



CHAPTER -04

ENVIRONMENTAL SAFETY AND OCCUPATIONAL EXPOSURES



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The protection of occupational worker, public and the environment is ensured through dose limitation as prescribed by AERB in its Directive No. 01/2011 under Rule 15 of the Atomic Energy (Radiation Protection) Rules, 2004. These dose limits are in line with the international standards and practices.

Environmental safety in the vicinity of nuclear installations is ensured through control on radioactive effluent discharges into the environment and elaborate environmental surveillance around the facility. These radioactive discharges are mainly in the form of liquid and gaseous radioactive effluents released during the operation of the facility. Solid waste disposal is further controlled by safe management of solid radioactive wastes and its final disposal in Near Surface Disposal Facility (NSDF). AERB issues authorization under the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 w.r.t. the volume and activity content of the radioactive effluents. AERB has also specified the requirements for safe management of radioactive wastes through AERB Safety Code titled 'Management of Radioactive Waste' (AERB/SC/RW) and has issued several guides thereunder providing guidance on various aspects to meet the requirements of the Code.

The Code is also applicable to the management of radioactive waste containing chemically and biologically hazardous substances, even though other specific requirements may additionally be applicable as per relevant standards.

4.0 Observance of Dose Limits

The exposure control consists of application of primary dose limits, action levels such as investigation level and operational restrictions. Operational restrictions are established based on dose, dose rate, air activity and surface contamination levels etc., at workplace such that the exposure of workers does not exceed the applicable dose limits. Individual exposures exceeding the investigation levels are investigated and reported to AERB. All cases of exposures exceeding the annual limits are reviewed by AERB Committee on Excessive Exposures.

The estimated dose to the members of the public due to discharge of radioactive effluents from all radiation and nuclear facilities at a site shall not exceed an effective dose of 1 mSv in a year taking into account local and regional sources as well. This is ensured through control on effluent discharges and solid waste disposal within authorised limit.

4.1 Authorised Limits of Environmental Releases/Discharge

The discharge of radioactive waste from licenced facilities is governed by the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987. It is mandatory for each licenced nuclear facility to obtain authorization under these rules from the Competent Authority for disposal of radioactive wastes and file a return annually to AERB indicating the actual quantity of radioactive waste discharged.

The operating data shows that releases from NPPs have been a small fraction of the specified release limits.

4.2 Environmental Safety

AERB has further specified limits on effluent discharges through gaseous and liquid routes in the Technical Specifications for operation of

It is seen that the effective dose to public around all NPP sites is far below the annual limit of 1 mSv (1000 μ Sv) prescribed by AERB.

NPPs to ensure radiation dose to the members of the public at a site shall not exceed annual limit of 1 mSv (i.e. 1000 μ Sv). The radionuclide specific dose constraint is small fraction of the annual dose limit of 1000 μ Sv to the public. While specifying these constraints, it is ensured that the discharge is controlled within public exposure limit following the principles of "As Low as Reasonably Achievable" (ALARA).

Periodic reports including information on effluent discharges are submitted by the plant sites to AERB in prescribed forms. AERB also conducts regulatory inspection of these plant sites to verify

