Remediation Strategies for Radioactive Contamination of Agricultural Environment toward Food Safety in Pakistan

Ihsanullah, PhD
NIFA/PAEC
Pakistan

Remediation of Radioactive Contamination in Agriculture

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History - PAEC

- Since 1956, Pakistan a conspicuous example of benefit of nuclear technologies for agriculture, engineering, medicine
- On 28 May 1998, Pakistan conducted first nuclear tests.
- In 2001, PAEC's focused back to peaceful research.
- PAEC is responsible for construction & proper operational function of the commercial NPP.
- PAEC's plans - NPP with a capacity of ~8800MW by 2030.
- Under this policy, KANUPP and CHASHNUPP power plants expanded/under construction.
- Pakistan signed the International Convention on Nuclear Safety in 1994 to establish an independent, PNRA.

Pakistan - NPPs

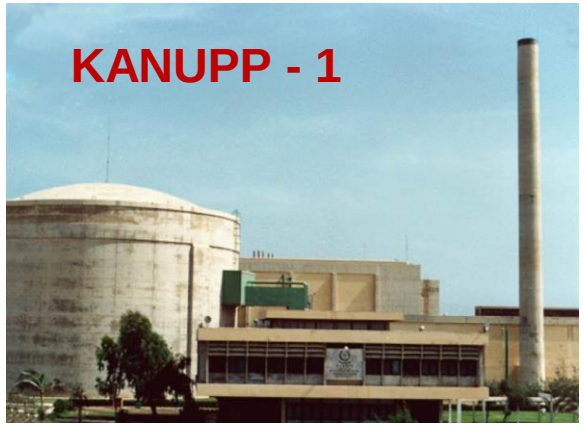
Research Reactors – PINSTECH

PARR-1 - Utilize Low-Enriched Uranium

PARR-2 - Utilize High-Enriched Uranium

Karachi Nuclear Power Plant (KANUPP) – Unit 1

KANUPP is Pakistan's first nuclear power plant, November 28, 1972, 137 MW



Chashma Nuclear Power Plants Unit-1 & Unit-2

C-1 and C-2 are 2 x 325 MW pressurized water reactors (PWR)

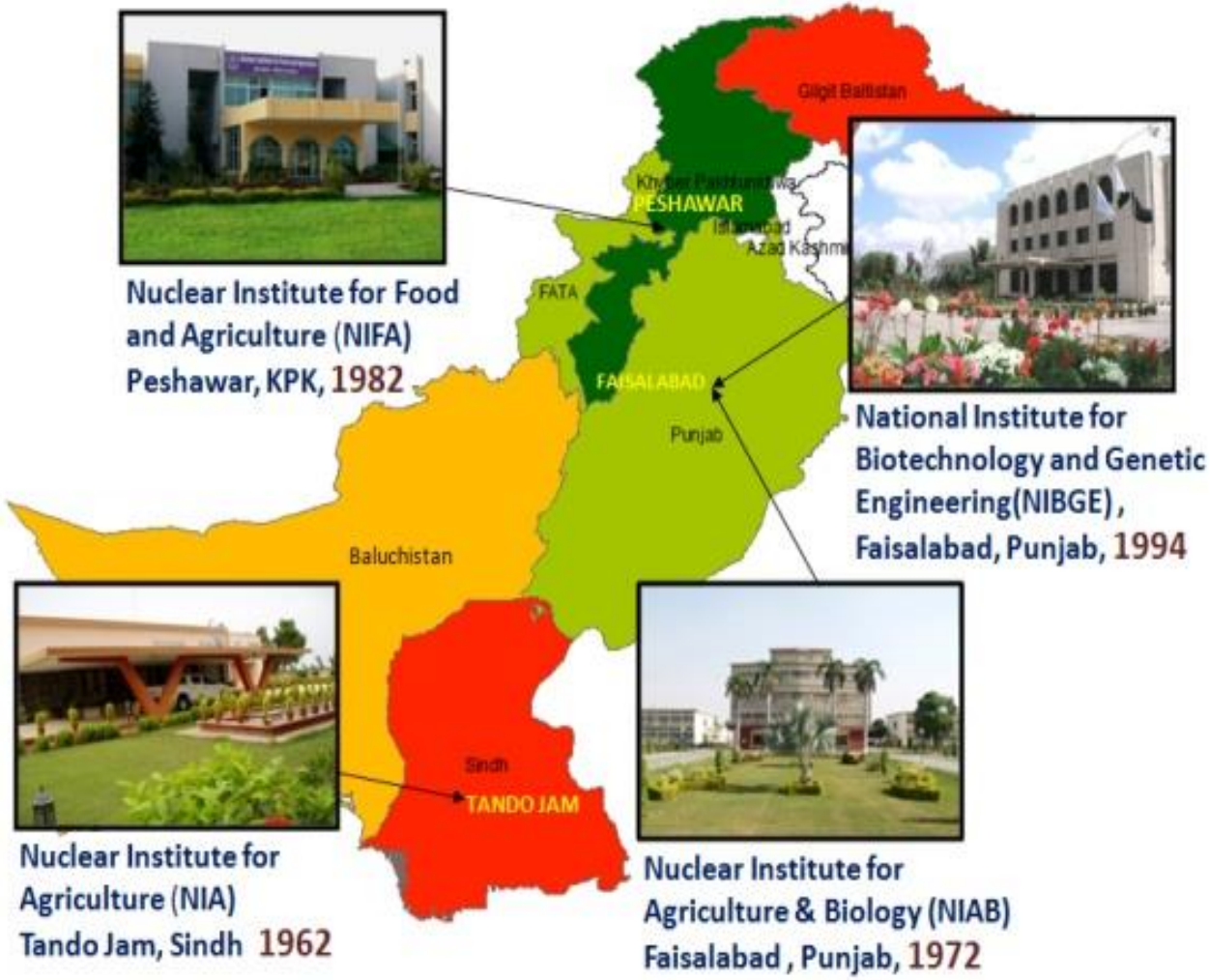
Chashma Nuclear Power Project Unit-3 & Unit-4

C-3 and C-4 are 2 x 340 MW pressurized water reactors (PWR) with a design life of 40 years. Both plants are under construction.

