

A Comparative Study on Radiological Impact from Chernobyl and Fukushima Nuclear Power Plant Accident: Lessons and Policy Reformation

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Abstract

According to The IAEA International Nuclear Event Scale (INES) the most devastating (INES Level-7) nuclear accident occurred at Chernobyl Nuclear power plant (NPP),USSR (April 26, 1986) and Fukushima Daiichi NPP, japan, (March 11, 2011) which has causes a great damages on life's, properties and more importantly it convulses people trust on nuclear energy. Radiological impact from these two nuclear accidents is analyzed in this study. Atmospheric release of radionuclides and maximum radionuclides concentrations in air, rain water, biological material, drink water (tap water) and soil were observed based on distance and continent from the NPPs after the Chernobyl and Fukushima Nuclear power plant Accident. Most of the radioactivity releases from both accidents were noble gases, iodine, cesium, and tellurium. The amount of refractory elements emitted from the Fukushima accident was approximately four orders lower in magnitude than the Chernobyl accident. After comparison on various issues how the laws and regulation have modified or changed (in some cases) by IAEA and other legislator organization including respective government are also observed. The main purpose of this paper is to analyze the lessons learn, implement the changes and abide by the guidelines to other currently used and under construction power plants. It must have to do to increase their safety and minimize the risk of future catastrophes. Finally our inherent objective is as Bangladesh is a newly emerged country

in nuclear energy sector, lesson from these two power plant accident might help to remain more careful and keep surveillance on every sector including operation and maintenance of the plant to increase its safety and become a successful nuclear plant operating country.

Keywords: *Nuclear accident, Radiological impact, Nuclear law, IAEA guidelines.*

INTRODUCTION

It is a clandestine truth that the main bolstering force of the world is electrical energy. Though it can get from versatile types of sources, when the questions are about secure sources (source will not be over) and environment friendly (green energy source or “green enthusiasts”) none one is good enough source than nuclear energy. Whether it’s a better alternative or not is a different issue. But after going on nuclear power production, maintenance is a challenging task as accidental and radiological consequences are very devastating. Unfortunately, nuclear accident put a negative impact on public perception. We hope that the public opinion about nuclear power will become slightly more positive with time. These accidents have some general causes like as operator error or natural calamity. Natural calamity is something that we can’t prevent or predict just can take preparation to mitigate its consequences. However when it comes to operator error, lessons

have to be learned, and reactor designs have to become safer and more robust with the development of newer form of technology.

In this study Chernobyl and Fukushima two Major INES (International Nuclear Event Scale) level 7 accidents are observed. The impact and consequences of these two major nuclear power plant accidents are compared based on the radiological consequences. Chernobyl emitted at least 0.4% of its fuel inventory [1]. Many reports on semi-volatile Ru-103,106 and refractory radionuclides (Zr-95, La-140, Ce-141,144, etc.) in air and other media have been published after Chernobyl. [1, 2, 3, 4, 5 and 6] More than 90% of the radio strontium and radio ruthenium activities at Chernobyl were emitted in the form of fuel particle [1, 7]. For Fukushima, Radioactive plumes spread erratically due to the wind, contaminating the sea water and soil [157], testing the waters for radionuclides,

affecting the livestock industry and infecting the human and cattle in the surrounding regions causing rapid depopulation and community breakups [8]. From these two accidents it is clear that unless there is proper preparation and emergency plans for accidents the consequences deteriorate rapidly. In this paper the reforms brought by IAEA, other legislative bodies and associated governing in policy, what changes have brought in reactor design by commercial organizations are also analyzed. The key factor of this thesis is to enable the nuclear community as a whole to reduce the occurrence of nuclear accidents across the world, would be to ensure a level of transparency between all parties involved, including the relevant authorities, physicians, experts, casualties, the population and the media.

Causes of accident

Chernobyl Disaster: There was no single cause of the Chernobyl accident. We can categorize the reasons in two ways. [9, 10 and 11] one is design Weakness such as positive void coefficient, defects on control rods design, absence of adequate cooling system, and absence of containment vessel and another one is Human Error: which includes Operation of the reactor at a very low

operative reactivity surplus, conducting of the experiment by the power below the level provided for test, switching off the emergency core cooling system (ECCS), blocking the protection system relaying on shutdown signal [133]. Finally, we can say that the lack of coordination, exchange of information (between the team charged for test and the team charged for operation and safety) and practice of safety culture are main reasons of the Chernobyl accident.

