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The Theoretical Investigation of Chitin Doped Concretes for Gamma-ray Shielding Properties

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Abstract

Various composites containing glucose are widely used in cement production. Glucose-containing materials are widely used in the production of various types of cements due to their advantageous properties such as being light, economical and easily accessible. In this study, radiation shielding parameters of $C_8H_{13}O_5N$ (chitin) mixture with Pb doped at various percentages (5, 10, 20%) such as linear attenuation coefficients (LAC), mass attenuation coefficients (MAC), half value layers (HVL), tenth value layers (TVL), mean free path (MFP), effective atomic number (Zeff), electron density (Neff) and effective conductivity energy (Ceff) parameters have been investigated by using Phy-X software between 1 keV to 40 MeV energy range, theoretically. It has been seen that the results obtained are effective in gamma-ray shielding and are also compatible with the literature.

Keywords: Lignocellulose, radiation shielding, concrete, Phy-X software

Kitin Katkılı Betonların Gama Zırhlama Özelliklerinin Teorik Olarak İncelenmesi

Özet

Çimento üretiminde glikoz içeren çeşitli kompozitler yaygın olarak kullanılmaktadır. Glikoz içerikli malzemeler, hafif, ekonomik ve kolay ulaşılabilir olması gibi avantajlı özelliklerinden dolayı çeşitli tipteki çimentoların üretiminde yaygın olarak kullanılmaktadır. Bu çalışmada, (%5, 10, %20) Pb katkılı $C_8H_{13}O_5N$ (kitin) karışımının, lineer soğurma katsayıları (LAC), kütle zayıflama katsayıları (MAC), yarı değer katmanları (HVL), onuncu değer katmanları (TVL), ortalama serbest yol (MFP), etkin atom numarası (Zeff), elektron yoğunluğu (Neff) ve etkin iletkenlik enerjisi (Ceff) gibi radyasyon soğurma parametreleri Phy-X yazılımı kullanılarak 1 keV ile 40 MeV enerji aralığında teorik olarak incelenmiştir. Elde edilen sonuçların gama ışını korumasında etkili olduğu ve literatürle de uyumlu olduğu görülmüştür.

Anahtar kelimeler: Lignocellulose, radiation shielding, concrete, Phy-X software

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1. Introduction

Today, the most important tools of human life and sustainable development efforts in the world energy demand, which is one of the world's population growth, industrialization and the development of scientific activities for reasons such as the need for energy is increasing every day. However, due to the limited energy resources and also the negative effects on the environment, new energy technologies are required (Kavun et al., 2021). For this purpose, many nuclear power plants have been established in the world and these power plants contribute to the energy supply to a large extent. However, besides the contribution of these power plants to the energy supply, they have the potential to harm nature with any radiation leakage. Therefore, there are parameters to be considered in order to prevent radiation leakage in the construction of power plants (James E. Martin and Tanır G, 2013).

Radiation shielding is important to prevent radioactive particles from harming living things and nature by interacting with the environment (Krane and Lynch, 1989). The higher the density of this shielding material, the greater the ability to shielding these high-energy particles (Knoll and Kraner, 1981). For this reason, concrete, which is low in cost, easy to use and has good structural properties, can also be used as a shielding material. However, high-density materials such as lead can be added to the concrete in order to increase its shielding properties against radiation (Madej et al., 2021). There are also studies that increase shielding and setting by adding natural materials to this mixture (Kılınçarslan Ş. et al., 2011).

Considering the excess of lignocellulosic biomass in agriculture, it seems attractive to use this biomass to be added to cement in the field of protection from radiation and the hardening of concrete (Fatma et al., 2018). Cell walls of advanced, higher plants contain a large amount of lignocellulose. Separation of lignin in its case, the polysaccharide derivative remains. Chitin ($C_8H_{13}O_5N$), which has a long-chain polymer with N-acetylglucosamine, a glucose derivative, is naturally found in many places. It is the main component of the fungal cell wall in the exoskeleton of arthropods, such as crustaceans. In addition, the kit is used for medical and industrial purposes. it is a biological substance that can be compared to cellulose, which is a polysaccharide, and keratin, which is a protein (Muzzarelli, 1977).

In this study, some radiation shielding parameters of various percentages (5, 10, 20%) Pb doped $C_8H_{13}O_5N$ (chitin) mixture of cement such as linear attenuation coefficients (LAC), mass attenuation coefficients (MAC), half value layers (HVL), tenth value layers (TVL), mean free path (MFP), effective atomic number (Z_{eff}), electron density (N_{eff}) and effective conductivity energy (C_{eff}) parameters have been investigated by using Phy-X software (Şakar et al., 2020). This investigation has been done between 1 keV to 40 MeV energy range, theoretically. According to the obtained results, it has been seen that the Pb doped $C_8H_{13}O_5N$ (chitin) cement mixture is usable for radiation shielding purpose in the building industry.

2. Material and Methods

The Phy-X program (Şakar et al., 2020) was developed by Şakar et al. (2020) to calculate parameters related to shielding and dosimetry. These photon shielding parameters include linear and mass attenuation coefficients (LAC, MAC), half and tenth value layers (HVL, TVL), mean free path (MFP), effective atomic number and electron density (Z_{eff}, N_{eff}), effective conductivity (C_{eff}) energy. This software can generate data between 1 keV-100 GeV in the continuous energy region. Photon shielding parameters available at predefined photon energies can be obtained. In addition, the fast neutron removal cross section parameter can also be obtained with this program. It is possible to use the software for free after registering with the Phy-X platform to use it. Further detailed information can be found in Şakar et al., (2020).

The Beer–Lambert law (Agar, 2018) have been used to calculate linear absorption coefficient (LAC) that can be seen in Eq.(1):

$$\mu = \ln\left(\frac{I_0}{I}\right) / (-x) \quad (\mathrm{cm}^{-1}) \tag{1}$$

μ is the linear attenuation coefficient, I_0 is the number of photons measured in the absence of the material, I is the number of photons measured after interacting with the material, while x is the thickness of the material.

