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CHARACTERIZATION AND RADIATION IMPACT OF CORRUGATED ASBESTOS ROOFING SHEETS IN SRI LANKA

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ABSTRACT

This paper describes a systematic procedure for characterizing corrugated asbestos-cement roofing sheets and evaluating their radiation status related to the asbestos fibre air dispersion that can cause carcinogenic diseases such as lung cancer and mesothelioma. X-ray powder diffraction analyses of powdered asbestos roofing sheet samples show that hazardous fibre of chrysotile has been detected in the three (03) out of four (04) commercially available asbestos roofing sheet samples in Sri Lanka. However, Radium Equivalent Activity (Ra_{eq}) of asbestos roofing sheet samples has ranged from 39.12 – 75.42 Bq kg^{-1}, which are below the internationally accepted value of 370 $Bqkg^{-1}$.The results showed that X-ray powder diffraction analyses and radiation techniques can furnish government authorities with an efficient, rapid and repeatable environmental mapping procedure that can provide information about the location of hazardous asbestos roofing sheets in Sri Lanka.

Key words: corrugated roofing sheets, asbestos fibre, XRD, radiation, Sri Lanka

INTRODUCTION

Asbestos is the name used to describe a group of fibrous hydrous silicates which have outstanding physical properties including high tensile strength, heat and electrical insulation,resistance to acids and alkali, resistance to biodegradation, non-combustibility, stability in the high pH range of the cement matrix, low electrical conductivity and a very powerful absorbant (Virta, 2003; Rawalt, 1998; Chissick, 1987). They were an important component in a variety of building materials, including loose-fill insulations, acoustic and thermal sprays, pipe and boiler wraps, plasters, paints, flooring products, roofing materials, and cementations products (Perkins and Harvey, 1993). These are almost always complex mixtures of solids and in many instances asbestos is present as a minor component.

ASBESTOS MINERALOGY AND ITS PRODUCTS

Asbestos cement (AC) is a composite material composed of "Portland" cement reinforced with asbestos fibres in the matrix ranging from 12% to 18% (Chandra and Berntsson, 2003). Asbestos fibres fall into two major classes, serpentine and amphiboles (Bassani *et al.*, 2007). The ideal chemical compositions and commercial names of the commercial asbestos fibres is shown in Table 1.

Serpentine class fibres generally occur in three polymorphs which are chrysotile, lizardite and antigorite. Chrysotile is a fibrous variety, antigorite is a variety occurring in corrugated plates or fibres and lizardite is a very fine grained, platy variety. Antigorite and lizardite of the serpentine class minerals are less fibrous whereas the morphology of the chrysotile fibres is generally cylindrical or tubular rolls. Approximately 95% of chrysotile have been used in building materials. These chrysotile asbestos fibres are long, ranging from a minimum of 20 μm up to greater than 1000 μm, and exhibit high tensile strength. All amphiboles fibres are usually recognized as solid rods.

HEALTH IMPACTS FROM ASBESTOS

Exposure to Asbestos happens through inhalation of fibres in air in the working

Table 1 The Ideal chemical composition of the commercial Asbestos fibres

Mineral Group	Composition	Commercial Name
Serpentine Group		
Chrysotile	$Mg_3Si_2O_5(OH)_4$	White asbestos
Lizardite	$Mg_3Si_2O_5(OH)_4$	Less fibre
Antigorite	$Mg_3Si_2O_5(OH)_4$	Less fibre, but not used for asbestos
Amphibole Group		
Gunerite	$Fe_7Si_8O_{22}(OH)_2$	Amosite brown asbestos
Riebeckite	$Na_2Fe_3^{2+}Fe_2^{3+}Si_8O_{22}(OH)_2$	Crocidolite or blue asbestos
Anthophylite	$Mg_7Si_8O_{22}(OH)_2$	More fibre
Tremolite	$Ca_2Mg_5Si_8O_{22}(OH)_2$	More fibre
Actinolite	$Ca_2(Mg, Fe^{2+})_5Si_8O_{22}(OH)_2$	More fibre

