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The Chernobyl Disaster and its Effects on Environment, The Aftermath

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ABSTRACT

On the night of 25th April, 1986 when most of the inhabitants of Chernobyl and Pripyat were asleep, an experiment was taking place at the Reactor 4 of Chernobyl Nuclear Power Plant. By the mid-night the fire fighters received emergency call to reach the spot of Chernobyl Reactor 4 as soon as possible. Even before they could understand what's going on, some of them collapsed on the spot of the supposedly accident which took place at Reactor 4 from a "mere fire", their skins were burnt and they were rushed to the hospitals. Around 28 of them died within the coming 10 days followed by the accident. It was only after almost 24 hours of the entire occurrence that people came to know the mere fire was nothing but the dangerous substance, graphite. Evacuation started taking place and soon the entire city of Pripyat became evacuated which is till today's time not occupied by many residents and most of the parts of it still being considered as contamination zone. The entire accident is known to us as the Chernobyl disaster of 1986 in the Soviet Union, which is, the worst disaster in the history of nuclear power generation till date.

Due to shutting down the reactor's power-regulating system and its emergency safety systems while allowing the reactor to continue running at just 7% power the chain reaction in the core went completely out of control. Several explosions triggered a large fire exploding the heavy lid of the reactor leading to a huge amount of environmental impact extending beyond border.

This paper deals with the entire accident, the causes and the effects on the environment, the paper also comes up with certain suggestions in order to avoid any such future accidents.

Keywords: nuclear disasters, radioactive explosion, environmental laws, nuclear laws.

I. AN OUTLOOK OF THE CHORNOBYL PLANT AND ITS LOCATION²

The complex was situated at Chernobyl with four nuclear reactors (the reactors were of the RBMK-1000 design) along with an artificial lake was constructed beside river Pripyat for the purpose of providing cooling water for the reactors. The first two units were constructed during the years 1970-1977, and the next two by the year 1983.

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² SSE Chernobyl NPP, <https://chnpp.gov.ua/en>

During the time when the accident occurred, two more reactors were being constructed on the site. In the city of Pripyat which was affected the worst after the accident, there were near 49,000 inhabitants just 3 km away from the reactor where it took place and also town of Chernobyl was just 15 km away from the reactor consisted of a population of nearly 12,500.

An introduction to the RBMK-1000 Reactor³:

It is a Soviet-built graphite moderated pressure tube type reactor which uses slightly enriched uranium dioxide fuel. The RBMK is a boiling light water reactor consisting of two loops for feeding steam directly to the turbines, without an intervening heat exchanger. The water pumped to the bottom of the fuel channels boils as it progresses up the pressure tubes, producing steam. The water acts as a coolant and also provides the steam used to drive the turbines. Also, the vertical pressure tubes contain zirconium alloy clad uranium dioxide fuel around which the cooling water flows. The extensions of the fuel channels penetrate the lower plate and the cover plate of the core and are welded to each. A specially designed refuelling machine allows fuel bundles to be changed without shutting down the reactor. The moderator (graphite) slows down the neutrons.

A mixture of the two gases, nitrogen and helium is circulated between the graphite blocks to prevent oxidation of the graphite and it helps improve the transmission of the heat produced by the neutron interactions in the graphite to the fuel channel. The power output of this reactor is 3200 MW thermal, or 1000 MW.

The most important and rather dangerous feature of this particular type of reactor is that, it may possess a positive void coefficient that is, where an increase in steam bubbles termed as void is accompanied by an increase in core. As gradually the production of steam in the fuel channels increase, the neutrons start producing increased fission in the fuel. That's exactly how and why the Chernobyl accident occurred. The reactor of Chernobyl 4's fuel burn-up, control rod configuration, and power level led to a positive void coefficient which was large enough to overwhelm all other influences on the power coefficient.

The D-day, 26th April, 1986⁴:

The day prior to the incident, on 25th of April at Chernobyl 4 preparations were going on by the reactor crew for conducting a test in order to determine the manner in which the long turbines would spin, supplying power to the circulating pumps followed by a loss of the main electrical power supply. Various incidents occurred during the attempt early on 26th April, including the

³ World Nuclear Association, <https://www.world-nuclear.org>

⁴ The 1986 Chernobyl nuclear power plant accident, <https://www.iaea.org/newscenter/focus/chernobyl>

disabling of the automatic shutdown mechanisms and a fault in the design in the control rods which caused a substantial power surge the moment they were inserted into the reactor, which ultimately caused the reactor to be in an extremely unstable and dangerous condition by the time the operator moved to shut it down.