In the Eq. (2), Mass Attenuation Coefficient (MAC) (μ_m) is given for a compound and mixture (Agar et al., 2019):

$$\mu_m = \frac{\mu}{\rho} = \sum w_i \left(\frac{\mu}{\rho}\right)_i \quad (\mathrm{cm}^2/\mathrm{g}) \tag{2}$$

here, w_i and ρ is the weight fraction and density, respectively.

3. Results and Discussion

The various percentages (5, 10, 20%) Pb doped $C_8H_{13}O_5N$ (chitin) mixture has been investigated in this study to obtain some radiation shielding parameters. The linear attenuation coefficients (LAC), mass attenuation coefficients (MAC), half value layers (HVL), tenth value layers (TVL), mean free path (MFP), effective atomic number (Zeff), electron density (Neff) and effective conductivity energy (Ceff) parameters have been obtained by using Phy-X software between 1 keV to 40 MeV energy range, theoretically.

$C_8H_{13}O_5N$ compound has been calculated and results can be seen in Figure 1 and Table 1. There is not Pb in this compound and LAC values varied between 4390.614 and 0.022 cm^{-1} for $C_8H_{13}O_5N$. So, the MAC value changed between 3081.133 and 0.016 cm^2/g. The HVL values changed between 0.00015 and 31.291 cm. TVL value changed between 0.001 and 103.948 cm and MFP varied 0.00022 and 45.144 cm. Z_{eff} values have been changed between 7.11 and 4.99. N_{eff} has been changed between $5.69*10^{23}$ and $3.99*10^{23}$ electrons/g. C_{eff} values have been changed between $5.86*10^8$ and $4.11*10^8$ s/m.

Table 1 Radiation shielding parameters of $C_8H_{13}O_5N$ by using Phy-X software

Energy	MAC	LAC	HVL	TVL	MFP	Neff	Ceff	Zeff
MeV	*cm²/g*	*1/cm*	*cm*	*cm*	*cm*	*electrons/g*	*S/m*	
0.001	3081.133	4390.614	0.00015	0.001	0.00022	5.69E+23	5.86E+08	7.11
0.002	1015.728	1447.412	0.00047	0.002	0.001	5.72E+23	5.88E+08	7.14
0.002	449.642	640.740	0.00108	0.004	0.002	5.73E+23	5.89E+08	7.16
0.003	138.247	197.002	0.004	0.012	0.005	5.74E+23	5.91E+08	7.17
0.004	58.818	83.816	0.008	0.027	0.012	5.74E+23	5.91E+08	7.17
0.005	30.094	42.884	0.016	0.054	0.023	5.73E+23	5.90E+08	7.16
0.006	17.353	24.727	0.028	0.093	0.040	5.71E+23	5.88E+08	7.14
0.008	7.289	10.387	0.067	0.222	0.096	5.65E+23	5.81E+08	7.06
0.010	3.758	5.355	0.129	0.430	0.187	5.54E+23	5.70E+08	6.92
0.015	1.214	1.730	0.401	1.331	0.578	5.10E+23	5.25E+08	6.38
0.02	0.616	0.878	0.790	2.623	1.139	4.59E+23	4.73E+08	5.74
0.03	0.314	0.448	1.549	5.145	2.234	3.88E+23	3.99E+08	4.84
0.04	0.238	0.339	2.043	6.788	2.948	3.55E+23	3.65E+08	4.44
0.05	0.208	0.296	2.342	7.779	3.379	3.40E+23	3.50E+08	4.25
0.06	0.192	0.273	2.539	8.436	3.664	3.33E+23	3.43E+08	4.16
0.08	0.173	0.247	2.804	9.316	4.046	3.27E+23	3.36E+08	4.08
0.1	0.162	0.231	2.999	9.963	4.327	3.24E+23	3.33E+08	4.05
0.2	0.144	0.205	3.385	11.246	4.884	3.22E+23	3.31E+08	4.02
0.2	0.131	0.187	3.713	12.335	5.357	3.21E+23	3.30E+08	4.01
0.3	0.114	0.162	4.284	14.233	6.181	3.21E+23	3.30E+08	4.01

0.4	0.102	0.145	4.788	15.904	6.907	3.20E+23	3.30E+08	4.00
0.5	0.093	0.132	5.245	17.424	7.567	3.20E+23	3.29E+08	4.00
0.6	0.086	0.122	5.673	18.844	8.184	3.20E+23	3.29E+08	4.00
0.8	0.075	0.107	6.460	21.459	9.319	3.20E+23	3.29E+08	4.00
1	0.068	0.096	7.185	23.868	10.366	3.20E+23	3.29E+08	4.00
2	0.055	0.079	8.828	29.327	12.737	3.20E+23	3.30E+08	4.00
2	0.047	0.067	10.286	34.171	14.840	3.21E+23	3.30E+08	4.01
3	0.038	0.054	12.822	42.593	18.498	3.23E+23	3.32E+08	4.04
4	0.032	0.046	14.977	49.752	21.607	3.26E+23	3.35E+08	4.07
5	0.029	0.041	16.839	55.937	24.293	3.29E+23	3.38E+08	4.11
6	0.026	0.038	18.456	61.310	26.627	3.32E+23	3.42E+08	4.15
7	0.024	0.035	19.871	66.009	28.667	3.35E+23	3.45E+08	4.19
8	0.023	0.033	21.116	70.144	30.463	3.39E+23	3.48E+08	4.23
9	0.022	0.031	22.209	73.777	32.041	3.42E+23	3.52E+08	4.27
10	0.021	0.030	23.181	77.006	33.443	3.45E+23	3.55E+08	4.31
11	0.020	0.029	24.043	79.869	34.687	3.48E+23	3.58E+08	4.35
12	0.020	0.028	24.813	82.426	35.797	3.51E+23	3.61E+08	4.38
13	0.019	0.027	25.503	84.719	36.793	3.53E+23	3.64E+08	4.42
14	0.019	0.027	26.115	86.752	37.676	3.56E+23	3.66E+08	4.45
15	0.018	0.026	26.664	88.576	38.468	3.59E+23	3.69E+08	4.48
16	0.018	0.026	27.154	90.203	39.175	3.61E+23	3.72E+08	4.51
18	0.017	0.025	27.998	93.007	40.392	3.66E+23	3.76E+08	4.57
20	0.017	0.024	28.680	95.272	41.376	3.70E+23	3.81E+08	4.63
22	0.017	0.024	29.224	97.081	42.162	3.74E+23	3.85E+08	4.68
24	0.016	0.023	29.675	98.579	42.812	3.78E+23	3.89E+08	4.72
26	0.016	0.023	30.050	99.823	43.353	3.81E+23	3.92E+08	4.77
28	0.016	0.023	30.349	100.819	43.785	3.85E+23	3.96E+08	4.81
30	0.016	0.023	30.598	101.644	44.143	3.87E+23	3.99E+08	4.84
40	0.016	0.022	31.291	103.948	45.144	3.99E+23	4.11E+08	4.99