environment, ambient air in the vicinity of point sources such as factories handling asbestos, or indoor air in housing and buildings containing friable (crumbly) asbestos materials.Amphibole class minerals are considered more hazardous because of their excessively brittle and thin fibres (Bassani *et al.*, 2007). In serpentine class, only chrysotile has been recognized as a hazardous fibre except antigorite and lizardite (WHO, 2014).The World Health Organization (WHO) has reported that asbestos fibres that can be inhaled are generally assessed on dimensional characteristics as length >5 µm, width <3 µm and a length/width ratio >3. Mesothelioma related lung cancers have been diagnosed after occupational exposure to crocidolite, amosite, tremolite and chrysotile**,** as well as among the general population living in the neighborhoods of asbestos factories and mines and in people living with asbestos workers (WHO, 2014).According to global estimates, resulting from occupational exposures at least 107,000 people die each year from asbestos related lung cancer, mesothelioma and asbestosis. In addition, nearly 400 deaths have been attributed to non-occupational exposure to asbestos (WHO, 2014). The International Labour Organization (ILO) established an Asbestos Convention (C162) in 1986 to promote national laws and regulations for the "prevention and control of, and protection of workers against, health hazards due to occupational exposure to asbestos" and 31 countries had ratified the Convention, 17 of them have banned use of all forms of asbestos, including chrysotile and other countries have introduced less stringent restrictions. As of March 2008, 44 countries banned asbestos products. Sri Lanka, however, has not ratified this convention, and the use of asbestos has not been banned other than blue asbestos in which production of blue asbestos was banned in 1987 (Extraordinary Gazette Notification No. 452/4 of the Government of Sri Lanka of 06.05.1987).

TREND OF DECLINING ASBESTOS PRODUCTS IN THE WORLD

According to the United States Geological Survey, 200 million tons of identified resources of asbestos fibres have been identified with world production at approximately 2 million tons per annum with Russia, China, Kazakhstan, Canada, and Brazil as the major producers in the world. The usage of asbestos has declined in many countries as a result of increasing health concerns in the world. Some developed countries have banned or restricted, however, are engaged in exporting to other countries. On the other hand, the asbestos consumption has been increased in Asia-Pacific region, especially in China, India, Sri Lanka and Vietnam(WHO, 2014).

IMPORTATION AND ASBESTOS USAGE IN SRI LANKA

The import quantity of Asbestos raw materials from year 2000 to 2014 has been increased drastically to a total of nearly half a million metric tons (*United States Geological Survey, 2014*). In 2014, annual importation of asbestos fibres in Sri Lanka was more than 56,000 metric tons/year. The top four exporting countries were Brazil, Russia, and Kazakhstan *(Sri Lanka Customs)*. Tiles are used for the roof in 48 percent of occupied housing units, whereas the corresponding percentages for asbestos and metal sheets are 35 and 10 respectively.

This paper describes a characterization of corrugated asbestos-cement roofing sheets available in Sri Lanka and an evaluation of their radiation status. To develop this procedure, laboratory measurements were made covering all available corrugated asbestos-cement roofing sheets in Sri Lanka. After presenting the context and the data obtained in this study, the wider issues surrounding asbestos use and its health impacts can be discussed in more extensive forums.

MATERIALS AND METHODS

The collection of asbestos roofing sheets was done after the field visits to the industrial areas and selling stores of *Rhino, Sigiri, Elephant Masconite and Sri Ramco* companies. Raw fibre samples as well as asbestos products were collected from each brand name.

Each asbestos roofing sheet sample was crushed, ground, dried and sieved to 50 µm mesh in order to characterize their mineralogy qualitatively using the X- ray powder diffraction (XRD) method. The main analyses were done using the *"Rigaku- Ultima IV"* XRD machine at the Industrial Technology Institute (ITI) whereas replicate analyses were done at the Department of Chemistry at the University of Peradeniya using the *D5000Xrd* X-ray diffractometer.The detector position was recorded as the angle 2theta (2θ). The detector records the number of X-rays observed at each angle 2θ. The X-ray intensity was recorded as "counts per second". Cu ($K\alpha_1$):1.54 Å radiation and applied voltage of 40 kV with a 30 mA current was used. The scan is over the 2θ range 5° to 70° with scan rate 2.00^0 min^{-1} and sampling width 0.03° were used for qualitative analysis of fibres present in each sample. Data refinement and phase analysis were carried out using PDXL2, Xpowder12 software and ICDD data base. Qualitative analysis was carried out by comparing diffraction patterns of the samples with the patterns of the standards of the amphibole and serpentine minerals.

In order to perform radiation studies, asbestos roofing sheet samples collected by a composite sampling method named were initially broken into coarse parts using manual hammer. These parts were ground into a homogenized material of particle size and sieved by using a 250 µm sieve. All samples were dried for 24 hrs in an air circulation oven at 110^o C. Before filling the samples in to a plastic container (Diameter-8.0 cm and height-2.5 cm) the weight of each empty container and the weight after filling the containers were measured. Each sample was packed in a plastic container and sealed for a minimum of 21days before radioactive determination of Uranium and Thorium to attain secular equilibrium of parent radionuclides with their daughter products and to prevent radon loss. The gamma spectroscopy system at the Department of Nuclear Science, University of Colombo was used for the quantitative and qualitative determination of radionuclide after attainment of secular equilibrium between ^{232}Th, ^{238}U and their daughter products. The analysis was carried out at the Department of Nuclear Science, University of Colombo. The radionuclide of relevance to this work was mainly γ – ray emitting nuclei in the decay series of ^{232}Th, ^{238}U, and ^{40}K. While ^{40}K can be measured by its own γ –ray, ^{232}Th and ^{238}U are not γ -ray emitters, however,it is possible to measure γ–rays of their decay products. Decay products, Bismuth (^{214}Bi, 609.3 keV) for ^{238}U and (^{208}Tl, 583.2 keV) for ^{232}Th were used by assuming the decay series to be in secular are equilibrium. Activity concentrations of ^{40}K were measured by its own gamma rays (1460 keV).The efficiency calibration of the analyzer channels using standard sources is a procedure periodically performed for the High – Purity Germanium crystal (HPGE) detector, as in establishing the connection between the energy of the gamma radiation and the number of the channel by using Genie 2000 software. After the identification of the energy using standard sources, the efficiency value is calculated taking into account the probability of disintegration for each energy (Daraban*et al.*, 2012). The data is used for the calibration of the detector in efficiency, as in the formula below.