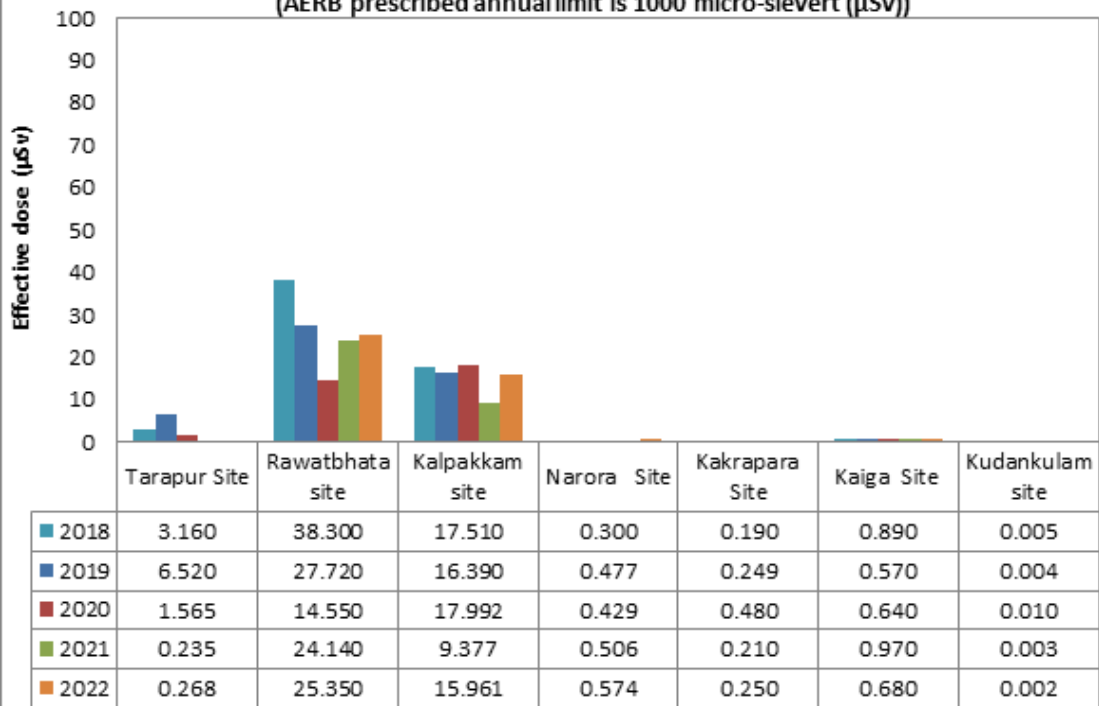
compliance with the laid down requirements. Every five years, prior to renewal of Licence for operation of these facilities, the adequacy of waste management arrangements, effluent release and their impact on the environment are thoroughly reviewed.

Environmental Survey Laboratories (ESLs) of the Health, Safety and Environment Group (HS&EG), BARC, carry out environmental surveillance at all the operating NPP Sites. The liquid and gaseous radioactive wastes discharged to the environment during the year 2022 from the operating units were only a small fraction of the prescribed technical specification limits.

Radiation dose to members of the public near the operating plants is estimated based on gaseous release and measurements of radionuclide concentration in items of diets, viz. vegetables, cereals, milk, meat, fish etc. and through intake of air and water. It is seen that the effective dose to public around all NPP sites is a small fraction of annual limit of 1 mSv (1000 μ Sv) prescribed by AERB.