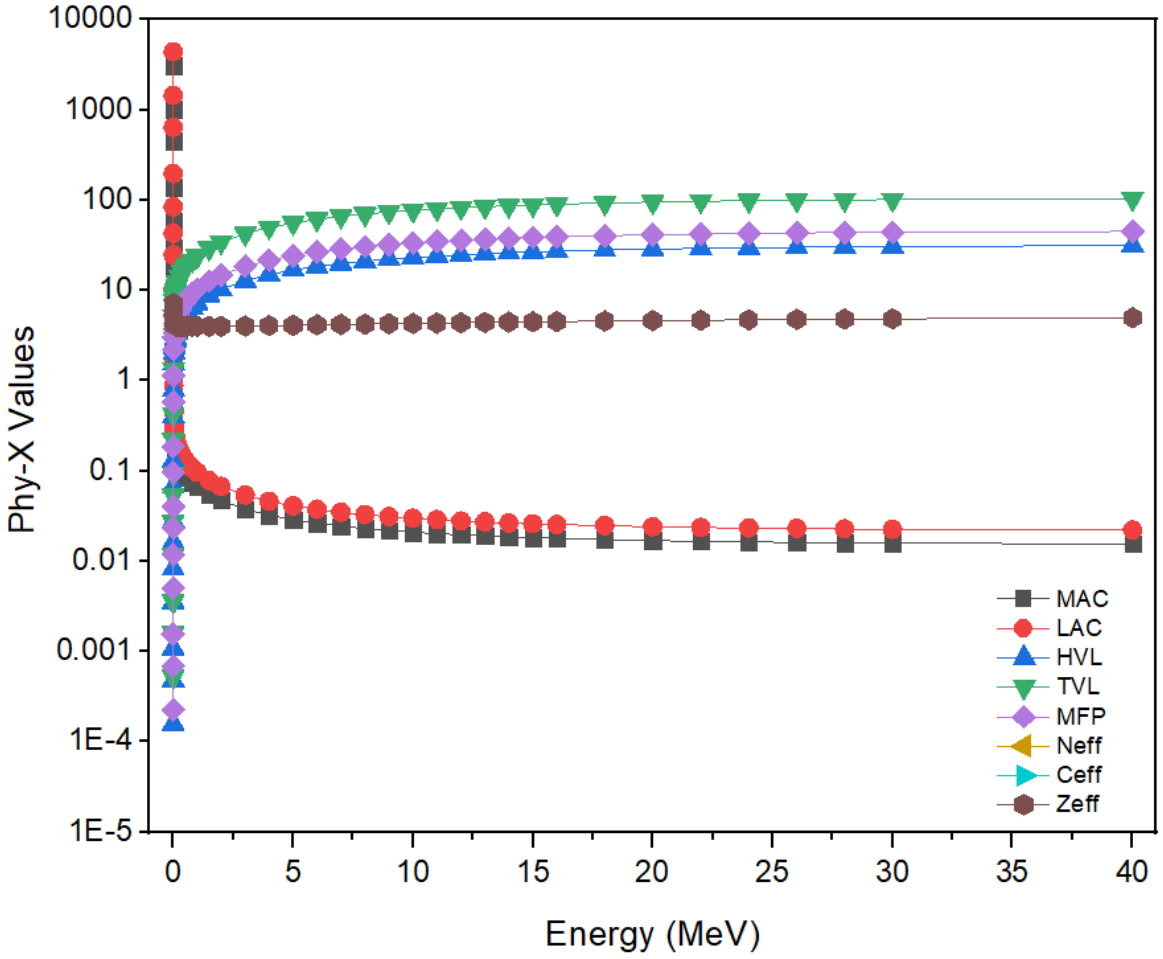

Figure 1. Phy-X software data of $C_8H_{13}O_5N$

In Figure 2 and Table 2, the radiation shielding values can be seen for 5% Pb doped $C_8H_{13}O_5N$. According to the obtained values, the LAC changed between 6117.516 and 0.036 cm^{-1} for $C_8H_{13}O_5N$. The MAC values have been obtained as 3189.529 cm^2/g for 0.001 MeV and 0.019 cm^2/g for 40 MeV. Also, HVL values changed between 0.0001 and 19.399 cm. TVL and MFP values are 0.0003 and 0.0001 cm at 1 keV and 64.443 and 27.987 cm respectively at 40 MeV energy. Z_{eff} changed between 7.70 and 6.20. N_{eff} has been fluctuated between $5.86*10^{23}$ and $4.72*10^{23}$ electrons/g. Finally, C_{eff} has been obtained between $8.11*10^8$ and $6.53*10^8$ s/m.