$A = C/\varepsilon PW$

where

A is the activity level of a certain radionuclide expressed in $BqKg^{-1}$ dry weight,

C is the net counting rate of sample subtracted from background (count per seconds),

ε is the counting efficiency of the used detector,

P is the absolute transition probability of gamma decay (abundance), and

W is the dried sample weight expressed in Kg

RESULTS

RESULTS OF X-RAY POWDER DIFFRACTION DATA

Study of X-ray diffraction patterns from unknown phases offers a powerful means of qualitative identification of mineral fibres in asbestos roofing sheets. The qualitative standard

Table 2 Principle lattice spacing of asbestiform and non-asbestiform mineral

Mineral		Principle *d* spacing (Å)			JCPDS powder diffraction file number
Serpentine Minerals	Lizardite	7.26	3.63	2.50	50-1625
	Chrysotile	7.37	3.65	4.57	21-543
		7.36	3.66	2.45	25-645
		7.10	2.33	3.55	22-1162 (theoretical)
		7.31	3.65	2.45	27-1275
Amphibole Minerals	Amosite	8.33	3.06	2.75	17-745 (non-fibrous)
		8.22	3.06	3.25	27-1170 (UICC)
	Anthophylite	3.05	3.24	8.26	9-455
		3.06	8.33	3.23	16-401 (Synthetic)
	Actinolite	2.72	2.54	3.40	25-157
	Crocidolite	8.35	3.10	2.72	27-1415 (UICC)
	Tremolite	8.38	3.12	2.70	13-437
		8.43	2.70	3.14	20-1310 (Synthetic)
		8.44	3.13	2.70	23-666 (Synthetic mixture with richterite

Table 3 Comparison of XRD results for four types of corrugated asbestos roofing sheet samples and United States Environment Protection Agency (USEPA) standard d - values of lizardite and chrysotile

Sample Name	Fibre Phase Detected	2θ	*d*, Å	USEPA Standard *d*, Å
Brand A	Lizardite	12.180^0	7.26	7.26
		24.501^0	3.63	3.63
		35.881^0	2.50	2.50
Brand B	Chrysotile	12.099^0	7.31	7.37 3.65 4.57
		24.337^0	3.65	7.36 3.66 2.45
		36.609^0	2.45	7.10 2.33 3.55
				7.31 3.65 2.45
Brand C	Chrysotile	12.099^0	7.31	7.37 3.65 4.57
		24.337^0	3.65	7.36 3.66 2.45
		36.609^0	2.45	7.10 2.33 3.55
				7.31 3.65 2.45
Brand D	Chrysotile	12.088^0	7.32	7.37 3.65 4.57
		24.310^0	3.66	7.36 3.66 2.45
		36.394^0	2.46	7.10 2.33 3.55
				7.31 3.65 2.45

XRD data of the asbestiform and non-asbestiform mineral used at United States Environment Protection Agency were obtained in order to make the comparison. The values obtained for asbestiform (chrysotile, amosite, tremolite, actinolite, anthophylite and crocidolite) and non- asbestiform mineral (lizardite) used at United States Environmental Protection Agency is shown in Table 2 with the corresponding d-values. Experiment XRD results were studied with the standard XRD *d*-values of lizardite, chrysotile and amphibole mineral phases (Table 2).