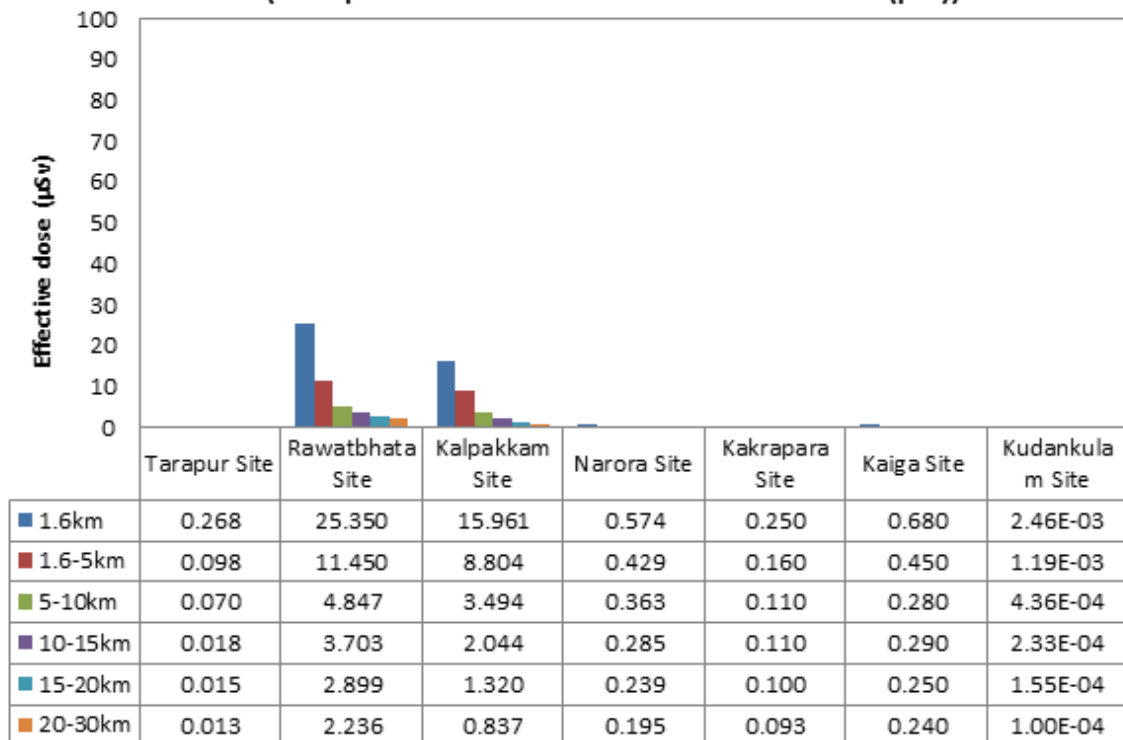
The effective doses to the members of the public (hypothetical person from Year 2018 to 2022) due to the release of radioactive effluents from the plants are presented in the Figures 4.1 (a) and 4.1 (b).

Fig-4.1 (a): Public dose at 1.6 km distance for Nuclear Power Plants during the year 2022
(AERB prescribed annual limit is 1000 micro-sievert (μSv))



Note: 1. Public dose at Rawatbhata and Kapakkam sites are relatively higher as compared to other reactor sites due to release of Ar-41 from RAPS-2 and MAPS.
2. 1.6 km boundary for KGS site is located at 2.3 km.

Fig-4.1 (b): Total Effective Dose in different Zones during the Year 2022
(AERB prescribed annual limit is 1000 micro-sievert (μSv))



Note: 1. Public dose at Rawatbhata and Kapakkam sites are relatively higher as compared to other reactor sites due to release of Ar-41 from RAPS-2 and MAPS.
2. 1.6 km boundary for KGS site is located at 2.3 km.

4.3 Occupational Exposures

4.3.1 NPPs and Nuclear Fuel Cycle Facilities

In each NPP and Nuclear Fuel Cycle Facility, a Radiological Safety Officer (RSO) and alternate RSO are designated by the Competent Authority for effective implementation of the radiation protection programme. The RSOs are entrusted with the responsibility for providing radiological monitoring of workplace, plant systems, personnel and effluent monitoring; carrying out exposure control; exposure investigations; and analysis & trending of radioactivity in plant systems.

All NPPs & Nuclear Fuel Cycle Facilities have established radiological surveillance programme and work procedures to effectively control and manage the occupational exposures within prescribed limits and ALARA. AERB Safety Manual on 'Radiation Protection for Nuclear Facilities' (AERB/NF/SM/O-2 (Rev.4), 2005) specifies Dose Limits for occupational radiation workers. As per AERB Directives, for an occupational radiation worker, annual effective dose limit is 30 mSv, with the condition that it should not exceed 100 mSv

in a span of 5 years. The specified annual effective dose limit for radiation exposure of temporary worker is 15 mSv.

For better exposure control, individual cases are investigated and controlled at an early stage so as to remain within the AERB specified dose limits. The following Investigation Levels (ILs) are applicable to the nuclear facilities.