Table 2 Radiation shielding parameters of $C_8H_{13}O_5N$ +5% Pb by using Phy-X software

Energy *MeV*	**MAC** *cm^2/g*	**LAC** *1/cm*	**HVL** *cm*	**TVL** *cm*	**MFP** *cm*	**Neff** *electrons/g*	**Ceff** *S/m*	**Zeff**
0.001	3189.529	6117.516	0.0001	0.0003	0.0001	5.86E+23	8.11E+08	7.70
0.002	1084.013	2079.137	0.0003	0.001	0.0004	6.05E+23	8.37E+08	7.94
0.002	492.209	944.057	0.001	0.002	0.001	6.20E+23	8.58E+08	8.15
0.003	231.287	443.608	0.002	0.005	0.002	9.02E+23	1.25E+09	11.85
0.004	119.549	229.295	0.003	0.010	0.004	1.06E+24	1.47E+09	13.97
0.005	65.769	126.145	0.005	0.018	0.008	1.13E+24	1.56E+09	14.81
0.006	40.265	77.229	0.009	0.030	0.013	1.18E+24	1.63E+09	15.51
0.008	18.566	35.609	0.019	0.065	0.028	1.26E+24	1.74E+09	16.54
0.010	10.221	19.604	0.035	0.117	0.051	1.30E+24	1.81E+09	17.13
0.015	6.835	13.110	0.053	0.176	0.076	2.08E+24	2.88E+09	27.34

0.02	4.984	9.560	0.073	0.241	0.105	2.44E+24	3.38E+09	32.05
0.03	1.842	3.534	0.196	0.652	0.283	1.74E+24	2.42E+09	22.93
0.04	0.957	1.836	0.377	1.254	0.545	1.22E+24	1.69E+09	16.00
0.05	0.607	1.164	0.596	1.979	0.859	8.99E+23	1.25E+09	11.82
0.06	0.437	0.839	0.826	2.744	1.192	7.11E+23	9.85E+08	9.35
0.08	0.288	0.552	1.255	4.171	1.811	5.24E+23	7.25E+08	6.88
0.1	0.437	0.837	0.828	2.750	1.194	8.01E+23	1.11E+09	10.53
0.2	0.239	0.458	1.512	5.024	2.182	5.17E+23	7.16E+08	6.79
0.2	0.175	0.336	2.063	6.853	2.976	4.22E+23	5.84E+08	5.54
0.3	0.128	0.246	2.817	9.358	4.064	3.60E+23	4.98E+08	4.73
0.4	0.108	0.208	3.338	11.090	4.816	3.40E+23	4.71E+08	4.47
0.5	0.096	0.185	3.755	12.475	5.418	3.31E+23	4.59E+08	4.36
0.6	0.088	0.168	4.119	13.684	5.943	3.27E+23	4.53E+08	4.30
0.8	0.076	0.146	4.756	15.800	6.862	3.23E+23	4.47E+08	4.24
1	0.068	0.130	5.325	17.689	7.682	3.21E+23	4.44E+08	4.21
2	0.055	0.105	6.577	21.847	9.488	3.19E+23	4.42E+08	4.20
2	0.047	0.091	7.652	25.421	11.040	3.20E+23	4.44E+08	4.21
3	0.038	0.073	9.470	31.459	13.662	3.25E+23	4.50E+08	4.27
4	0.033	0.063	10.964	36.421	15.818	3.30E+23	4.57E+08	4.34
5	0.030	0.057	12.213	40.569	17.619	3.36E+23	4.66E+08	4.42
6	0.027	0.052	13.262	44.057	19.134	3.43E+23	4.74E+08	4.50
7	0.026	0.049	14.151	47.007	20.415	3.49E+23	4.83E+08	4.58
8	0.024	0.046	14.907	49.518	21.506	3.55E+23	4.92E+08	4.67
9	0.023	0.045	15.548	51.651	22.432	3.61E+23	5.00E+08	4.75
10	0.022	0.043	16.100	53.482	23.227	3.67E+23	5.08E+08	4.82
11	0.022	0.042	16.572	55.051	23.908	3.73E+23	5.16E+08	4.90
12	0.021	0.041	16.979	56.404	24.496	3.79E+23	5.24E+08	4.97
13	0.021	0.040	17.332	57.577	25.005	3.84E+23	5.32E+08	5.05
14	0.020	0.039	17.633	58.576	25.439	3.89E+23	5.39E+08	5.12
15	0.020	0.039	17.895	59.446	25.817	3.94E+23	5.46E+08	5.18
16	0.020	0.038	18.120	60.195	26.142	3.99E+23	5.53E+08	5.24
18	0.020	0.037	18.490	61.423	26.676	4.08E+23	5.65E+08	5.36
20	0.019	0.037	18.766	62.341	27.074	4.17E+23	5.77E+08	5.47
22	0.019	0.037	18.967	63.008	27.364	4.24E+23	5.87E+08	5.58
24	0.019	0.036	19.119	63.510	27.582	4.31E+23	5.97E+08	5.67
26	0.019	0.036	19.232	63.889	27.746	4.38E+23	6.06E+08	5.75
28	0.019	0.036	19.309	64.143	27.857	4.44E+23	6.15E+08	5.83
30	0.019	0.036	19.363	64.322	27.935	4.50E+23	6.22E+08	5.91
40	0.019	0.036	19.399	64.443	27.987	4.72E+23	6.53E+08	6.20