Standard diagnostic peak regions are lizardite-7.2 Å, chrysotile -7.3 Å and amphibole 8.2-8.5 Å. According to XRD data, experimental results of lizardite and chrysotile mineral phases were well compared with standard diagnostic peak regions of lizardite and chrysotile mineral phases (Table 3). Although the XRD *d*- values of standard and studied samples were similar to those of standard powder diffraction data, smaller differences in some of *d*-values were observed. Serpentine minerals such aslizardite and chrysotile were detected, whereas amosite, tremolite, actinolite, anthophylite and crocidolite were not detected in all four commercial asbestos sheet productions in Sri Lanka. Hazardous fibre such as chrysotile mineral phase was detected in all samples other than one sample in which non-hazardous lizardite was the main constituent (Fig.1).The *d* – values of the eight most intensive maxima in XRD diagram of the studied samples are accompanied by practically the same *d* – values found in the standard serpentine XRD. XRD patterns in similar 2θ ranges of four different samples have shown that chysotile is main constituent in three samples [Figs. 2 (a) and (b)].The comparison showed that the powder XRD of chysotile samples is practically identical to the standard diagram. Although the XRD patterns of powders were similar to those of standard powders, smaller differences in some of 2θ values were observed.

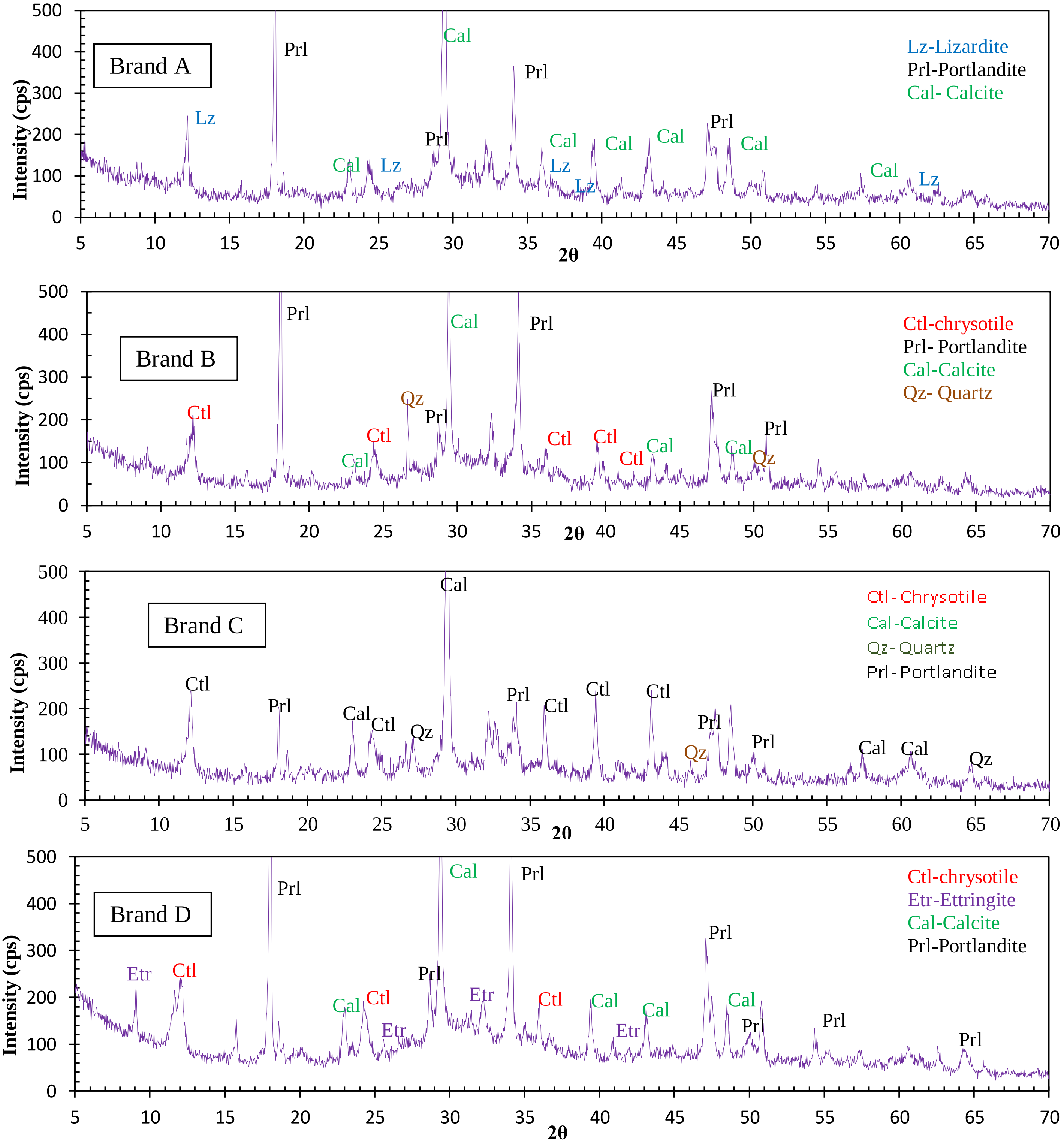

Fig. 1 X-Ray Diffraction Spectrum of Asbestos Roofing Sheets available in Sri Lanka

RESULTS OF THE RADIATION ANALYSES OF ASBESTOS

Using equation A = C/εPW& data calculations were done for the efficiency (ε) for each energy levels of uranium standard sample (RGU) (Fig.3). Sample weight and Specific Activity of Uranium standard sample are 0.169 Kg, 4940 $BqKg^{-1}$respectively.This Efficiency-Energy curve was drawn for standard RG-Uranium was used to find the activity of radionuclides gained from ^{232}Th, ^{238}U and ^{40}K decay series (Fig. 3). Results of specific activities of ^{40}K, ^{238}U and ^{232}Th of the samples of corrugated asbestos roofing sheet samples are shown in Table 4.