Karachi Nuclear Power Project Unit-2 & Unit-3

K-2 and K-3 are 2 x 1100 MW PWRs. Groundbreaking of K-2 and K-3 at Karachi near KANUPP was performed on November 26, 2013.

PAEC Agriculture & Biotechnology Institutes



PAEC Nuclear Medical Centers

Lessons Learnt from accidents

- On 26th April 1986, one of the four graphite reactors at Chernobyl, resulted in the increase of radioactive contamination at a global level.
- Interim International Radionuclide Action Levels for Food (IRALF) were introduced in an expert consultation organized at FAO Headquarters, Rome in December 1985.
- To avoid undesirable exposure to public, Pakistan like other countries imposed radioactive contamination levels on food items, The gazette of Pakistan, PNSRP Regulations, 1990.
- Radioactive materials released during the accident at Tokyo Electric Power Company's (TEPCO) Fukushima Dai-ichi Nuclear Power Plant (F1NPP) in March 2011, contaminating soil, green leafy vegetables and fresh milk.
- ~ 22% of radionuclides released deposited on land.
- A low level environmental laboratory with modern counting systems set up at PINSTECH, used for the measurement of various radionuclides.

Table 2: Program of the Gamma Spectrometric Analysis of Environmental Samples

S. No.	Nature of sample	Frequency of sampling	Sample size/ Volume	Sample collection Method	Technique of Analysis
1	Air borne particulates	Continuous (Filter change every week)	67,000 m^3 of air	Filtration through polystyrene filter medium	Computer based high resolution Ge (Li) gamma spectrometry
2	Seasonal vegetables	Biannual	5 kg	Purchased from local market	NaI (T1) Scintillation gamma spectrometry (after ashing samples)
3	Meat, poultry fish	Biannual	3-4 kg	Purchased from local market	NaI (T1) Scintillation gamma spectrometry (after ashing samples)
4	Wheat	Annual	1-2 kg	Purchased from suburban localities	NaI (T1) Scintillation gamma spectrometry (after ashing samples)
5	Prepared Meal	Monthly	2 meals	Procured from PINSTECH Cafeteria	NaI (T1) Scintillation gamma spectrometry (after ashing samples)

Table 3: Radiation levels in powder milk samples.

Date of Sampling	Sample name or Code No.	Bq / kg	
		Cs-137	Cs-134
14.7.87	Powder Milk HP-I	29.5	13.2
14.7.87	Powder Milk HP-II	38.2	22.2
20.1.89	Powder Milk IGM 466/897	5.0	-
20.1.89	Powder Milk IGM 466 Index-20	59.4	-
21.1.89	Powder Milk HP-I	83.8	-
30.1.89	Powder Milk DNSRP-I	35.5	-
30.1.89	Powder Milk DNSRP-54 (14)	31.2	-
30.1.89	Powder Milk DNSRP-5(28)	4.6	-
6.3.89	Powder Milk IMP/7588/89	30.8	-
6.3.89	Powder Milk IGM/25571/88, Index-20	20.4	-
20.1.90	Powder Milk IGM 466/89	13.0	-
20.1.90	E.H.Q. Karachi Powder Milk	53.0	-
13.3.90	Skimmed Milk Powder Code No.B/E17664	17.5	-
1.9.90	Milk powder spray	22.0	-
29.10.90	Powder Milk A	51.6	-
11.11.90	Powder Milk CIL/1	16.0	-
11.11.90	Powder Milk CIL/2	5.0	-

Table 4: Concentration of ^{99}Tc in environmental samples using ICP-MS.

Sample	Location	Date of sampling month/yr	Dry wt taken (gms)	^{99}Tc activity Bq g^{-1}(dry weight) ± S.D.
Fucus vesiculosus	Colwyn Bay	9/89	24	0.74 ± 0.05
	Ravenglass	10/89	25	10.18 ± 0.53
	Whitehaven	10/89	23	1.98 ± 0.06
	Sandyhill	10/89	24	1.78 ± 0.09
	Ettrick Bay	4/90	25	0.49 ± 0.04
	Tongue	4/90	24	0.14 ± 0.02
	Aberdeen	4/90	25	0.10 ± 0.05
Ascophyllum nodosum	Ettrick Bay	4/90	20	1.06 ± 0.31
Porphyra (Sloke)	Dounreay	7/90	5	$< 2.5 \times 10^{-3}$
Silt	Ravenglass	11/86	30	0.025 ± 0.001
Moss	Chernobyl*	10/89	1	$< 12.6 \times 10^{-3}$
Lichen	"	10/89	0.2	$< 63.0 \times 10^{-3}$
Water	Tongue	3/90	7.5**	< 17 Bq l^{-1}

* (Forest of Miracle) & ** (litres).

Future Remediation Strategies

- Pakistan will be benefitted from the cost and effectiveness of decontamination strategies adopted in radiation contaminated areas in Fukushima in regard to external radiation dose.
- In case of any nuclear accident, data on the population and agriculture produce will be used to assess costs and avertable doses in the whole affected area.
- Further, in collaboration with IAEA, an advanced approach for deriving remediation strategies for the contaminated territory/agricultural produce and remedial actions necessary to reduce annual exposures below 1 mSv.

Thank you