Fukushima Disaster

The causes of Fukushima accidents are observed from [12, 13, 14 and 15]. The main reason includes: Natural Disaster (tsunami): At a 2008 meeting of the G8's Nuclear Safety and Security Group in Tokyo, an IAEA expert warned that a strong earthquake with a magnitude above 7.0 could pose a serious problem for Japan's nuclear power stations [167]. But they were somewhat callous about this. Violation of safety regulations: In 2008 in-house study identified an immediate need to better protect the facility from flooding by seawater. This study mentioned the possibility of tsunami-waves up to 10.2 meters (33 ft). Headquarters officials insisted that such a risk was unrealistic and did not take the prediction seriously [134]. They also underestimated of the "design-

basis tsunami height” parameter used in design considerations of the plant A series of equipment failures: The diesel generators started to provide power to the cooling systems and operated until the tsunami hit the rooms where they were located, causing them to fail. Also the secondary emergency pumps run by backup electric batteries stopped working a day after the tsunami hit. Finally, the situation gravely worsened when hydrogen-air chemical explosions occurred. For Fukushima, the main problem were about natural disaster

however the disobeying some regulation and not to heed the warning are also possible causes of the accident.

Types and amounts of radionuclides released from the accidents

From Chernobyl and Fukushima accident a large amount of radio nuclides release which are very dangerous for human and environment. The amount of radio nuclides release from the Chernobyl and Fukushima accidents are given in Table 1 and 2 respectively.

Table 1: Atmospheric release estimates of radio nuclides for the nuclear accidents at Chernobyl

Radionuclides	T _{1/2}	Activity (PBq)	Source
Xe-133	5.25 d	6500	[37]
I-133	20.8 h	2500, 910	[37, 121]
I-131	8.03 d	~1760 1200–1700	[121, 37]
Np-239	2.36 d	1700 400	[121, 37]
Te-132	3.20 d	~1150 1000	[121, 37]
Te-129m	33.6 d	240	[37]
Ba-140	12.8 d	240 170	[121, 37]
Mo-99	66.0 h	210 >72	[121, 37]
Ce-141	32.5 d	200 84	[121, 37]

Zr-95	64.0 d	170 87 84	[12 1, 37]
144-Ce	285 d	140 50	[121, 37]
Sr-89	50.5 d	~115 81	[121, 37]
Cs-137	30.1 d	98 85 74-85	[121, 37, 20]
Ru-106	372 d	>73 30	[121, 37]
Cs-134	2.07 y	~47	[121, 37]
Cs-136	13.0 d	36	[37]
Kr-85	10.75 y	33	[37]
Sr-90	28.9 y	~10 8 4	[121, 37, 64]
Pu-241	14.3y	~2.6	[121]
H-3	12.3 y	(inventory) 1.4	[68]
Cm-242	163 d	~0.4	[121]
Sb-125	2.76 y	0.23	[64]
Eu-154	8.60 y	0.13	[64]
Pu-239 + 240		0.031	[121]
Pu-240	6560 y	0.018	[64]
Pu-238	87.7 y	0.015 0.03	[121, 37]
Pu-239	24100 y	0.013	[64]
Cm-244	18.1y	0.0027	[121]
Am-241	433y	0.0024	[64]
I-129	5.7E6 y	8.4E-6 4E-5 - 4.8E-5	[100, 105, 64]
Pu-242	3.76E5y	4E-5	[121]
Total (excluding noble gases)		~143100	[121]

Table 2: Atmospheric release estimates of radionuclides for the nuclear accidents at Fukushima

Radionuclides	$T_{1/2}$	Activity (PBq)	Source
Xenon - 133	5.25 d	15,300	[112]
		14,000	[113]
I-131	8.03 d	200	[153]
		190–380	[152]
		150	[151]
		130–160	[45]
Te-132	3.20 d	65.2	[116]
		~180	This study
I-133	20.8 h	88	[155]
		146	This study
Cs-137	30.1 d	62.5	[154]
		17	[116]
Kr-185	10.75 y	44	[18]
		18	[44]
Cs-134	2.07 y	11.8	This study
		~15	This study
Te-129m	33.6 d	2.6	This study
		2.2	This study
Cs-136	13.0 d	~0.2	This study
		~0.02	This study
Sr-89	50.5 d	1.1×10^{-4} – 2.6×10^{-4}	[156]
		5.5×10^{-5}	[51]
Sr-90	28.9 y	6.6×10^{-6}	This study
		2×10^{-6} – 5×10^{-6}	This study
Pu-241	14.3 y	1.1E-65E-6	[156]
I-129	15.7E6 y		
Pu-238	87.7 y		
Pu-239+240			
Total (excluding noble gases)		~520 (340–800)	This study

