Nuclear Power Plant Accidents and Its Effects

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Key points: *The potential impact of nuclear power plant accidents could be the release of radioactive materials such as Iodine-131 and Caesium-137 in the environment. These radioactive materials can cause widespread effects on human and environment including deaths and thyroid cancer in humans, and contamination of drinking water, environmental water and food, in addition, bioaccumulation of radioactive materials in the food chain can also occur. It is essential to ensure that old and new reactors used for power generation are safe.*

Table 1: World uranium production from mines (tonnes) [http://world-nuclear.org/info/inf23.html]

Country	2008	2009
Kazakhstan	8521	14 020
Canada	9000	10173
Australia	8430	7982
Namibia	4366	4626
Russia	3521	3564
Niger	3032	3243
Uzbekistan	2338	2429
USA	1430	1453
Ukraine (est)	800	840
China (est)	769	750
South Africa	655	563
Brazil	330	345
India (est)	271	290
Czech Repub.	263	258
Malawi		104
Romania (est)	77	75
Pakistan (est)	45	50
France	5	8

A nuclear accident is an event that can cause significant consequences to people, the environment or the facility. Currently 30 countries use the nuclear power plants (NPP) to produce electricity (in total 442 operating nuclear reactors spread over 30 countries). Countries such as the USA, France, Japan, and Russia have the most nuclear reactors, whereas many countries such as Australia and Bangladesh donot have any nuclear power plants at this moment (*Figure 1*). NPP can be categorised as environmentally friendly in the sense that there are little or no greenhouse gas emissions from using uranium to generate electricity (*see Table 1; note: 63 percent of world's uranium production is from Kazakhstan, Canada and Australia*) and electricity produced by nuclear power tends to be much cheaper than other forms of production (e.g. coal, natural gas and oil). Therefore, in the future there may be more demand to construct NPP, for example, over 45 countries are actively considering embarking upon nuclear power programs; the front runner countries of which are Iran, United Arab Emirates (UAE), Turkey, Italy, Vietnam and Jordan. However, consequences of any nuclear accidents could be catastrophic (e.g. 1986 Chernobyl nuclear disaster).

On 11 March, 2011 a major earthquake and tsunami devastated Sendai of Japan despite it has the world's densest seismometer (*instruments that measure motions of the ground, including those of seismic waves generated by earthquakes*) network, the biggest tsunami barriers and the most extensive earthquake early-warning system. The 2011 Sendai tsunami caused severe damage to Fukushima Daiichi (*dai-ichi* means 'number one') nuclear power plant resulting release of radioactive materials such as Iodine-131 (half-life 8.02 days) and Caesium-137 or Cesium-137 (half-life 30.17 years) (*Table 2*) into the environment (*note: half-life is the time required for a radioactive substance to lose 50% of its activity through decay*). Abnormal levels of radiation in milk, spinach, fish from areas near Fukushima, and in tap and seawater water have been reported. The main source has been wind-borne dust which is deposited on fruit or vegetables or which falls on the soil, where it is absorbed by grass and leafy plants. Radioactive particles are then transmitted through the food chain (see *Figure 2*). Additionally direct release of effluents from the plant into the sea can cause significant effects on marine organisms including seafood.

There is a short-term risk to human health if radioactive Iodine-131 in food is absorbed into the human body as it can increase the risk of thyroid cancer via accumulation in human body; in particular children and young people are particularly at risk. However, the longer-term problem comes from Caesium-137, whose 'half life' is 30 years meaning that it may take long time before it breaks down totally. Japan itself has banned fishing within 20 km of the Fukushima plant, since it fears that seaweeds and marine organisms may have been contaminated with radioactive materials. Furthermore, Caesium-137 tends to accumulate in larger fish near the top of the food chain.