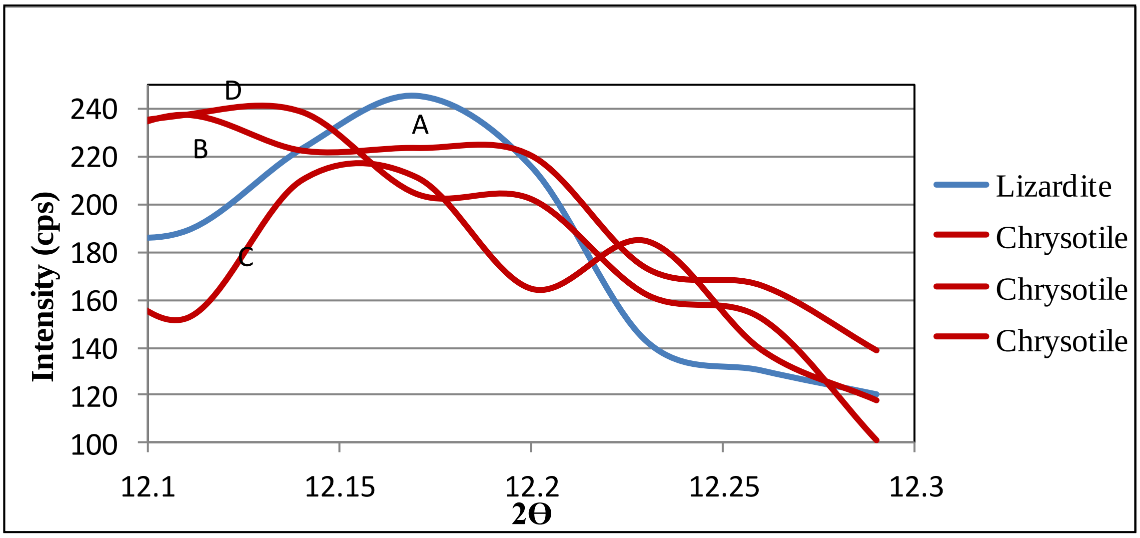

Fig. 2 (a) Comparison of XRD peaks of 2θ vs Relative intensity of all asbestos samples in 2θ range between 12.1 and 12.3

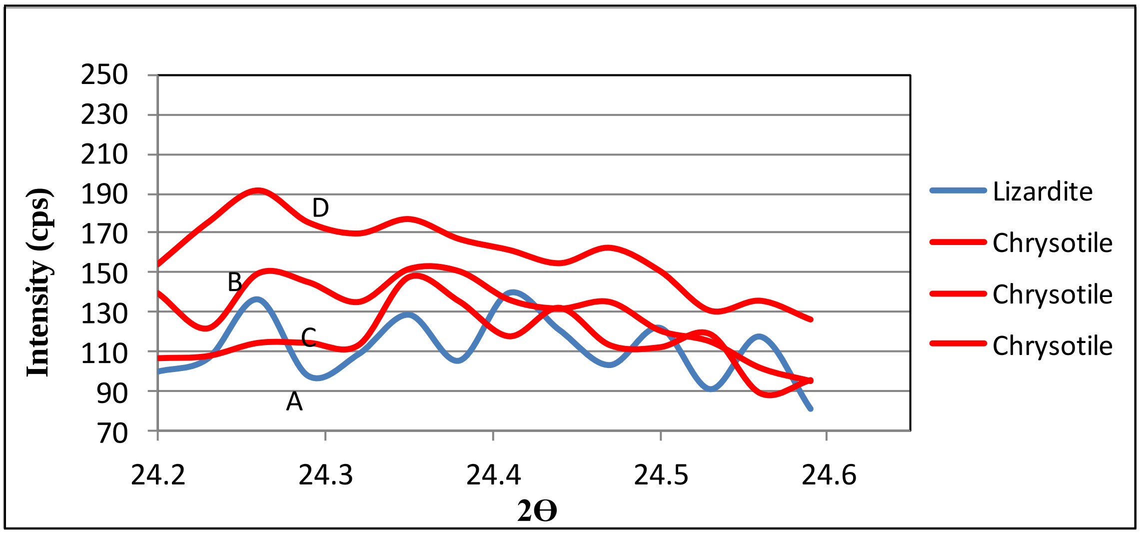

Fig. 2 (b) Comparison of XRD peaks of 2θ vs Relative intensity of all asbestos samples in 2θ range between 24.2 and 24.6