Impact of the released radionuclides on Environment

Radionuclide contamination of the atmosphere, hydrosphere, biosphere and pedology over the entire northern

hemisphere are caused by the Chernobyl and Fukushima accidents. Activity concentrations of the important radionuclides such as I-131, Cs-137, Sr-90 and the sum activity of Pu-239 and Pu-240

(if available) in Air, Rainwater, Plant material/animal thyroids and Soil are illustrated in Tables 3-6 for Chernobyl accidents and Table 7-10 for Fukushima

accidents. The radionuclide concentrations are observed at different continents based on the distances from the respective Nuclear Power Plant.

Table 3: Selected maximum radionuclide concentrations in air after the accidents of Chernobyl arranged by distance and continent from the NPPs (activities in (Pico curie) pCi•m-3 at the time of sampling).

Location	Distance to NPP (km)	I-131	Cs-137	Sr-90	Pu- 239+240	Source
Europe Continent						
Chernobyl NPP	0	20250000	3240000	–	–	[126]
Chernobyl, UA	1	1566000		–	–	[99, 39]
Berezinsky Natural Res., BY	400	5400	267.3	–	–	[118]
Vilnius, LT	500	1220.4	753.3	–	–	[78]
Mikolajki, PL	650	216	50.76	–	–	[62]
Prague, CZ	1100	-		–	0.000756	[50]
Nurmijärvi, FIN	1100	-	270	–	0.000864	[94]
Sweden	1150	324	135	–		[35]
Austria	1200	-	270	4.59	0.00243	[59, 60]
Thessaloniki, GR	1300	135	54	–		[96]
Bologna, IT	1700	173.88	51.3	–		[42]
Monaco	1900	125.01	42.12	–		[125]
Paris	2000	54	54	–		[119]
Yavne, IL	2200	113.4		–		[100]
Chilton, UK	2200	25.92	13.5	–	2.3E-05	[32]
Asisa Continent						
Mumbai, IN	5100	-	44.55	–	–	[86]
Chiba, JP	8200	27	1.998	–	–	[48]
North America continent						
New York, US	7500	0.54	0.27	–	–	[74]
Livermore, CA, US	9800	1.998	0.99	–	–	[25]

Table 4: Selected maximum radionuclide concentrations in rain water after the accidents of Chernobyl, arranged by distance and continent from the NPPs (activities in $pCiL^{-1}$) at the time of sampling).

Location	Distance to NPP (km)	I-131	Cs-137	Sr-90	Pu-239+240	Source
Europe Continent						
Northern Austria	1100		–	8640	–	[24, 115]
Göteborg, S	1300	81000	25650	–	–	[82]
Thessaloniki, GR	1300	226800	45900	–	–	[96]
Munich, D	1400	1566000	175500	–	–	[47]
Northern England, UK	2200	5400	2160	–	–	[75]
Shetlands, UK	2200	43200	7830	–	–	[32]
Asia Continent						
Jerusalem, IL	2200	513	–	–	–	[100]
Taiwan	7600	37.8	–	–	–	[33]
Japan	8100	2646	297	.54	–	[48]
North America Continent						
Arkansas, US	8900	45.9	–	–	.00512	[72]

Table 5: Selected maximum radionuclide concentrations in biological material after the accidents of Chernobyl, arranged by distance and continent from the NPPs (activities in $pCi \cdot Kg^{-1}$ and $pCi \cdot L^{-1}$) for milk, respectively, at the time of sampling/measurement). Values are usually activity per fresh mass, unless noted otherwise.