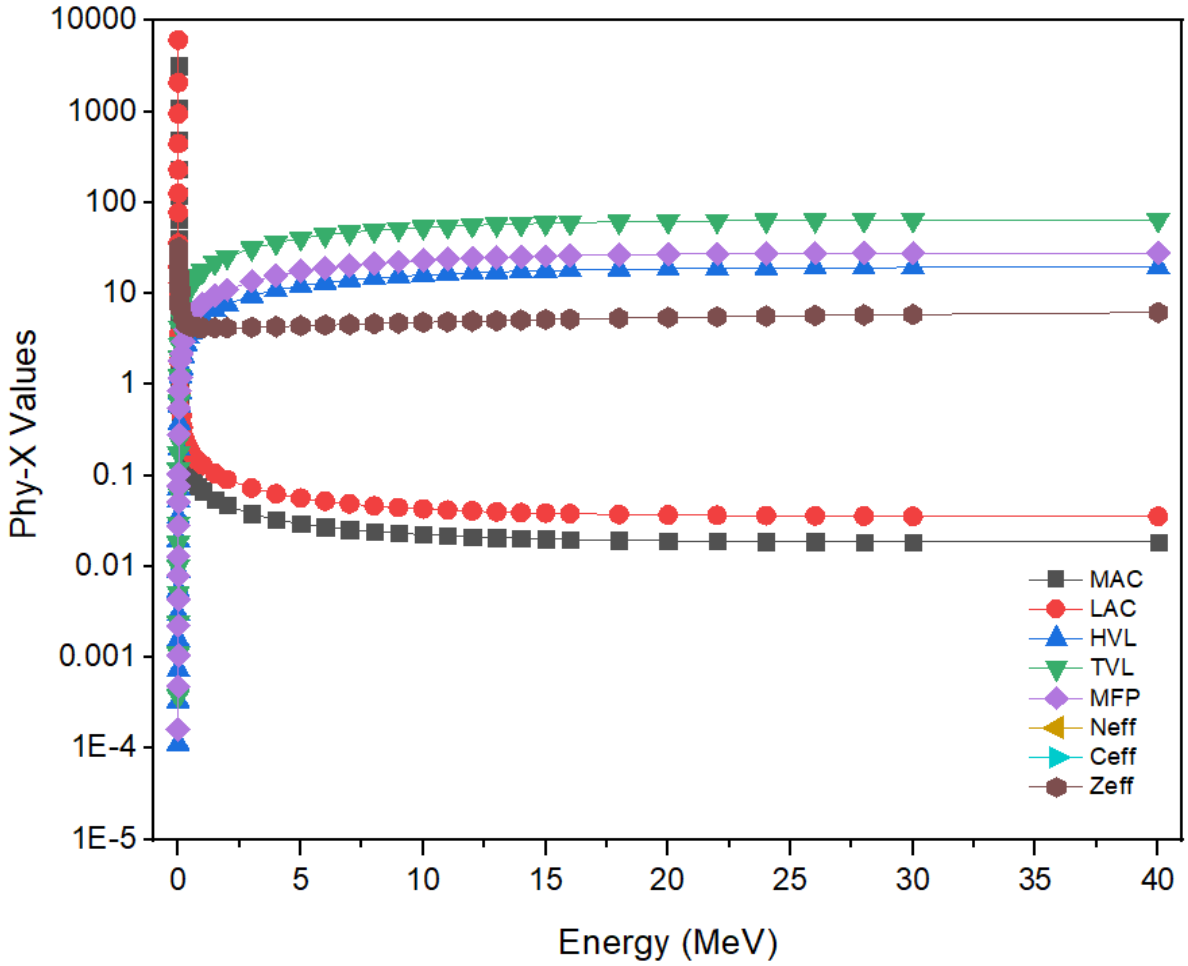

Figure 2. Phy-X software data of $C_8H_{13}O_5N$ +5% Pb

10% Pb doped $C_8H_{13}O_5N$ mixture radiation shielding performance results have been given in Figure 3 and Table 3. The radiation shielding performance of this mixture shows that the LAC varies between 7950.783 and 0.052 cm^{-1}. By using these LAC values, The MAC values have been obtained and it was located 3297.712 cm^2/g for 0.001 MeV and 0.022 cm^2/g for 40 MeV. In association with LAC, HVL TVL and MFP values were obtained as 0.000087 cm, 0.000290 cm and 0.000126 cm, respectively. The effective electron density (Z_{eff}) has been fluctuated between 8.34 and 7.50. Lastly, N_{eff} and C_{eff} have been obtained $6.02*10^{23}$ electrons/g, $1.05*10^9$ s/m for 0.001 MeV and $5.42*10^{23}$, $9.43*10^8$ s/m for 40 MeV respectively.

Table 3 Radiation shielding parameters of $C_8H_{13}O_5N$ +10% Pb by using Phy-X software

Energy *MeV*	**MAC** *cm^2/g*	**LAC** *1/cm*	**HVL** *cm*	**TVL** *cm*	**MFP** *cm*	**Neff** *electrons/g*	**Ceff** *S/m*	**Zeff**
0.001	3297.712	7950.783	0.000087	0.000290	0.000126	6.02E+23	1.05E+09	8.34
0.002	1152.164	2777.869	0.000250	0.000829	0.000360	6.36E+23	1.11E+09	8.82
0.002	534.692	1289.142	0.000538	0.001786	0.000776	6.65E+23	1.16E+09	9.22
0.003	324.144	781.512	0.001	0.003	0.001	1.18E+24	2.06E+09	16.41
0.004	180.160	434.367	0.002	0.005	0.002	1.46E+24	2.54E+09	20.20
0.005	101.374	244.413	0.003	0.009	0.004	1.56E+24	2.72E+09	21.66
0.006	63.133	152.214	0.005	0.015	0.007	1.65E+24	2.87E+09	22.85
0.008	29.820	71.895	0.010	0.032	0.014	1.78E+24	3.09E+09	24.62
0.010	16.671	40.195	0.017	0.057	0.025	1.85E+24	3.22E+09	25.65
0.015	12.445	30.006	0.023	0.077	0.033	2.90E+24	5.05E+09	40.21