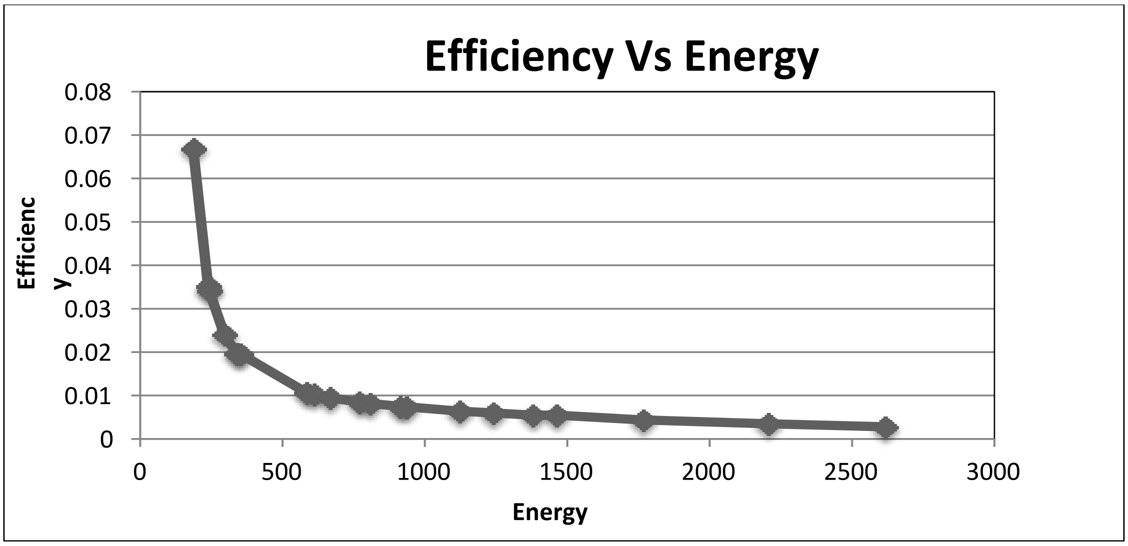

Fig. 3 Energy Vs efficiency of Uranium Standard (RGU) sample. Source: RG standard uranium International Atomic Energy Agency (2004)

Table 4 Specific activities of $^{232}Th^{238}U$ and ^{40}K in studied samples

	Brand A		**Brand B**		**Brand C**		**Brand D**	
	value	error	value	error	value	error	value	error
^{232}Th	27.21	3.06	13.54	2.08	21.98	3.00	24.55	3.15
^{238}U	17.85	2.42	15.34	2.35	14.00	2.39	24.55	3.15
^{40}K	225.46	16.09	57.42	14.21	59.11	14.63	24.55	3.15

Table 5 Radium Equivalent Activity (Ra_{eq}), Gamma index ($I\gamma$), Absorbed gamma dose in air (D_{in}), Absorbed gamma dose out in air (D_{out}), Annual indoor effective dose rate (D_{effin}) and Annual Outdoor Effective Dose Rate (D_{effout})

Sample Name	**Ra_{eq} ($Bqkg^{-1}$)**	**$I\gamma$ ($Bqkg^{-1}$)**	**D_{in} ($nGyh^{-1}$)**	**D_{out} ($nGyh^{-1}$)**	**D_{effin} ($mSvy^{-1}$)**	**D_{effout} ($mSvy^{-1}$)**
Brand A	74.16	0.27	6.82	34.10	0.03	0.04
Brand B	39.12	0.14	3.52	17.60	0.02	0.02
Brand C	49.98	0.18	4.44	22.20	0.02	0.03
Brand D	75.42	0.28	6.81	34.08	0.03	0.04
Internationally Accepted Value	**370**			**80**		**0.48**

For Brand A, the specific activities concentrations of ^{40}K,^{238}U and ^{232}Th 225.46 ± 16.09 $Bqkg^{-1}$, 17.85 ± 2.42 $Bqkg^{-1}$, 27.24 ± 3.06 $Bqkg^{-1}$ respectively. For Brand B, the specific activities concentrations of ^{40}K,^{238}U and ^{232}Th 57.42 ± 14.21 $Bqkg^{-1}$, 15.34 ± 2.35 $Bqkg^{-1}$, 13.54 ± 2.08 $Bqkg^{-1}$ respectively. For Brand C, the specific activities concentrations of ^{40}K,^{238}U and ^{232}Th 59.11 ± 14.63 $Bqkg^{-1}$, 14.00 ± 2.39 $Bqkg^{-1}$, 21.98 ± 3.00 $Bqkg^{-1}$ respectively. For Brand D, the specific activities concentrations of ^{40}K,^{238}U and ^{232}Th, 82.09 ± 19.45 $Bqkg^{-1}$, 34.27 ± 3.32 $Bqkg^{-1}$, 24.55 ± 3.15 $Bqkg^{-1}$ respectively.

