



Review of Public Safety in Some Non Governmental Medical Radiation Facilities in Bangladesh

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Abstract: The use of ionizing radiations is being greatly extended especially in medical diagnostic radiological facilities in Bangladesh. Diagnostic Radiology is the use of x-rays to investigate the structure and function of the human body. The underlying aim in radiology is to obtain the best possible diagnostic image with the least radiation exposure to concerned people. In order to ensure radiation safety of the public adequate shielding is required during operation of the x-ray machine. Therefore, to find out the adequacy of shielding of an x-ray room shielding calculation is performed by the application of National Radiological Council and Measurements (NCRP 49 & 147) concepts incorporating real data at applicable points. To perform the work thirty facilities were randomly chosen in Narayanganj district of Bangladesh. A data collection checklist was utilized during investigation of the facilities in order to accumulate the shielding calculation information. In the chosen facilities, mostly lead and brick have been found as the shielding materials for the entrance door and walls of the x-ray room respectively. The average thickness of lead used in the entrance door of x-ray facilities have been calculated 1.04 and 0.51 mm respectively based on NCRP 49 and 147 approaches. In most of the facilities, the existing thicknesses of the shielding material are found higher than the calculated values. Besides, radiation dose was measured across the existing shielding thicknesses to examine the safety of the public.

Keywords: NCRP Approach, Shielding Adequacy, Permissible Level, Shielding Material, Safety, Radiation Dose.

I. INTRODUCTION

The traditional x-ray machines have become an important tool over the years, in medical diagnosis even though many powerful imaging techniques are available these days. The use of x-ray machine is expanding as the people are becoming more and more health conscious. The trend is likely to be continued at future dates too, as the facilities are still inadequate to meet the needs of over 150 million population of the country. However, the x-ray facilities for diagnostic purposes in several third world countries are very few compared to the demand. Because of high patient workload and less preventive maintenance of the facilities, breakdowns are common and sometime even two x-ray machines are found in operation at the same room. In addition to that most of the rooms used to host x-ray facilities are not originally intended for the purposes and are often smaller than the recommended size (6m x 3m) for general purpose x-ray machines [1]. In most of the cases, the location of the x-ray machines are not optimized relative to the layout of the rooms and the real composition of building materials used to construct most walls are precisely unknown. Therefore, the issue of the radiation safety of occupational and the public are needed to be ensured by the introduction of sufficient amount of shielding in the x-ray room. In this connection, the NCRP 49 report which provides widely accepted traditional methodology for radiation shielding design [2]. These traditional techniques for designing radiation barriers may be unrealistic because the assumptions taken in shielding designing do not reflect the existing situation. It has, for example, underestimated or overestimated the scattered and leakage radiation respectively from modern x-ray units. However, the new NCRP 147 report was published to overcome the deficiencies outlined in NCRP 49 [2, 3]. The calculated shielding thickness based on NCRP 49 approach which didn't reflect the real value [4]. The current study has addressed the deficiencies found in NCRP 49 report by including real data for the workload, KVp and design dose mentioned in NCRP 147 report for controlled and uncontrolled areas. The introduction of NCRP 147 report for shielding calculation which reduces the shielding cost significantly [5]. However, in some other studies existing thickness was found even larger than the calculated one [6]. In the present study in the 73 % of the facilities, the existing thicknesses are found larger than the average thickness calculated by NCRP 147 approach.

II. MATERIALS AND METHODS

A cross sectional investigation among the 30 private facilities of Narayanganj district was carried out to collect the information which are required to perform shielding calculation for the facilities in order to evaluate the safety of the public. A data collection checklist was prepared before. Thirty facilities of the concerned areas were randomly selected. The checklist mainly includes machine specification, machine location, number of patients studied per day, thickness of aluminum filter, room size, distance from tube to patient bed, wall, door etc, status of control panel barrier, entrance door, wall thickness, attenuated dose, unattenuated dose etc. Radiation doses were recorded at different locations by using radiation dose rate meter. Shielding calculations were done by using NCRP approaches 49 and 147. For radiation dose rate measurements a gas filled radiation monitor was utilized during investigation of the facilities. Before use, this equipment was calibrated in Secondary Standard Dosimetry Laboratory of Atomic Energy Research Establishment, Savar, Dhaka. Radiation dose rate were measured at different points of the 24 facilities to assess the safety of the public. Radiation facilities have been identified in the table by putting code number NFC.

III. RESULTS AND DISCUSSION

Generally lead was found as a shielding material in the entrance doors of x-ray facilities and its average thickness was recorded 0.87 mm. However, the non uniform thicknesses of lead were also found in some of the facilities of the Narayanganj district. Based on the approaches NCRP 49 and NCRP 147, the average lead shielding for entrance door were estimated in the work 1.04 and 0.51 mm respectively as shown in Table 1. The thickness calculated by NCRP 147 is significantly lesser than the NCRP 49 approach. The barrier thicknesses calculated by different approaches are shown in (Table1).