External + Internal Exposure

Monitoring Period	Exposure Level
1 month	10 mSv
3 months	15 mSv
1 year	20 mSv

The information on radiation dose received by workers in NPPs and Nuclear Fuel Cycle Facilities during the year 2022 is given in Table 4.1 and 4.2 respectively. In the year 2022, there was no case of individual radiation exposure above the prescribed annual dose limit. Figure 4.2 gives collective dose (Person-Sv) for operation and maintenance of NPPs for last 5 years.

Table 4.1: Radiation Doses Received by Workers in Nuclear Power Plants for the Year 2022

NPP	Number of Monitored Persons	Average Dose for Monitored Person (mSv)	Number of Persons Received Dose	Average Dose Among Dose Receivers (mSv)	Number of Workers Received Dose in the Range	
					< 20 mSv	>20 mSv
TAPS-1&2	1,010	1.17	665	1.77	1,010	NIL
RAPS-1&2	1,215	1.51	884	2.07	1,215	NIL
MAPS-1&2	1,001	0.75	775	0.98	1,001	NIL
NAPS-1&2	1,360	1.45	1,136	1.74	1,360	NIL

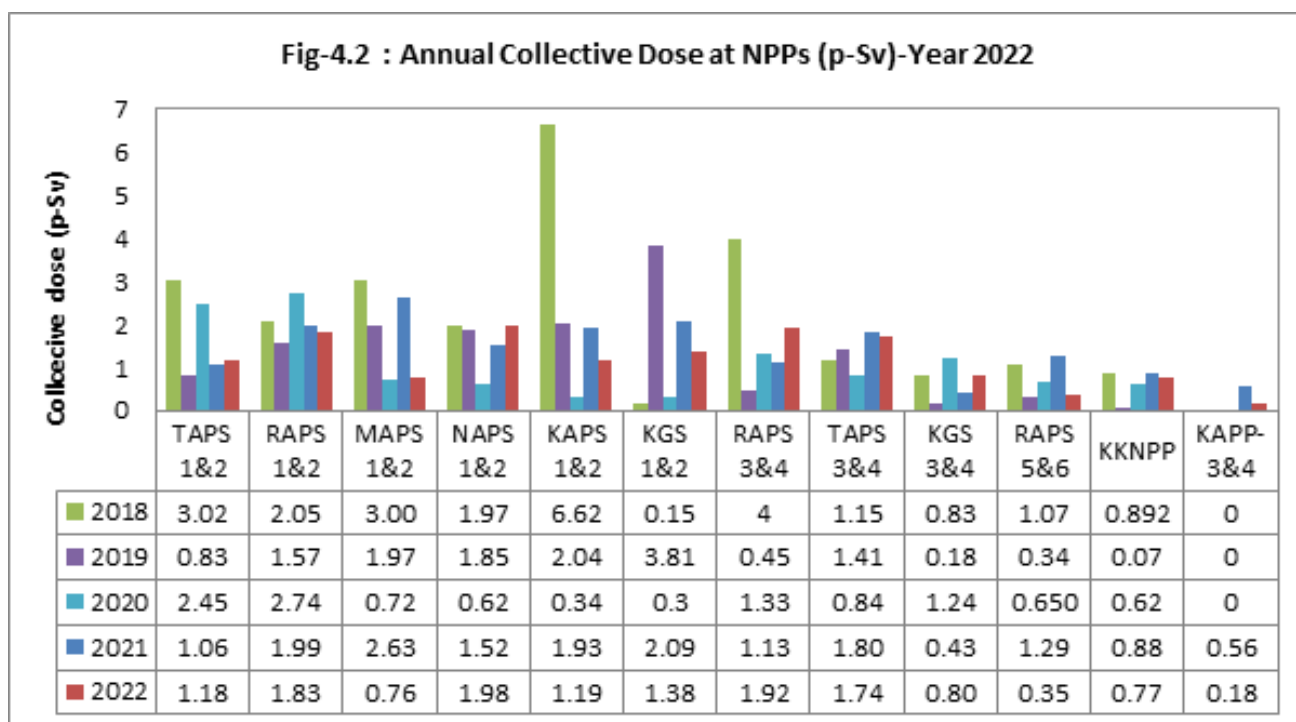
NPP	Number of Monitored Persons	Average Dose for Monitored Person (mSv)	Number of Persons Received Dose	Average Dose Among Dose Receivers (mSv)	Number of Workers Received Dose in the Range	
					< 20 mSv	>20 mSv
KAPS-1&2	1,147	1.04	741	1.61	1,147	NIL
KGS-1&2	1,239	1.11	940	1.46	1,239	NIL
RAPS-3&4	1,201	1.60	904	2.12	1,201	NIL
TAPS-3&4	1,312	1.33	971	1.80	1,312	NIL
KGS-3&4	1,207	0.66	733	1.09	1,207	NIL
RAPS-5&6	1,022	0.35	576	0.62	1,022	NIL
KKNPP-1&2	2,380	0.32	668	1.15	2,380	NIL
KAPP-3&4	2,085	0.09	501	0.37	2,085	NIL
Total	16,179	-	9,494	-	16,179	NIL