Table 5 shows the Radium Equivalent Activity (Ra_{eq}), Gamma index ($I\gamma$), Absorbed gamma dose in air (D_{in}), Absorbed gamma doseout in the air (D_{out}), Annual indoor effective dose rate (D_{effin}) and Annual Outdoor Effective Dose Rate (D_{effout}). Radium Equivalent Activity of samples A, B, C, D 74.16 $Bqkg^{-1}$, 39.12 $Bqkg^{-1}$, 49.98 $Bqkg^{-1}$, 75.42 $Bqkg^{-1}$ respectively. Gamma index of samples A, B, C, D 0.27 $Bqkg^{-1}$, 0.14$Bqkg^{-1}$, 0.18 $Bqkg^{-1}$, 0.28 $Bqkg^{-1}$ respectively. Absorbed gamma dose in air of samples A, B, C, D, 6.82 $nGyh^{-1}$, 3.52 $nGyh^{-1}$, 4.44 $nGyh^{-1}$,6.81$nGyh^{-1}$respectively.

Absorbed gamma dose out in air of samples A, B, C, D, 34.10 $nGyh^{-1}$, 17.60 $nGyh^{-1}$, 22.20 $nGyh^{-1}$, 34.08 $nGyh^{-1}$respectively. Annual indoor effective dose rate of samples A, B, C, D, 0.03 $mSvy^{-1}$, 0.02 $mSvy^{-1}$, 0.02 $mSvy^{-1}$, 0.03 $mSvy^{-1}$respectively.Annual Outdoor Effective Dose Rate of samples A, B, C, D, 0.04 $mSvy^{-1}$, 0.02 $mSvy^{-1}$, 0.03 $mSvy^{-1}$, 0.04 $mSvy^{-1}$ respectively.

By using formula $y = 11.174x^{-1.065}$ from the graph (Fig. 3) and formula $A = C/\varepsilon PW$, specific activities can be calculated in the studied samples. Following equations have been used to measure Radium Equivalent Activity (Ra_{eq}), Gamma index ($I\gamma$), Absorbed Gamma Dose Out in air (D_{out}), Absorbed Gamma Dose in air (D_{in}), Annual Indoor Effective Dose Rate (D_{effin}), Annual Outdoor Effective Dose Rate (D_{effout}) of studied samples (Augustine and Aku, 2013).

The specific activity of ^{40}K, ^{238}U and ^{232}Th in studied samples could be calculated. Tables 6, 7 and 8 show the details of ^{40}K, ^{238}U and ^{232}Th for studied samples A, B, C, D respectively. This data is necessary to calculate the specific activity of the studied samples using above equation (1). The specific activity concentration

Table 6 Details of studied samples A, B, C, for Uranium (U)

Sample Name	**Energy (kevV)**	**Efficiency**	**Abundance**	**Weight (kg)**	**Samples (cps)**	**Background (cps)**	**Specific activity (Bqkg^{-1})**
Brand A	609.316	0.010	0.452	0.119	0.018	0.010	17.850
Brand B	609.316	0.010	0.452	0.125	0.017	0.009	15.340
Brand C	609.316	0.010	0.452	0.121	0.016	0.008	14.000
Brand D	609.316	0.010	0.452	0.110	0.022	0.017	34.270

Table 7 Details of studied samples A, B, C, D for potassium (K)

Sample Name	**Energy (kevV)**	**Efficiency**	**Abundance**	**Weight (kg)**	**Samples (cps)**	**Background (cps)**	**Specific activity (Bqkg^{-1})**
Brand A	1460.80	0.0055	0.107	0.119	0.029	0.015	225.460
Brand B	1460.80	0.0055	0.107	0.125	0.009	0.004	57.420
Brand C	1460.80	0.0055	0.107	0.121	0.008	0.004	59.110
Brand D	1460.80	0.0055	0.107	0.110	0.010	0.005	82.090

Table 8 Details of studied samples A, B, C, D for Thorium (Th)

Sample Name	**Energy (kevV)**	**Efficiency**	**Abundance**	**Weight (kg)**	**Samples (cps)**	**Background (cps)**	**Specific activity (Bqkg^{-1})**
Brand A	583.187	0.011	0.306	0.119	0.016	0.009	24.240
Brand B	583.187	0.011	0.306	0.125	0.013	0.006	13.540
Brand C	583.187	0.011	0.306	0.121	0.015	0.008	21.980
Brand D	583.187	0.011	0.306	0.110	0.013	0.008	24.550

of ^{232}Th was determined from gamma line of 583.187 keV from ^{208}Tl, The specific activity concentration of ^{238}U was determined from gamma line of 609.316 keV from ^{214}Bi and the ^{40}K specific activity concentration was calculated from its 1460.800 keV gamma line.