0.02	9.344	22.528	0.031	0.102	0.044	3.31E+24	5.76E+09	45.89
0.03	3.368	8.119	0.085	0.284	0.123	2.54E+24	4.41E+09	35.13
0.04	1.675	4.039	0.172	0.570	0.248	1.83E+24	3.19E+09	25.38
0.05	1.005	2.423	0.286	0.950	0.413	1.35E+24	2.34E+09	18.67
0.06	0.683	1.647	0.421	1.398	0.607	1.04E+24	1.80E+09	14.36
0.08	0.402	0.969	0.715	2.376	1.032	7.05E+23	1.23E+09	9.76
0.1	0.710	1.713	0.405	1.344	0.584	1.20E+24	2.08E+09	16.57
0.2	0.334	0.805	0.861	2.859	1.242	6.97E+23	1.21E+09	9.66
0.2	0.219	0.529	1.311	4.355	1.891	5.18E+23	9.01E+08	7.17
0.3	0.143	0.345	2.010	6.678	2.900	3.98E+23	6.92E+08	5.51
0.4	0.115	0.277	2.502	8.312	3.610	3.59E+23	6.25E+08	4.98
0.5	0.100	0.240	2.883	9.577	4.159	3.43E+23	5.96E+08	4.75
0.6	0.090	0.216	3.204	10.645	4.623	3.34E+23	5.81E+08	4.62
0.8	0.077	0.185	3.750	12.457	5.410	3.25E+23	5.66E+08	4.51
1	0.068	0.164	4.226	14.037	6.096	3.21E+23	5.59E+08	4.45
2	0.055	0.132	5.246	17.426	7.568	3.18E+23	5.54E+08	4.41
2	0.047	0.114	6.096	20.250	8.794	3.20E+23	5.56E+08	4.43
3	0.038	0.093	7.490	24.880	10.805	3.26E+23	5.68E+08	4.52
4	0.033	0.081	8.596	28.556	12.402	3.35E+23	5.82E+08	4.64
5	0.030	0.073	9.490	31.525	13.691	3.44E+23	5.98E+08	4.76
6	0.028	0.068	10.216	33.937	14.738	3.53E+23	6.14E+08	4.89
7	0.027	0.064	10.809	35.908	15.595	3.62E+23	6.30E+08	5.02
8	0.025	0.061	11.297	37.527	16.298	3.71E+23	6.46E+08	5.14
9	0.025	0.059	11.696	38.852	16.873	3.80E+23	6.62E+08	5.27
10	0.024	0.058	12.025	39.946	17.348	3.89E+23	6.77E+08	5.39
11	0.023	0.056	12.297	40.848	17.740	3.97E+23	6.92E+08	5.51
12	0.023	0.055	12.521	41.593	18.064	4.06E+23	7.06E+08	5.62
13	0.023	0.055	12.707	42.212	18.332	4.14E+23	7.20E+08	5.73
14	0.022	0.054	12.857	42.711	18.549	4.22E+23	7.34E+08	5.84
15	0.022	0.053	12.983	43.128	18.730	4.29E+23	7.47E+08	5.94
16	0.022	0.053	13.086	43.469	18.878	4.36E+23	7.59E+08	6.04
18	0.022	0.052	13.241	43.985	19.103	4.49E+23	7.82E+08	6.23
20	0.022	0.052	13.341	44.318	19.247	4.62E+23	8.03E+08	6.39
22	0.021	0.052	13.398	44.508	19.330	4.73E+23	8.23E+08	6.55
24	0.021	0.052	13.429	44.609	19.374	4.83E+23	8.41E+08	6.69
26	0.021	0.052	13.441	44.650	19.391	4.92E+23	8.57E+08	6.82
28	0.021	0.052	13.435	44.629	19.382	5.01E+23	8.72E+08	6.95
30	0.021	0.052	13.418	44.574	19.358	5.09E+23	8.86E+08	7.06
40	0.022	0.052	13.244	43.995	19.107	5.42E+23	9.43E+08	7.50