Table 4.2: Radiation Doses Received by Workers in Front End Fuel Cycle Facilities for the Year 2022

Type of facilities	Location	Number of Persons Received Dose	Average Dose Among Dose Receivers (mSv)	Maximum Dose Among Dose Receivers (mSv)	No of Workers received Dose in the range		
					<20 mSv	20-30 mSv	>30 mSv
Uranium Mines (UCIL)	Jaduguda	656	4.76	9.13	656	NIL	NIL
	Bhatin	28	2.19	3.58	28	NIL	NIL
	Narwapahar	876	3.87	6.35	876	NIL	NIL
	Bagjata	413	2.46	6.32	413	NIL	NIL
	Banduhurang	359	2.16	3.04	359	NIL	NIL
	Mohuldih	312	4.14	6.96	312	NIL	NIL
	Turamdih	583	2.78	4.76	583	NIL	NIL
	Tummalapalle	1986	4.94	10.08	1986	NIL	NIL
Uranium Mill (UCIL)	Jaduguda	852	1.48	4.17	852	NIL	NIL
	Turamdih	916	1.52	4.58	916	NIL	NIL
	Tummalapalle	791	0.50	1.71	791	NIL	NIL

Type of facilities	Location	Number of Persons Received Dose	Average Dose Among Dose Receivers (mSv)	Maximum Dose Among Dose Receivers (mSv)	No of Workers received Dose in the range		
					<20 mSv	20-30 mSv	>30 mSv
Thorium Mines and Mills (IREL)	Chavara	58	0.27	3.83	58	NIL	NIL
	Udyogamandal	159	0.785	7.47	159	NIL	NIL
	Manavalakurichi	168	1.44	10.6	168	NIL	NIL
	OSCOM	501	3.57	14.87	501	NIL	NIL
Fuel Fab. (NFC)	Hyderabad	1285	0.74	8.32	1285	NIL	NIL
	Total	9943	2.87	14.87	9943		

Fig-4.2 : Annual Collective Dose at NPPs (p-Sv)-Year 2022



4.3.2 Radiation Facilities

In each Radiation facility, a Radiological Safety Officer(s) (RSO) is designated by employer and approved by the Competent Authority. The RSO is entrusted with the responsibility for providing radiological surveillance and safety support functions. These include radiological monitoring

of workplace & personnel, effluent monitoring (in handling of open sources), excessive exposure investigation etc.

The radiation doses received by workers in medical, industrial and research institutions for year 2022 are given in Table 4.3.