It is observed that the Ra_{eq} values for all the studied samples A, B, C, D 74.16 Bqkg^{-1}, 39.12 Bqkg^{-1}, 49.98 Bqkg^{-1} and 75.42 Bqkg^{-1} respectively, are lower than the recommended maximum value of 370 Bqkg^{-1}.Iγ $\leq$ 1 corresponds to an absorbed gamma dose rate less or equal to 1 mSv y^{-1}, while Iγ $\leq$0.5 corresponds to a dose rate less or equal to 0.3 mSv y^{-1}. The values of the gamma index (Iγ) are 0.27 Bqkg^{-1}, 0.14 Bqkg^{-1}, 0.18 Bqkg^{-1} and 0.28 Bqkg^{-1} for A, B, C, D samples respectively. It is observed that the Iγ values do not exceed the upper limit.

The calculated absorbed gamma dose out rates were 34.10 nGyh^{-1}, 17.60 nGyh^{-1}, 22.20 nGyh^{-1}, 34.08 nGyh^{-1} for A, B, C, D respectively, which was lower than the permissible level of 80 $nGyh^{-1}$. The corresponding annual effective out dose rates were calculated to be 0.04 $mSvy^{-1}$, 0.02 $mSvy^{-1}$, 0.03 $mSvy^{-1}$, 0.04 $mSvy^{-1}$for A, B, C, D samples, respectively, which were lower averages than the average annual outdoor effective dose rate of 0.46 $msvy^{-1}$. These samples are within the recommended safety limit when used as products.Based on the values of radiological parameters radiant equivalent, gamma index, absorbed gamma dose rate, annual effective out dose rate obtained in this study, all current samples considered do not pose any significant hazard.

DISCUSSION

Sri Lanka's use of corrugated asbestos roofing sheets made up of white asbestos has gone up since the restriction imposed on the usage of blue asbestos since 1987. In 1995, the first occupational patient has been diagnosed with asbestos related diseases named asbestosis and eventually he died (reports from the Central Environmental Authority of Sri Lanka). According to reports from the World Health Organization, white asbestos with chrysotile fibre also has been recognized as carcinogenic fibre (Peterson, 1991, WHO, 2014). On the other hand, around 18,000 people in Sri Lanka are annually diagnosed with cancer, without knowing its real cause. It was reported by the case studies from other countries that asbestos related cancer patients have shown an increasing trend in the recent past (e.g. Ladou, 2004;Trosic and Milkovic´-Kraus, 2004; Lim, *et al.*, 2008; Silverstein *et al.* 2009; Akira, 2010; Antonescu-Turcu and Schapira, 2010; Zen *et al.*, 2013).Therefore, this study focuses to characterize asbestos roofing sheets available in the local market in order to find out the presence of any known hazardous substances, which could lead to cardiogenic cancer in the human body.

This study revealed that a large amount of corrugated asbestos roofing sheets from three (03) out of four (04) branded companies operating asbestos roofing sheets contain some form of toxicity as it was detected the hazardous chrysotile fibre, which is identified as carcinogenic fibre.

The use of construction materials with some form of radiological contamination is known to be a matter of concern to public health because exposure over a long term even of low doses can develop cancer formations. All building raw materials and products derived from rocks contain various amounts of mainly natural radionuclides of the uranium (^{238}U) and thorium (^{232}Th) series, and the radioactive isotope of potassium (^{40}K) (Turhan, 2008). However, the corresponding annual effective dose rates in Sri Lankan corrugated roofing sheets were lower averages than the average annual outdoor effective dose rate of 0.46 $msvy^{-1}$ from the terrestrial radionuclides in the world. The calculated internal and external hazard indices in all the amount samples were less than unity. Asbestos building materials have originated from mantle derived olivine and amphibole minerals, which could lead to substitute radioactive cations. Industrial materials produced with such raw materials may also have the same level of radioactivity and could hard for human health.

CONCLUSIONS

This study has given a reader on detailed status of asbestos and its products as corrugated roofing sheets in Sri Lanka and the world trend. Hazardous fibre, namely chrysotile was detected in the three out of four large scale asbestos roofing sheet samples in Sri Lanka. The usage of corrugated asbestos sheets may be a potential hazard for human in the future in the country. The specific activity of ^{40}K, ^{238}U and ^{232}Th, the radium equivalent activity and gamma index are below the internationally accepted values. Based on the values of the radiological parameters obtained in this study, all the currently used corrugated asbestos roofing sheets, samples considered do not pose any significant radiation hazard. It is suggested to introduce to asbestos management plan and the phasing out plan with proper alternative for asbestos roofing sheets.

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