815	1.275999	0.3495888

Table-7
Attenuation coefficient of soil samples using Mn-54 of energy 840keV

S. No.	Soil density (ρ_s) gm/cc	Slope (m)	Intercept on Y-axis (c)	Linear absorption coefficient cm^{-1}	Mass attenuation coefficient (μ/ρ_s) cm^2/gm
1	1.52	0.10274	0.88991	1.0460748	0.6882071
2	1.86	0.09774	0.90819	1.0899864	0.5860142
3	1.97	0.08728	0.91247	1.0844116	0.5504627
4	2.28	0.07725	0.93264	1.10877	0.4863026
5	2.43	0.0909	0.90952	1.130407	0.4651881
6	2.51	0.09361	0.91797	1.1529311	0.4593351
7	2.64	0.0862	0.93165	1.159218	0.4390977
8	2.86	0.09602	0.89955	1.1741672	0.410548
9	3.65	0.09731	0.88674	1.2419215	0.3402525

Table-8
Attenuation coefficient of soil samples using Co-60 of energy 1170 keV

S. No.	Soil density (ρ_s) gm/cc	Slope (m)	Intercept on Y-axis (c)	Linear absorption coefficient cm^{-1}	Mass attenuation coefficient (μ/ρ_s) cm^2/gm
1	1.52	0.05606	0.86285	0.94806	0.62372
2	1.86	0.06576	0.9357	1.05801	0.56882
3	1.97	0.03625	1.06486	1.13627	0.57678
4	2.28	0.057	1.01997	1.14993	0.50435
5	2.43	0.05774	0.96853	1.10883	0.45631
6	2.51	0.0225	1.18203	1.23850	0.49342
7	2.64	0.05839	0.95237	1.10651	0.41913
8	2.86	0.07708	0.93867	1.15911	0.40528
9	3.65	0.0556	1.052	1.25494	0.34381

Table-9
Attenuation coefficient of soil samples using Na-22 of energy 1280 keV

S. No.	Soil density (ρ_s) gm/cc	Slope (m)	Intercept on Y-axis (c)	Linear absorption coefficient cm^{-1}	Mass attenuation coefficient (μ/ρ_s) cm^2/gm
1	1.52	0.0858	1.0760	1.20641	0.79369
2	1.86	0.06886	1.11676	1.24483	0.66926
3	1.97	0.04126	0.83568	0.91696	0.46546
4	2.28	0.06014	1.06034	1.19745	0.52520
5	2.43	0.07137	0.94266	1.11608	0.45929
6	2.51	0.07145	0.99814	1.17747	0.46911
7	2.64	0.07223	1.13233	1.32301	0.50114
8	2.86	0.07775	0.95201	1.17437	0.41062
9	3.65	0.08234	1.01459	1.31513	0.36030

Table-10
Attenuation coefficient of soil samples using Co-60 of energy 1330 keV

S. No.	Soil density (ρ_s) gm/cc	Slope (m)	Intercept on Y-axis (c)	Linear absorption coefficient cm^{-1}	Mass attenuation coefficient (μ/ρ_s) cm^2/gm
1	1.52	0.07712	1.05844	1.175662	0.77346211
2	1.86	0.06632	0.9278	1.051155	0.5651372
3	1.97	0.04721	0.99518	1.088184	0.55237751
4	2.28	0.05712	0.9747	1.104934	0.48462
5	2.43	0.04307	0.98427	1.08893	0.44811938
6	2.51	0.09737	0.89495	1.139349	0.45392378
7	2.64	0.0663	0.96002	1.135052	0.42994394
8	2.86	0.07273	0.95775	1.165758	0.40760762
9	3.65	0.09758	0.91828	1.274447	0.34916356