Location	Distance to NPP (km)	I-131	Cs-137	Sr-90	Pu-239+240	Source
Plant material						
Europe Continent						
Pripyat/Yanov, UA	4	-	6153300	27405000	39339	[124]
Christinovka, UA	64	-	-	–	33.75	[49]

Kiev, UA	100	-	333450	35640		[57]
Styria, AT	1200	17280	15660	-	-	[115]
Thessaloniki, GR	1300	-	72900	-	-	[96]
Munich, D	1400	-	5400	-	-	[47]
Bremen, D	1500	66150	14985	-	-	[101]
Northern Italy	1500	4428	1377	-	-	[25]
Nice, FR	1900	-	91800	-	-	[23]
Harrington, UK	2100	-	137700	-	-	[32]
United Kingdom	2200	5400	2700	-	-	[41]
Asia Continent						
Mumbai, IN	5100	248.4	216	-	-	[86]
Taiwan	7600	324	-	-	-	[86]
Ibaraki	8100	2862	183.6	-	-	[86]
Thyroids						
Europe Continent						
Austria	1100	8.53E+08	83700	-	-	[114]
Munich, D	1400	307800	-	-	-	[73, 90]
Ulm, D	1500	32400000	2592	-	-	[122]
Ioannina, GR	1500	16686	-	-	-	[58]
Birmingham, UK	2200	-	17712	-	-	[122]
United Kingdom	2200	54000000	-	-	-	[130]
Asia Continent						
Japan	8.000	81000	-	-	-	[122]
Cow milk						
Europe Continent						
Kiev, UA	100	-	-	7.29	-	[22]
		0	0			
Minsk, BY	350	1393.2	2295	-	-	[22]
Bratislava, SK	1000	20466	-	-	-	[71]
Sweden	1150	270	-	-	-	[38]
Northern Albania	1300	94500	10260	-	-	[70]
Greece	1300	-	3510	-	-	[96]
Bremen, D	1500	1080000	-	-	-	[101]
United Kingdom	2200	10800	10800	-	-	[41]
Asia Continent						
Mumbai, IN	5100	75.6	29.7	-	-	[86]
Taiwan	7600	108	-	-	-	[86]

Nagoya, JP	8000	567	-	-	-	[90]
North America Continent						
New York, US	7500	40.5	-	-	-	[39]
			0			
Livermore, CA, US	9800	9.99	-	-	-	[25]

Table 6: Selected maximum radionuclide concentrations in soil after the accidents of Chernobyl, arranged by distance and continent from the NPPs (activities in pCi Kg⁻¹ at the time of sampling/ measurement).

Location	Distance to NPP (km)	I-131	Cs-137	Sr-90	Pu 239+240	Source
Europe Continent						
Pripyat/Yanov, UA	4	-	33453000	11340000	-	[124]
Novo-Shepelichi, UA	5	-	-	-	8478	[49]
Christogalovka, UA	5	-	1998000	972000	-	[79]
Christinovka/ Poleskoye, UA	64	-	405000	3510	480.6	[49, 79]
Kupetsch, UA	100	-	93420	1188	30.807	[40, 49]
Minsk, BY	350	-	6949.8	-	-	[22]
Vöcklabruck, AT	1250	-	13662	-	-	[110]
Athens, GR	1600	-	594000	-	-	[108]
Mercantour Mass., FR	1900	-	40500	-	-	[[102]
Asia Continent						
Mumbai, IN	5100	39.42	256.5	-	-	[86]

Table 7: Selected maximum radionuclide concentrations in air after the accidents of Fukushima, arranged by distance from the NPPs (activities in $pCi \cdot m^{-3}$ (Pico curie) at the time of sampling).

Location	Distance to NPP (km)	I-131	Cs-137	Sr-90	Pu-239+240	Source
Fukushima Daiichi	0	151200	–	–	–	[118]
Fukushima Daiichi	10	56700	-	–	–	[118]
Futoba, JP	25	14310	178.2	–	–	[118]
Tsukuba, JP	190	864	0.432	–	–	[118]
Takasaki, JP	220	396.9	-	–	–	[118]
Wako, JP	220	1269	-	–	–	[118]
Busan, ROK	1100	0.03564	0.03375	–	–	[133]
Andong, ROK	1100	0.01863	0.00405	–	–	[133]
Daegu, ROK	1120	0.03024	0.0054	–	–	[133]
Seoul, ROK	1200	0.03483	0.0027	–	–	[133]
Gunsan, ROK	1300	0.08424	0.01215	–	–	[133]
Jeju, ROK	1400	0.02403	0.0135	–	–	[133]
Jilin, CN	1500	0.216	0.00621	–	–	[117]
Liaoning, CN	1600	0.0378	0.0027	–	–	[117]
Anhui, CN	2200	0.04293	0.0027	–	–	[117]
Taiwan	2400	0.01593	0.0162	–	–	[52]
Saipan	2500	0.26973	0.03996	–	–	[118]
Manila, RP	3200	0.01296	0.00324	–	–	[118]
Wake Island	3200	0.0621	0.00945	–	–	[118]
Dalat, VN	3800	0.00513	0.000972	–	–	[76]
Midway Island	4000	0.2511	0.027	–	–	[118]
Dutch Harbor, AK, US	4350	0.6885	0.08775	–	–	[117]
Tibet	4700	0.00864	-	–	–	[117]
Nome, AK, US	4600	0.04293	0.1188	–	–	[117]
Oahu, US	6000	0.6588	0.11988	–	–	[118]
Ketchikan, AK, US	6500	0.05751	0.00621	–	–	[85]
Dubna, RUS	7400	0.10422	-	–	–	[81]
Seattle, WA, US	7500	0.1188	0.00594	–	–	[36]
Vilnius, LT	8000	0.1026	0.027	–	1.202E-6	[78]
Reykjavik, IS	8600	0.081	0.0216	–	–	[117]
Krakow, PL	8700	0.135	0.01188	–	–	[81]
Bremen, D	8900	0.054	-	–	–	[101]
Tessaloniki, GR	9300	0.013419	0.003915	–	–	[80]