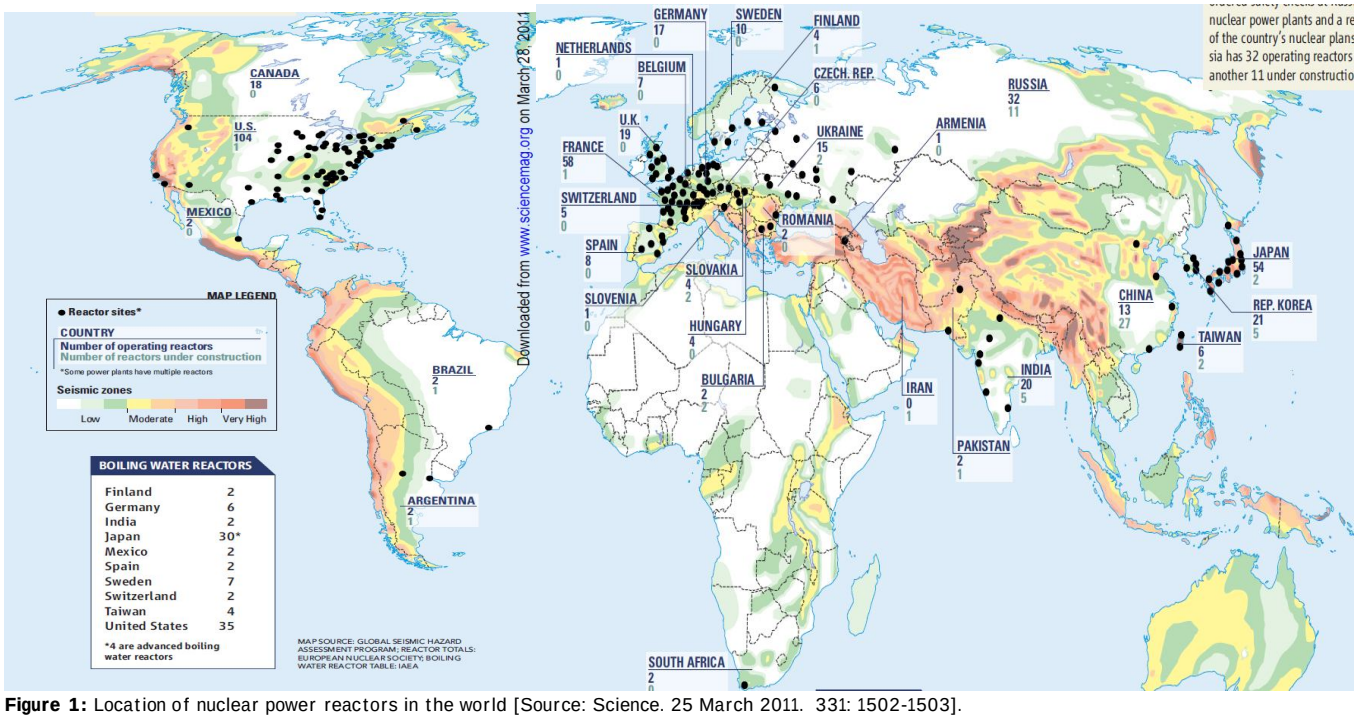

Figure 1: Location of nuclear power reactors in the world [Source: Science. 25 March 2011. 331: 1502-1503].

Many countries have already set food import restriction from Japan including Australia, Canada, China, France, Hong Kong, Philippines, Russia, Singapore, and United States. Australia banned produce from the Fukushima area, including seaweed and seafood, milk, dairy products, fresh fruit and vegetables (both fresh and frozen). Indian government has also announced a ban on all food imports from Japan. Many countries have expressed concern over the radiation effects.

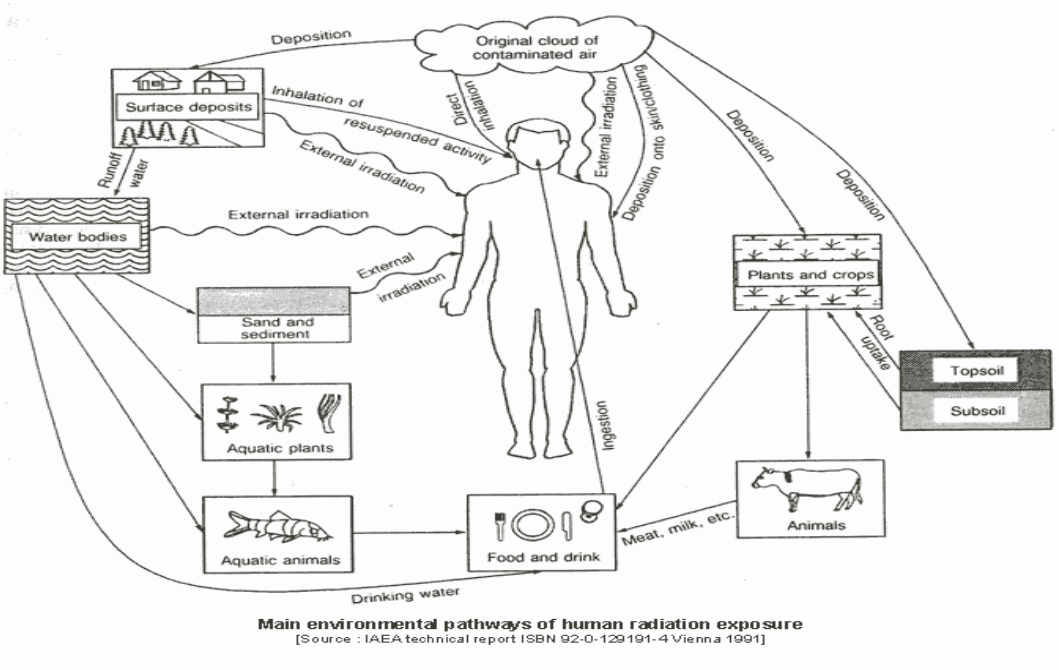

Figure 2: Paths of radiation exposure [source: http://www.world-nuclear.org/info/chernobyl/inf07.html].