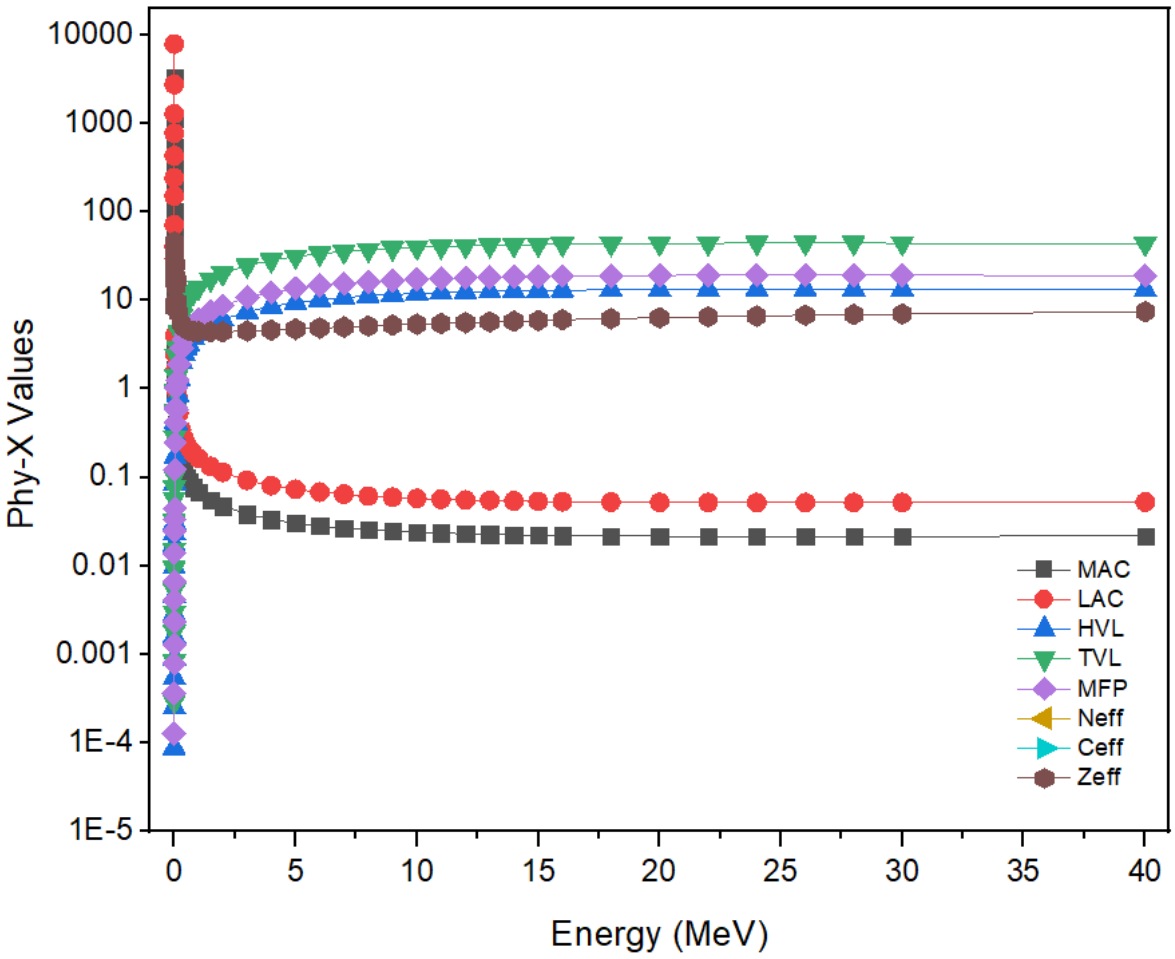

Figure 3. Phy-X software data of $C_8H_{13}O_5N$ + 10% Pb

As can be seen in Figure4 and Table 4 for 20% Pb doped $C_8H_{13}O_5N$ mixture, The LAC has been obtained 11938.668 cm^{-1} for 1 keV and 0.095 cm^{-1} for 40 MeV. As in the previous mixture results, the mac value varies between 3513.440 and 0.028 cm^2/g. HVL TVL and MFP have been changed between 0.00006 cm, 0.00019 cm, 0.00008 cm for 1 keV and 7.325 cm, 24.335, 10.568 cm for 40 MeV respectively.

Table 4 Radiation shielding parameters of $C_8H_{13}O_5N$ +20% Pb by using Phy-X software

Energy *MeV*	**MAC** *cm^2/g*	**LAC** *1/cm*	**HVL** *cm*	**TVL** *cm*	**MFP** *cm*	**Neff** *electrons/g*	**Ceff** *S/m*	**Zeff**
0.001	3513.440	11938.668	0.00006	0.00019	0.00008	6.31E+23	1.55E+09	9.81
0.002	1288.065	4376.846	0.00016	0.00053	0.00023	6.96E+23	1.71E+09	10.81
0.002	619.408	2104.748	0.00033	0.00109	0.00048	7.49E+23	1.84E+09	11.63
0.003	509.311	1730.640	0.00040	0.00133	0.00058	1.62E+24	3.98E+09	25.18
0.004	301.026	1022.886	0.00068	0.00225	0.00098	2.01E+24	4.93E+09	31.25
0.005	172.373	585.725	0.00118	0.004	0.002	2.15E+24	5.28E+09	33.42
0.006	108.734	369.478	0.002	0.006	0.003	2.26E+24	5.55E+09	35.15
0.008	52.262	177.585	0.004	0.013	0.006	2.42E+24	5.94E+09	37.61
0.010	29.534	100.356	0.007	0.023	0.010	2.51E+24	6.16E+09	39.05
0.015	23.633	80.304	0.009	0.029	0.012	3.55E+24	8.71E+09	55.20
0.02	18.037	61.290	0.011	0.038	0.016	3.88E+24	9.51E+09	60.22
0.03	6.409	21.778	0.032	0.106	0.046	3.25E+24	7.98E+09	50.56
0.04	3.107	10.557	0.066	0.218	0.095	2.55E+24	6.26E+09	39.67
0.05	1.799	6.113	0.113	0.377	0.164	1.97E+24	4.83E+09	30.58

0.06	1.172	3.984	0.174	0.578	0.251	1.54E+24	3.77E+09	23.87
0.08	0.630	2.140	0.324	1.076	0.467	1.02E+24	2.49E+09	15.80
0.1	1.256	4.270	0.162	0.539	0.234	1.77E+24	4.34E+09	27.52
0.2	0.524	1.780	0.389	1.294	0.562	1.01E+24	2.47E+09	15.65
0.2	0.307	1.044	0.664	2.205	0.958	6.94E+23	1.70E+09	10.78
0.3	0.172	0.586	1.183	3.931	1.707	4.70E+23	1.15E+09	7.31
0.4	0.128	0.435	1.592	5.288	2.297	3.96E+23	9.73E+08	6.16
0.5	0.107	0.362	1.912	6.352	2.759	3.64E+23	8.93E+08	5.66
0.6	0.094	0.318	2.178	7.234	3.142	3.47E+23	8.51E+08	5.39
0.8	0.078	0.265	2.614	8.685	3.772	3.30E+23	8.09E+08	5.13
1	0.068	0.232	2.983	9.911	4.304	3.22E+23	7.90E+08	5.01
2	0.055	0.185	3.742	12.431	5.399	3.16E+23	7.75E+08	4.91
2	0.047	0.160	4.337	14.406	6.256	3.18E+23	7.81E+08	4.95
3	0.039	0.132	5.253	17.450	7.579	3.29E+23	8.08E+08	5.12
4	0.034	0.117	5.929	19.694	8.553	3.43E+23	8.41E+08	5.33
5	0.032	0.108	6.436	21.378	9.284	3.58E+23	8.77E+08	5.56
6	0.030	0.102	6.817	22.647	9.835	3.73E+23	9.14E+08	5.79
7	0.029	0.098	7.106	23.606	10.252	3.88E+23	9.51E+08	6.02
8	0.028	0.095	7.324	24.329	10.566	4.02E+23	9.87E+08	6.25
9	0.027	0.093	7.486	24.867	10.799	4.17E+23	1.02E+09	6.48
10	0.027	0.091	7.605	25.265	10.972	4.31E+23	1.06E+09	6.70
11	0.027	0.090	7.693	25.555	11.099	4.45E+23	1.09E+09	6.91
12	0.026	0.089	7.754	25.760	11.187	4.58E+23	1.12E+09	7.12
13	0.026	0.089	7.797	25.900	11.248	4.71E+23	1.16E+09	7.32
14	0.026	0.089	7.822	25.983	11.284	4.83E+23	1.19E+09	7.51
15	0.026	0.088	7.837	26.033	11.306	4.95E+23	1.21E+09	7.69
16	0.026	0.088	7.842	26.051	11.314	5.06E+23	1.24E+09	7.87
18	0.026	0.088	7.835	26.028	11.304	5.27E+23	1.29E+09	8.20
20	0.026	0.089	7.809	25.942	11.266	5.47E+23	1.34E+09	8.49
22	0.026	0.089	7.771	25.813	11.210	5.64E+23	1.38E+09	8.77
24	0.026	0.090	7.725	25.661	11.145	5.80E+23	1.42E+09	9.02
26	0.027	0.090	7.677	25.503	11.076	5.95E+23	1.46E+09	9.25
28	0.027	0.091	7.625	25.331	11.001	6.09E+23	1.49E+09	9.46
30	0.027	0.092	7.574	25.160	10.927	6.21E+23	1.52E+09	9.65
40	0.028	0.095	7.325	24.335	10.568	6.71E+23	1.65E+09	10.43