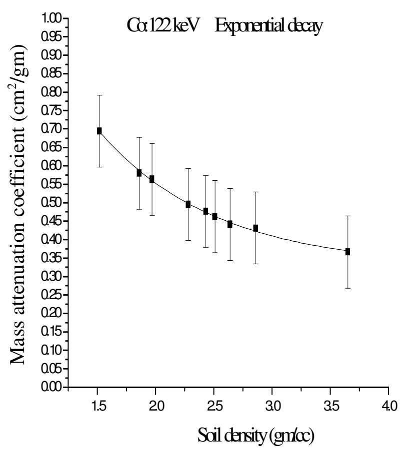

Figure-3

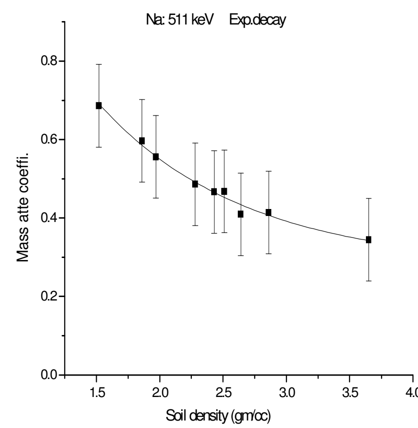

Figure- 5

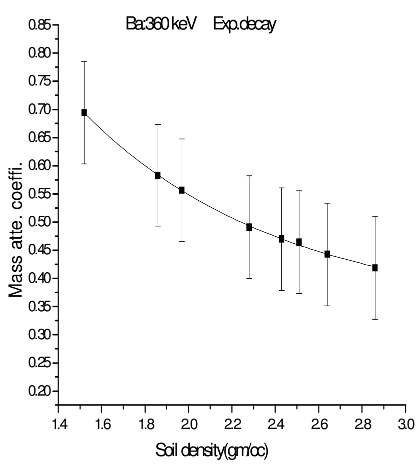

Figure- 4

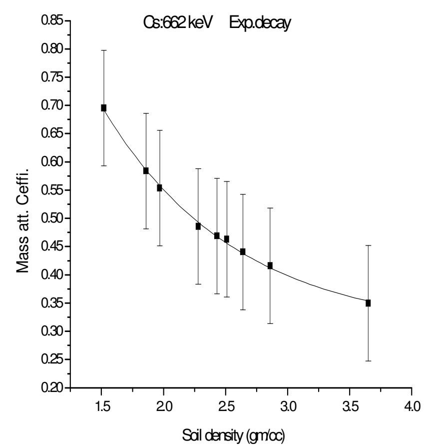

Figure- 6

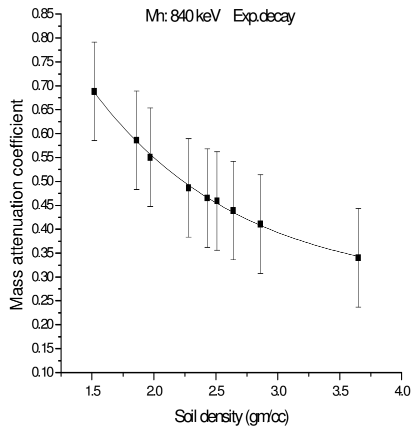

Figure- 7

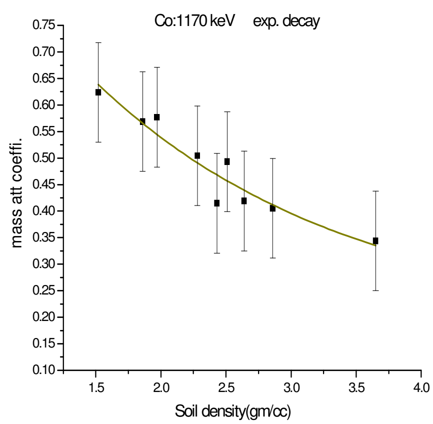

Figure- 8

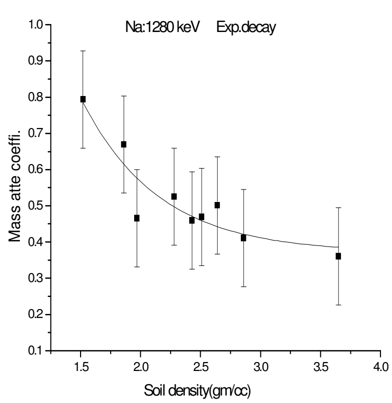

Figure- 9

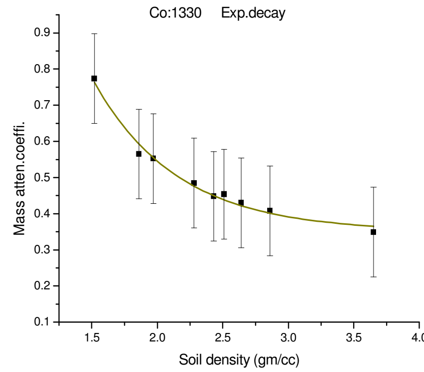

Figure- 10

Conclusion

The effect and chemical components like C, K, S, P, Ca, Na, CaCO3,, Mg, Cu, Fe, Zn, , etc. .and physical properties like sand, moistness, water holding capacity, particle density, porosity etc. of soil samples on linear and mass attenuation coefficient have been studied at gamma ray energies from 123 keV to 1280 keV. These parameters usually depend on the energy of the radiations and composite materials of the soil and are useful for quantitative evaluation of interaction of gamma rays with the soil samples. As density increases the mass attenuation coefficient of soil samples decreases. This validates the gamma absorption law. This method is useful for the study of properties the soils in agriculture purposes.

Acknowledgement

Authors are thankful to Prin. Dr.M.M.Andar, Secretary, M.E.Society, Pune, Prin. Dr.B.B.Thakur, Principal, Nowrosjee Wadia College, Pune, Dr.S.L.Bonde, Vice-Principal, Dr.K.V.Desa, Head, Dept. of Physics, Nowrosjee Wadia College ,Pune for encouragement to us. Authors are also thankful to President, Secretary and Principal of Rajarshi Shahu Mahavidyalaya, Latur for motivation, moral support to us. Authors are also thankful to U.G.C.W.R.O., Pune and B.C.U.D., University of Pune, Pune for providing financial support for research.