Table 1: Existing and calculated thickness of shielding material at entrance door (ED)

Facilities Code	Distance from scatterer to ED (dsec) in m	Existing shielding material thickness in mm(lead)	Average of existing material thickness in mm	Calculated thickness in mm (lead) As per NCRP 49	Average of calculated thickness in mm(lead)	Calculated thickness in mm (lead) as per NCRP 147	Average of calculated thickness in mm(lead)
NFC-01	2.82	1mm	0.87	0.76	1.04	0.43	0.51
NFC-02	1.7	0.5mm		0.89		0.69	
NFC-03	2.38	1mm		1.02		0.35	
NFC-04	1.6	1mm		1.38		0.45	
NFC-05	2.08	1mm		0.72		0.85	
NFC-06	1.57	1mm		0.71		0.46	
NFC-07	2.26	1mm		1.3		1.1	
NFC-08	3.12	1mm		0.9		0.22	
NFC-09	1.72	0.5mm		0.92		0.5	
NFC-10	1.4	1mm		0.81		0.7	
NFC-11	2.41	1mm		1.22		0.5	
NFC-12	3.02	1mm		1.23		0.34	
NFC-13	2.08	1mm		1.08		0.58	
NFC-14	1.55	0.5mm		1.42		0.75	
NFC-15	2.1	1mm		1.21		0.41	
NFC-16	2.92	1mm		1.77		0.64	
NFC-17	2.13	1mm		1.65		0.57	
NFC-18	1.93	1mm		1.08		0.37	
NFC-19	3.05	1 mm		0.73		0.21	
NFC-20	2.43	0.5mm		0.83		0.43	
NFC-21	2.13	0.5mm		0.68		0.27	
NFC-22	1.67	0.5mm		1.01		0.77	
NFC-23	1.22	1 mm		1.27		0.68	
NFC-24	3.45	0.5mm		0.53		0.15	
NFC-25	1.95	1 mm		0.85		0.39	
NFC-26	1.37	1 mm		1.47		0.82	
NFC-27	1.54	1 mm		1.35		0.55	
NFC-28	3.3	1mm		0.77		0.3	
NFC-29	2.49	1mm		1.1		0.42	
NFC-30	2.44	0.5mm		0.44		0.3	

The shielding thickness required for scattered radiation according to national standard is 2 mm of lead which is found significantly higher value in this study that has been verified by measuring radiation dose rate across the facilities [1]. The measured dose rates are shown in Table 2. In some facilities dose rate couldn't be measured due to power failure. The door shielding in the 30 % facilities were not sufficient according to Nuclear Safety and Radiation Control (NSRC) Rules'97 as a result public receive more radiation doses than the permissible level ($0.5\mu\text{Sv/h}$) [7]. On the other hand, the walls of x-ray room in the 17 % of the facilities were not in proper thickness to ensure the safety of the public. Fig. 1 shows a comparison of the calculated shielding with the existing shielding of the facilities. The shielding for primary and secondary barriers calculated by NCRP 49 is higher than the existing shielding of the facilities. NCRP 147 approach leads to smaller value of shielding thickness for the primary and the secondary barriers (control panel and entrance door) compared to existing one. This means that the occupational and public are safe in most of the facilities of Narayanganj district since NCRP 147 approach is a more realistic approach for shielding calculation. However, for the confirmation of 100 % safety of the public in the x-ray facilities still significant improvement is required from the present status. During calculation of barrier thickness by using NCRP 49, the entire workload is considered at a single kVp, 1000 mA min wk^{-1} at 100 KVp. This may cause over estimation in the barrier thickness calculation. The penetration of radiation through barrier varies exponentially with KVp [8]. Therefore, for shielding design KVp is more vital than the workload. In the present study real workload is considered for NCRP approach for example 70 KVp is utilized. Still it results in overestimation in thickness calculation. This is because in the diagnostic radiology a wide range of x-ray potentials is utilized. Apart from this, the limitations of NCRP 49 approach are quite a lot such as the design dose P is considered to 0.02 mSv/week for public exposure, use factor 1 and occupancy factor 1. In the NCRP 147 approach more realistic value of design dose P, use factor U and Occupancy factor T are assumed to 0.02 mSv/week, 1 and 0.5 respectively and the reasonable workloads are utilized. The recommended workloads for NCRP 147 in the earlier study were 240 mA min wk^{-1} for an average and 320 busy radiography room respectively [4]. These values are still higher in practice. In the present study average workload is estimated less than 150. However, according to Table 1, the average calculated thickness by NCRP 147 is 0.51mm which is almost half of the value obtained by NCRP 49 (1.04 mm lead). According to NCRP 147 approach the calculated value was found reasonably smaller by considering radiation attenuation caused by patient, image receptor for the primary beam [6]. The door thicknesses in the 30 % of the facilities for the secondary radiation are almost same by the both approaches. According to Table 2, for about 70% of the facility's entrance door with average shielding thickness of 0.87 mm are adequate for controlling of public exposure. On the other hand, for the wall it is 83 %. In Bangladesh, the permissible limit for public exposure is 1 mSv per year as per national regulations [7]. Therefore, the acceptable radiation dose limit for the public is $0.5\mu\text{Sv/h}$.