Table 8: Selected maximum radionuclide concentrations in rain water after the accidents of Fukushima, arranged by distance from the NPPs (activities in pCi•L⁻¹ at the time of sampling).

Location	Distance to NPP (km)	I-131	Cs-137	Sr-90	Pu-239+240	Source
Kashiwa, JP	200	163944	20304	–	–	[46]
Tokyo, JP	250	7668	6372	–	–	[110]
Tokyo, JP	250	16578	734.4	–	–	[46]
Nagoya, JP	400	21870	6480	–	–	[93]
Osaka, JP	600	1.512	-	–	–	[46]
Hiroshima, JP	840	11.88	4.671	–	–	[46]
Jeju, ROK	1240	75.87	54.54	–	–	[133]
Krasnoyarsk, RU	4000	16.74	2.025	–	–	[26]
Novosibirsk, RU	4700	22.41	2.484	–	–	[83]
Boise, ID, US	8100	389.61	35.91	–	–	[117]
San Francisco, US	8100	432	13.5	–	–	[92]
Richmond, CA, US	8100	137.97	7.83	–	–	[117]
Vartop, RO	8900	45.63	1.053	–	–	[34]
Bremen, D	8900	1.836	81	–	–	[101]
Vienna, AT	9000	140.4	-	–	–	[110]
Denver, CO, US	9100	42.93	-	–	–	
Thessaloniki, GR	9300	18.9	-	–	–	[80]

Table 9: Selected maximum radionuclide concentrations in biological material after the accidents of Fukushima, arranged by distance from the NPPs (activities in pCi•kg⁻¹ and pCi•L⁻¹ for milk, respectively, at the time of sampling/measurement). Values are usually activity per fresh mass, unless noted otherwise.

Location	Distance to NPP (km)	I-131	Cs-137	Sr-90	Pu-239+240	Source
Plant material						
Fukushima Daichi, JP	0.88	4050000	34830000	30780	13.23	[103, 107 and 111]

Odaka, JP	16	-	20250	3375	4.59	[103, 111]
Iitate, JP	35	54000	270000	-	-	[107]
Kyoto, JP	550	91800	7560	-	-	[21]
Alemeda, CA, US	8100	268.11	190.08	-	-	[118]
Cluj, RO	8700	68.85	-	-	-	[34]
Bremen, D	8900	96.66	42.93	-	-	[101]
Vienna, AT	9000	129.6	-	-	-	[98]
Agen, FR Thyroids	10,000	243	-	-	-	[98]
Cluj, RO	8700	4860	-	-	-	[34]
Northern Austria Cow milk	9000	40770	-	-	-	[109]
Kawamata, JP	46	40824	496.8	-	-	[118]
Fukushima prefecture	70	143100	540	-	-	[45]
Ibaraki, JP	130	45900	1728	-	-	[45]
Kyoto, JP	550	0	18.9	-	-	[69]
Hilo, HI, US	6500	18.09	18.9	-	-	[117]
San Francisco, CA, US	8100	78.3	12.96	-	-	[117]
Cluj, RO	8700	9.99	.54	-	-	[34]
Bremen, D	8900	2.16	-	-	-	[101]
Little Rock, AR, US	10,000	8.91	-	-	-	[118]
Agen, FR	10,000	17.793	-	-	-	[98]

Table 10: Selected maximum radionuclide concentrations in soil after the accidents of Fukushima, arranged by distance from the NPPs (activities in $pCi \cdot kg^{-1}$ at the time of sampling/ measurement).