References

1. Hubbell J.H., Photon mass attenuation and energy absorption coefficients from 1 keV to 20 keV, *Appli. Radiat. Isot.,* **33**, 1269 **(1982)**

2. Hubbel J.H. and Sheltzer S.M., Tables of X-ray mass attenuation coefficient and mass energy absorption coefficients 1 keV to 230 MeV for elements z=1 to 92 and 48 additional substances of dosimetric interest, *NISTIR*-5632 **(1995)**

3. Bradley D.D., Chong C.S., Shukri A., Tajuddin A.A. and Ghose A.M., A new method for the direct measurement of the energy absorbtion coefficient of gamma rays, *Nucl. Instrum. Meth.Phys. Res.,* A280, 39 **(1989)**

4. Cunningham J.R. and Johns H.E., Calculation of the average energy absorbed in photon interactions, *Med.Phys,* **7,** 51 **(1980)**

5. Carlsson G.A., Absorbed Dose Equations, On the Derivation of a General Absorbed Dose Equation and Equations Valid for Different Kinds of Radiation Equilibrium*, Radiation research,* **5**, 219-237 **(1981)**

6. Jahagirdar H.A., Hanumaiah B. and Thontadarya B.R., Determination of narrow beam attenuation coefficients from broad beam geometrical configuration for 320KeV photons, Int., *Appli.Radiat .Isot***, 43,** 1511 **(1992)**

7. Singh K., Bal H.K., Sohal I.K. and sud S.P., Measurement of absorption coefficients at 662 keV in soil samples, *Applied radiation Isotop,* **42**, 1239 **(1991)**

8. Gerwad L., Comments on attenuation co-efficients of 123 KeV gamma radiation by dilute solutions of sodium chloride, *Appl. Radiat. Isot.,* **47,** 19149 **(1996)**

9. Gerward L., On the attenuation of X-rays and gamma rays in dilute solutions, *Radiat. Phys. Chem.,* **48,** 697 **(1996)**

10. Bhandal G.S., Study of Photon attenuation coefficients of some multielement materials, *Nuclear Science and Engineering,* **116,** 218-222 **(1994)**

11. El-Kateb A.H. and Abdul Hamid, Photon attenuation study of some materials containing Hydrogen, Carbon and Oxygen*., Applied radiat.Isot.,* **42**, 303-307 **(1991)**

12. Singh Jarnail, Singh Karamjit, Mudahar S. and Kulwant S., Gamma ray attenuation studies in Telurite glasses, *National Symposia on radiation Physics,* **15,** 36-39(**2003)**

13. Demir D. Ozgul A. Un.M. and Sachin Y., Determination of Photon attenuation Coefficioent, Porocity and field capacity of soil by gamma ray transmission for 60, 356 and 662 keV gamma rays, *Applied Radiation and Isotopes,* **66,** 1834-1837 **(2008)**

14. Appoloni C.R. and Rios E.A., Mass attenuation coefficients of Brazilian soils in the range10-1450 keV, *Applied Radiat. Isot,* **45**, 287-291**(2004)**

15. Teli M.T., Chaudhari L.M. and Malode S.S., Attenuation coefficients of 123 keV gamma radiation by dilute solution of sodium chloride, *Appli. Radiat isot*, **45(10)**, 987 **(1994)**

16. Teli M.T., Chaudhari L.M. and Malode S.S., Study of absorption of 123 keV gamma radiation by dilute solution of zinc sulphate*, J. of Pure & applied Physics,* **32**, 410 **(1994)**

17. Teli M.T., Chaudhari L.M., *Appli. Radiat. Isot.,* Attenuation coefficient of 662 keV gamma radiation by dilute solutions of sodium chloride, **461**, 369 **(1995)**

18. Teli M.T., Chaudhari L.M., Linear attenuation coefficient of gamma radiation in dilute solutions of potassium chloride*, Appli.Radiat. Isot.,* **47**, 365 **(1996)**

19. Teli M.T. On Attenuuation Coefficients of 123 KeV γ-Radiation by Dilute Solutions of Sodium Choride, Answer to the comments by L.Gerward, *Appli.Radiat. Isot*, **48**, 87 **(1997)**

20. Teli M.T. On the attenuation of X-rays and gamma rays for aqueous solutions of salts, *Radiat.Phys.& Chem.*, **53, (1998)**

21. Raje D.V. and Chaudhari L.M., Mass attenuation coefficients of soil samples in Maharashtra State (India) by using gamma energy at 0.662 MeV, *Bulg. J. Phys.,* **37**, 158-164 (**2010)**

22. Chaudhari L.M. and R. Nathuram, Absorption coefficient of polymers (Polyvinyl Alcohol) by using gamma energy of 0.39 MeV, *Bulg. J. Phys.*, **38 (2010)**

23. Chaudhari Laxman M. and Raje Dayanand V., Study of photon attenuation coefficient of soil samples from Maharashtra and Karnataka states (India) from 122 keV to 1330 keV., *Research Journal of Chemical Sciences,* **2(2) (2012)**

24. Chaudhari Laxman M. and Raje Dayanand V. Mass Attenuation Coefficient Measurements in Soil Sample, *Research journal of Chemical sciences*, **2(5)**, **(2012)**