Worldwide there have been 99 accidents at nuclear power plants from 1952 to 2009, of which Fukushima (2011), Chernobyl (1986), and Three Mile Power Plant accidents (1979) caused major effects on environment and human (*see Table 2*). The severity of any nuclear accident is measured on the international event scale (INES) from 0 to 7 (where O means no consequences and 7 is the major accident; level 1-3 are called incidents and level 4-7 are called accidents). The Fukushima accident (2011) has been classified at level 5 or 6 accidents, whereas the Chernobyl nuclear power plant disaster (1986) is the worst nuclear disaster (INES level 7) and the Three Mile Island accident (1979) was a level 5 accident (*see Table 2*). Nuclear plants are designed to withstand earthquakes and to shut down safely in the event of major earth movement. However, no nuclear facilities is 100% safe since meltdown of the reactor (*due to loss of coolant water leading to overheating*) if occurs would create a major public hazard and may cause human fatalities. Therefore it is essential to ensure that old and new reactors are safe and are fully prepared for any worst situation. Moreover, nuclear reactors produce toxic waste, which is highly radioactive and can remain in the environment for several hundred years (see *Appendix 1* –page 3 for pros and cons. of various power generation options)

Table 2: Major nuclear power plant accidents and their effects

INES event scale: Level 7=major accident; level 6= serious accident; level 5= accident with wider consequences; level 4= accident with local consequences; Level 3= serious incident; 2= incident; 1= anomaly; level O= no safety significance

Date	Location	Causes	INES level	Effects
2011-March 11	Fukushima Daiichi Power Plant Explosion, Okuma, Fukushima, Japan	Cooling failure in 4 reactors following an earthquake, tsunami and multiple fires and Hydrogen explosions	7	ongoing; release of radioactive Iodine-131 and Caesium-137; vegetables, fish, food & water contamination; 2 deaths
1986-April 26	Chernobyl disaster, Ukraine, USSR	steam explosion and fire	7	major release of radioactive material (iodine-131, caesium-137, tellurium) with widespread health and environmental effect; 57 direct deaths; 6,000 thyroid cancer fatalities from contaminated milk
1979-March, 28	Three Mile Island Accident, Middletown, Pennsylvania, USA	Loss of coolant and partial core meltdown	5	major radioactive release including harmless noble gases (xenon-131) and iodine-131; zero deaths

Key references

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Appendix 1: Pros and cons of various power generation options

	Fuel	Pros	Cons
Fossil fuel	Coal	Low cost	- requires huge amount of freshwater - produces more carbon dioxide (CO_2) or green house gas than any other electricity generation method - contains sulphur, arsenic, selenium, mercury and radioactive elements uranium, thorium, radium and radon - not sustainable
	Natural gas	Low cost	- produces CO_2 - not sustainable - gas reserves are limited
	Oil	Low cost	- produces CO_2 - requires substantial amount of cooling water - oil reserves are limited
Non-fossil fuel-nuclear	Nuclear	- doesn't contribute to green house gas emissions (GHG) or pollutants - efficient power generation (less fuel required)	- produces radioactive waste which are harmful to living organisms (can cause cancer, genetic mutation) - requires substantial amount of cooling water - high capital and maintenance costs - may take 10-15 years to build - a target for terrorist attack
Non-fossil fuel - Renewable	Geothermal (hot water)	- sustainable, non-polluting - low cost	- can be developed only in selected volcanic areas
	Hydro (dams)	- sustainable, non-polluting -simpler and cheaper	- impair migration of native species - causes cold water pollution since water released from bottom of dams is cold affecting native species - can cause flooding - can produce significant amounts of carbon dioxide and methane (greenhouse gases)
	Wind	- sustainable, non-polluting - requires little or no cooling water	- doesn't produce power when wind is not blowing - need numerous turbines spread over large areas - depends on wind velocity - can kill birds etc. - can cause noise pollution
	Solar (sun)	- sustainable, non-polluting - can be produced in any part of the world	- requires large space - may require substantial amount of cooling water - solar electricity could be expensive
	Wave	- sustainable, non-polluting	- installation would damage the local sea-bed
	Biomass (wood, alcohol fuels, solid waste)	- uses renewable fuel	- a large area of land is required for the production of fuel - requires fertiliser for crops - burning of biomass may create pollution - expensive (requires lot of resources)

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