Location	Distance to NPP (km)	I-131	Cs-137	Sr-90	Pu-239+240	Source
Fukushima Daiichi, JP	0.88	1323000	48330000	28890	<59.697	[103, 107, 111]
Fukushima Daiichi, JP	4.3	270000	73980000	6264	<13.5	[103, 107, 111]

J village	20	540810	309960	–	–	[132]
Kawamata, JP	40	75870	253260	-	–	[65]
Fukushima prefecture	60	-	8775	-	–	[94]
Sendai, JP	95	-	135000	<81	–	[111]
Kashiwa, JP	195	-	11367000	945	<14.31	[111]
Mekong River Delta, VN	4700	-	945	–	–	[131]
Bremen, D	8900	1.836	81	–	–	[101]
Vienna, AT	9000	<10.8	577.8	–	–	[110]

Radiological consequences of the Fukushima and Chernobyl nuclear accidents

Both the Chernobyl and the Fukushima Daiichi releases resulted in contamination of the environment, including residential areas, agricultural lands, forests and bodies of water. The total deposition of radio cesium on the terrestrial environment, which largely determine the potential radiation doses to people in the existing situation and are relevant to environmental remediation, were lower by approximately an order of magnitude for the Fukushima Daiichi accident compared with the Chernobyl accident (see Table 11) [158]

Table 11: Comparison of radio cesium deposition and dose to the population due to the Chernobyl and Fukushima accidents [159, 160]

Accident	Total release of Cs-134 and Cs-137 (PBq)	Total ground deposition of Cs-134 and Cs-137 (PBq)	Area with Cs-137 deposition above 100 kBq/m² (km²)	Maximum first year settlement average effective dose (mSv)	Projected collective effective dose (person-Sv)
Chernobyl, 1986	130	100	56000	~ 90	430000
Fukushima, 2011	~18	4–6	~ 3000	~ 10	~ 50000
Ratio Chernobyl/ Fukushima, dimensionless	~7	~20	~20	~9	~9

Lesson from Chernobyl Accident [134]

After the accident at Chernobyl, several measures were taken to improve the safety of RBMK plants. INSAG has been told that measures had been developed and implemented that were aimed at:

- Reducing the positive steam (void) coefficient of reactivity
- Introduction of calculation programs to provide an indication of the value of the operating reactivity margin in the control room.
- Prevention of the emergency safety systems from being bypassed while the reactor is operating.
- In order to ensure adequate sub-cooling at the core inlet, the avoidance of modes of operation that cause a reduction in the departure from nuclear boiling (DNB) ratio of the coolant at the reactor inlet.
- Retrofitting of control rods with a design that does not give rise to water columns at the bottom of the channels. Scram (shut down) rod insertion time cut from 18 to 12 seconds.
- The installation of a fast-acting emergency protection (FAEP) system.

Lesson from Fukushima Accident [134]

- Nuclear designers and operators should evaluate and provide protection against the risks of all natural hazards
- Defense in depth
- Severe long-term combinations of external events should be adequately covered in design, operations, resourcing and emergency arrangements.
- Hydrogen risks should be subject to detailed evaluation

POLICY CHANGES

Changes In regulation and Law by IAEA [138]

Selected International Actions and Activities of the IAEA in Convention

- a) Convention on Early Notification of a Nuclear Accident,
- b) Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency,
- c) Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management,

d) Convention on Nuclear Safety,

e) Convention on Supplementary
Compensation for Nuclear Damage

Selected International Actions and
Activities of the IAEA for reviews

Operational Safety Review Team
(OSART), Emergency Preparedness
Review (EPREV), Integrated Regulatory
Review Service (IRRS).