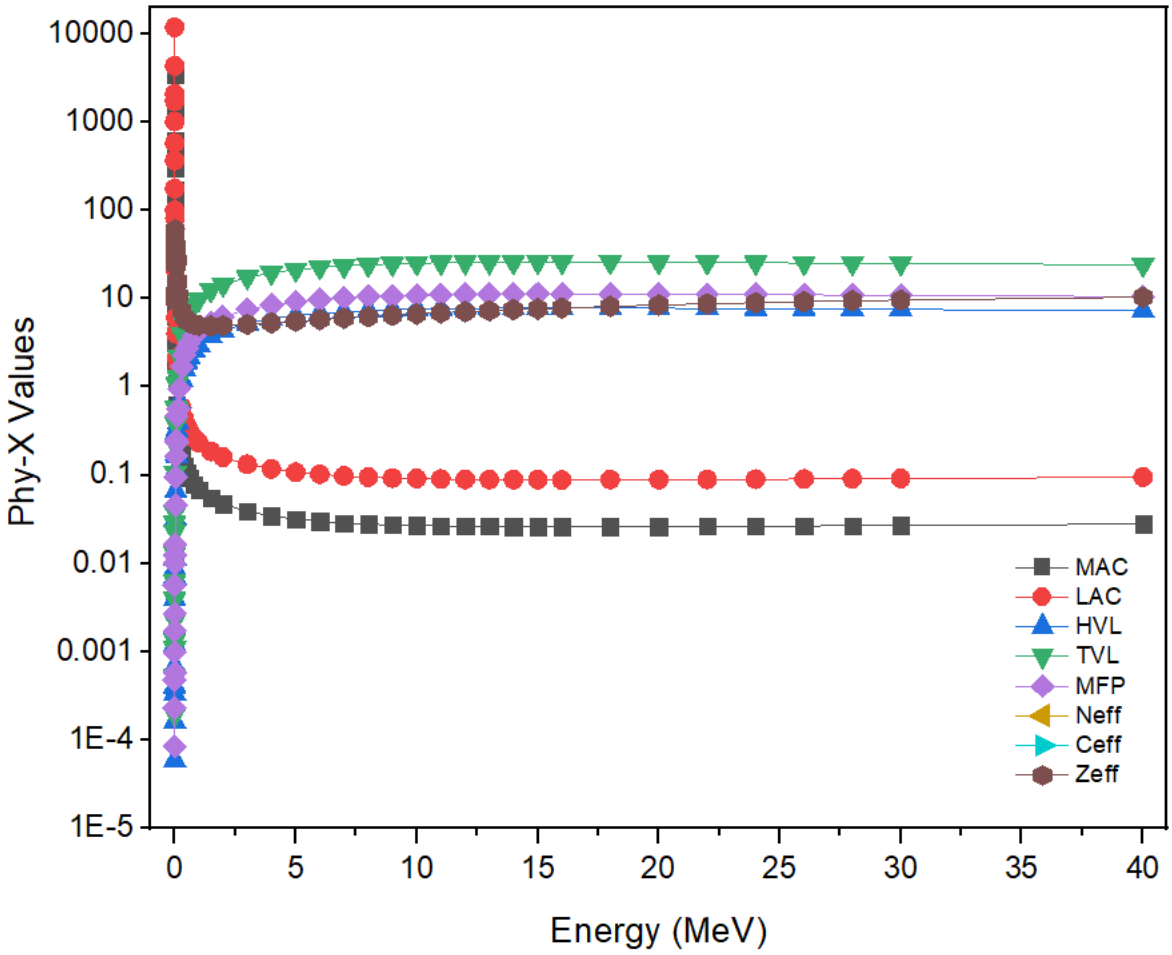

Figure 4. Phy-X software data of $C_8H_{13}O_5N$ + 20% Pb

4. Conclusion

In the scope of this study, some radiation shielding parameters of various percentages (5, 10, 20%) Pb doped $C_8H_{13}O_5N$ (chitin) mixture such as linear attenuation coefficients (LAC), mass attenuation coefficients (MAC), half value layers (HVL), tenth value layers (TVL), mean free path (MFP), effective atomic number (Zeff), electron density (Neff) and effective conductivity energy (Ceff) parameters have been investigated by using Phy-X software between 1 keV to 40 MeV energy range, theoretically. The obtained results of these mixtures have been given in Figure1-4 and Table 1-4.

According to the LAC results obtained, the LAC value increased as Pb was added to the $C_8H_{13}O_5N$ (chitin) compound. This shows us that the Pb mixture has a positive effect on radiation shielding. Other shielding parameters that are obtained by using Phy-X software also gave positive results depending on the LAC values, showing that this mixture will give effective results in shielding when mixed with materials such as concrete in radiation shielding.

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