Table 4.3: Radiation Doses Received by Workers in Medical, Industrial and Research Institutions for the Year 2022

Category of Radiation Worker	No. of Monitored Persons	Average Dose for Monitored Persons (mSv)	No. of Persons Received Dose	Average Dose among Dose Receivers (mSv)	No. of Workers Received Annual Individual Dose excluding Zero Dose (mSv)				No. of Persons who Received Cumulative Dose > 100 mSv during 5-Year Block (2017 to 2021)
					0<D≤20	20<D≤30	30<D≤50	D>50	
Diagnostic X-rays	1,62,003	0.25	44,271	0.91	44,224	42	3	2	17
Radiation Therapy	16,730	0.14	3,742	0.64	3,741	1	0	0	0
Nuclear Medicine	2,829	0.54	1,349	1.14	1,346	3	0	0	0
Industrial Radiography	8,523	0.26	1,672	1.32	1,681	1	0	0	6
Radiation Processing Facility	540	0.18	95	1.02	95	0	0	0	0
Research	4,217	0.12	772	0.64	771	1	0	0	0
Total	1,94,842	0.24	51,911	0.90	51,858	48	3	2	23

For better exposure control, individual cases are investigated and controlled at an early stage so as to remain within the AERB specified dose limits. However, any person exceeding 10 mSv in a monitoring period is investigated to establish the root cause, work practice and assignment of dose.

4.4 Initiatives Taken by AERB for Dose Reduction

4.4.1 Review of Radiation Protection Aspects during Project Stage

During design and commissioning stages, it is

ensured that an elaborate radiation monitoring system comprising of area radiation monitors, process monitors, environmental monitors and effluent monitors are in place. This enables to retrieve history, trend and instantaneous readings of the parameters for exposure control.

4.4.2 Operation Phase

Radiation protection programme during the operation of facility is periodically revised by the facility which is subsequently reviewed and approved by AERB. This programme comprises of organizational, administrative and technical elements. ALARA measures are put in place for

exposure control of the plant personnel and the public. AERB reviews arrangements made by plant management for implementation and effectiveness of the radiation protection programme. RSO for each Nuclear Facility is authorized by AERB, who carries out radiological safety functions.

The environmental surveillance programme is also reviewed to evaluate the impact of operation of the NPP on the surrounding areas of the plant site and to ensure that effluent releases and public exposures are below the regulatory limits.

4.4.3 Collective Radiation Dose Budgeting

Collective Dose Budget (CDB) is prepared by each facility annually on the basis of jobs (having potential of radiation exposures) that are likely to be executed, anticipated collective dose in these jobs, collective dose consumed in the previous years as well as the existing radiological conditions, benefits accrued by design improvements, identification of improvements based on operating experience and corrective actions taken etc. The aim is to optimize the collective dose through ALARA principle. AERB carries out review of the CDB. Dose incurred in any unplanned activity is to be recorded as unanticipated dose which is discussed for justification prior to approval of the same by AERB.

4.4.4 Review of Radiological Safety Aspects

Routine quarterly and annual reports on radiological safety aspects are prepared by the RSO of the facility and periodically submitted to AERB. These reports are reviewed at AERB and necessary corrective measures as required for

exposure control are recommended to respective facility. In addition, exposure investigation reports, significant event reports (radiological aspects) are also reviewed and corrective actions are recommended. The compliance to radiological safety aspects are also verified through routine inspection and special inspections.

4.4.5 Exposure Control and Implementation of ALARA

AERB ensures that all nuclear facilities have radiation safety programmes and work procedures intended to control the occupational exposures. Exposures to Site personnel are controlled by combination of radiation protection measures such as:

- i. All NPPs and nuclear fuel cycle facilities have ALARA Committees at Station and sectional level. Periodic ALARA reviews are conducted at the NPPs to identify areas for dose reduction and to implement corrective actions.
- ii. The operating experiences on radiological events at NPPs in India and in other countries are reviewed and the lessons learned are communicated to all concerned.
- iii. Programme of collective dose budgeting.
- iv. Restricting the external exposure by means of shielding, remote operation, source control, rehearsing the work on mock-ups and minimizing the exposure time.
- v. Minimizing the internal exposures by source control.
- vi. Periodic review of radioactive work practices.
- vii. Periodic training of radiation workers on radiation protection aspects, and
- viii. Trending and analysis of radiological data.