Selected International Actions and
Activities of the IAEA for reviews for
Services databases actions

- i. Response and Assistance Network
(RANET),
- ii. IAEA Unified System for Incidents
and Emergencies (USIE),
- iii. Nuclear Events Web-based System
(NEWS), Inter-Agency Committee
on Radiological and Nuclear
Emergencies (IACRNE),
- iv. International Nuclear and
Radiological Event Scale (INES),
- v. International Reporting System for
Operating Experience (IRS),
- vi. Convention Exercise (ConvEx)

***Selected International Actions and
Activities of the EU [138]***

- “Post-Chernobyl” legislation
related to a contamination of
agriculture products originated
from the accident,
- “Future accident” legislation, also
called “sleeping legislation”
containing maximum levels of
radioactive contamination of food
stuffs and of feeding stuffs,
- European approach to nuclear and
radiological emergency
management and rehabilitation
strategies (EURANOS),
- Medical Effectiveness of Iodine
Prophylaxis in a Nuclear
Emergency Situation and Overview
of European Practices,
- European Community Urgent
Radiological Information
Exchange (ECURIE),
- European Radiological Data
Exchange (EURDEP), European
Clearing House for NPP
Operational Safety Feedback
(2010)

Chronology of advancement of nuclear law and regulations post Chernobyl period [139]

After the Chernobyl nuclear accident, immediate comprehensive and continuous actions of the international community of

states. Considerable number of new international instruments aimed at doing away with, or mitigating the shortcomings of the 1986 international nuclear law regime which became evident through the accident:

Table 12: Chronology of advancement of nuclear law and regulations post Chernobyl period

Title	Date	Source
Adoption of the Convention on Early Notification of a Nuclear Accident	6 September 1986	[143]
Adoption of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	6 September 1986	[144]
Adoption of the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention	1 September 1988	[145]
Adoption of the Convention on Nuclear Safety	7 June 1994	[146]
Adoption of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management	September 1997	[147]
Adoption of the Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage	2 September 1997	[148]
Adoption of the Convention on Supplementary Compensation for Nuclear Damage	2 September 1997	[149]
Adoption of the “Amendment to the Convention on the Physical Protection of Nuclear Material”.	July 2005	[150]

Changes Brought to Regulatory Agencies since the Fukushima Daiichi Nuclear Accident [140]

After the occurrence of a major nuclear accident, the role of the regulatory body often comes under scrutiny. Following the nuclear accident at Fukushima Daiichi, many States have reviewed the structure of their nuclear regulator and emphasized the importance of having independent

regulators, in order to ensure that such events will not occur again in the future. Following the Fukushima Daiichi nuclear accident, many States have reconsidered their legislative framework to ensure better regulatory independence.

For instance, Japan has adopted new law to create a nuclear regulatory agency independent from the ministry responsible

for the promotion of nuclear energy. On June 27, 2012, Japan adopted the Nuclear Regulatory Commission Establishment Act. The accident also precipitated the adoption of the Energy Bill 2012 by the United Kingdom, which aims to reform their nuclear regulatory body. Finally, following a negative perception of its nuclear regulator.

India also introduced a bill to modify its regulatory body. In September 2011, the Indian Parliament introduced the Nuclear Safety Regulatory Authority Bill, 2011, to establish the Nuclear Safety Regulatory Authority (NSRA).

According to section 20 of the Bill, the Authority shall “take measures [...] to ensure that the use of radiation and atomic energy is safe for the health of the radiation workers, members of the public and the environment” [141]. The NSRA will regulate nuclear safety and activities related to nuclear material and facilities. [142]

CONCLUSION

After the 4th Arab-Israel war in 1973 for sustainable source of energy security, for “green enthusiasts” sources worlds are deeply seeking for renewable energy sources. Nuclear is a good alternative source

though NPP accident causes a negative perception. Nuclear accidents can occur by human error or natural disasters. Natural disasters can't prevent or predict just can take preparation to mitigate its consequences. As a result of more than two decades of research in the field of severe accidents in NPPs, it has become increasingly clear how the consequences of such accidents can be reduced or even eliminated through

- ❖ use of improved training
- ❖ development of more realistic accident management strategies
- ❖ development of more advanced reactor designs
- ❖ ultimately, the obey the law and guidelines of IAEA
- ❖ Develop a Nuclear safety culture.
- ❖ Emergency preparedness including monitoring capabilities during severe accidents and availability of capable staff during such accidents.
- ❖ International cooperation regarding knowledge management and capabilities of personnel and equipment in case of a severe accident.

We should give more focus on to promote and practice of a safety culture. Accident can't skip. Rather the main purpose is to use the acquired knowledge reduce the possibility of accident and to mitigate the consequences if it occur.

It is essential to create awareness among the people so that they should not living in a bubble of fear and should invest into nuclear education and for development nuclear power. So that more secure technology can develop, build up a safety culture and a conscious public about nuclear power.

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