Table 2: Measurement of external dose rate in the x-ray facilities

Facilities Code	Dose rate at ED in $\mu\text{Sv/h}$	Percentage of facilities emit exposure through ED more than permissible level	Dose rate outside the wall in $\mu\text{Sv/h}$	Percentage of facilities emit exposure through wall more than permissible level	Permissible limit of exposure for public as per national requirements in $\mu\text{Sv/h}$
NFC-01	0.8	30%	0.6	17%	0.5
NFC-02	0.25		0.25		
NFC-03	120		0.25		
NFC-04	0.25		0.25		
NFC-05	0.5		0.25		
NFC-06	N/A		0.25		
NFC-07	0.5		N/A		
NFC-08	N/A		N/A		
NFC-09	0.25		0.25		
NFC-10	20		N/A		
NFC-11	N/A		N/A		
NFC-12	0.5		0.25		
NFC-13	0.6		0.25		
NFC-14	0.25		0.25		
NFC-15	0.2		0.2		
NFC-16	20		N/A		
NFC-17	0.25		N/A		
NFC-18	0.25		0.25		
NFC-19	0.25		10		
NFC-20	0.2		0.8		
NFC-21	8		0.25		

NFC-22	180		0.25		
NFC-23	0.25		0.25		
NFC-24	0.25		0.25		

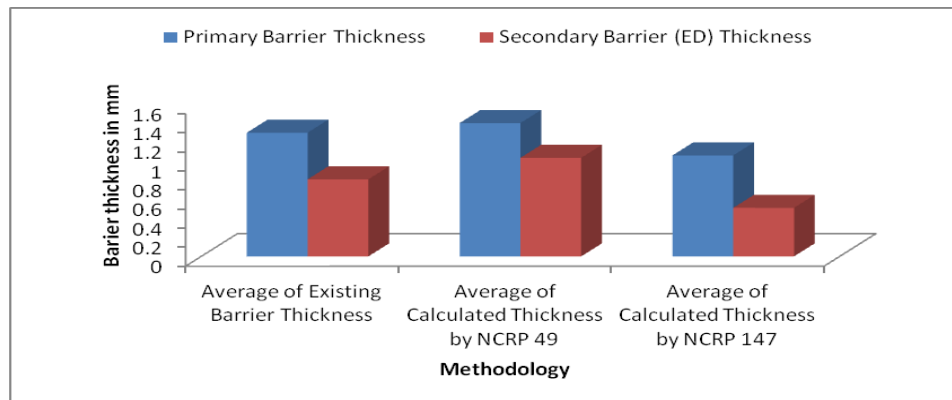


Figure 1: Comparison of existing and calculated thickness of x-ray facilities in Naryanganj District

According to the Table 1, 30 % of the entrance doors of the facilities are not adequately shielded to protect the radiation hence to ensure safety of the public. From these facilities, the public are receiving more radiation dose than their acceptable limit ($0.5 \mu\text{Sv/h}$). Outside the wall of the x-ray room the average dose received by the public is $0.70 \mu\text{Sv/h}$. According to the national requirements the recommended thickness for door shielding is 2 mm of lead and the thickness for brick wall is 10 inch. In this work, this recommendation has been found overestimated which is found even higher than the value calculated NCRP 49 approach.

IV. CONCLUSION

According to dose rate measurement the door shielding of about 70 % facilities and the shielding of brick wall in the 83 % facilities are safe for the public. The rest of the facilities required considerable improvement for their shielding status in order to ensure public and environmental safety. Although x-ray is a very powerful tool in modern medical diagnosis, but its useful uses may cause a great biological radiation hazard to human body. Therefore, the radiation exposure to the concerned people should not exceed the limit according to the national and international standard [7, 9]. Each x-ray installation should be provided with adequate shielding arrangements. Even though the dose rates recorded in the most of the facilities are within the regulatory limit, it doesn't still make sense until 100% of facilities would become safe for the public and other concerned parties. Additionally, the result of radiation dose measurement might have been more accurate if it could have been accomplished by introducing TLD badges including more facilities for longer period of time. Therefore, the barrier thicknesses have been evaluated in this work by applying NCRP approach is still influencing the calculation to be performed involving more realistic values considering national aspects from which more reasonable shielding thickness can be estimated in order to ascertain the radiation safety of the public.

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