Hot fuel came into contact with the cooling water causing fuel fragmentation and an extreme fast production of steam leading to increased pressure, the 1000-t cover plate of the reactor got partially detached, rupturing the fuel channels and jamming the control rods, which at that time were just halfway down.

The entire event of actions led to destruction of the reactor. A heavy steam generation did spread throughout the entire core leading to steam explosion and a rapid release of fission products in the atmosphere. Another explosion occurred just a few seconds later, which threw out fragments from the fuel channels which included extremely heated graphite both of which became incandescent causing multiple fires and thus the release of radioactivity into the environment leading to a huge disaster affecting both Chernobyl and Pripyat at first, and the entire Soviet Union and the surrounding countries, spreading far beyond. The burning graphite then began burning in the open air causing clouds of smoke, gas, and radiation.

On 27th the fire continued getting worse and by 28th April, Sweden after monitoring its own plants discovered the monitoring stations throughout the country were resisting unusually high levels of radiation. Soon the radiation from Chernobyl spread from Soviet Union to Norway, Finland, and Sweden and finally it was spread to Europe due to fast shifting winds.

By May 6, a mild level of the Chernobyl radiation travelled across the Pacific Ocean and over much of the United States. Almost 33 Diplomats were withdrawn from Moscow, nearly 34 tourists were returned to their homelands, sales of milk from grass-fed cows were banned, and the European Community banned the import of fresh food products from the Eastern Europe due to the contamination.

The Efforts to Control the Spread⁵:

The Soviet Union tried its best not to disclose the event completely in front of the United States and denied any possibility of getting from the country. It started trying to cool down the reactor with the help of almost about 200 to 300 tonnes of water every hour which was just after an effort of half a day due to the possible risk of flooding the first and the second units. From day 2 till day 10 there were extreme efforts to extinguish the blaze and to limit the release of the

⁵ Chernobyl explained: www.express.co.uk

particles by dumping almost 5000 tonnes of boron, dolomite, sand, clay, and lead on to the burning core by helicopter which partially failed since the pilots fell sick and burnt themselves with the oozing radioactive particles.

The next effort was made to cleaning up the radioactivity at the site and that the damaged reactor be shielded more permanently. About 200,000 workers from all over the Soviet Union were involved in the recovery and clean-up process, some of whom volunteered and others were bound to do so in order to serve their nation and fulfil duties. The workers including liquidators, pilots flying the helicopters and others received high doses of radiation, the highest being received by about 1000 of the emergency workers and onsite personnel during the first day of the accident. Most of them died due to the radiation causing extreme burns, infections from the burns and the ones who received relatively less amount of radiation, died within a few years due to one or the other type of cancer, lungs disorders and other fatal diseases.

II. THE IMMEDIATE IMPACT OF THE CHERNOBYL ACCIDENT

Large amount of radioactive substances kept being released into the air the next 10 days followed by the accident causing serious social and economic disruption in Belarus, Russia, and Ukraine. It is estimated that all of the xenon gas, about half of the iodine and caesium, and at least 5% of the remaining radioactive material in the Chernobyl 4 reactor was released due to the accident. Most of the released materials were deposited as dust and debris, and the lighter particles were carried by wind over Ukraine, Belarus, Russia, and to some extent over Scandinavia and Europe. Radiation doses on the first day caused almost 28 deaths.

The doses were high enough to result in Acute Radiation Syndrome (ARS). Doses ranging between 4000 mg to 5000 mg is efficient to kill 50% of those exposed whereas the doses received by the fire-fighters and the worker at the plant who died, were estimated to range up to 20,000 mg.

On 27th April almost 45,000 residents were evacuated from Pripjat leaving the town completely empty and by 14th May nearly 116,000 people living within a 30-kilometre radius were evacuated and later relocated. About 1000 of these returned unofficially to live within the contaminated zone, and some refused to evacuate their birth place. Animals, birds and those who refused to leave the contamination zone were shot dead due to the high possibility of spreading radiation from them. Many of the residents suffered serious health issues years after the accident and giving birth of deformed babies became common. Till date the people whose ancestors came in contact with the exposure suffers from various diseases related to radioactivity.

III. EFFECTS OF THE ACCIDENT ON ENVIRONMENT⁶:

Contamination in the urban areas of Chernobyl:

Huge amounts of the radioactive particles got deposited in the urban areas near the power plant. Other urban areas have received different levels of deposition, and their residents have received, and are still receiving, some amount of external radiation. These were deposited mostly on open surfaces such as lawns, parks, building roofs, road etc., for instance, by high breezes and contaminated rain. The surface contamination in urban areas have decreased to some extent due to the continuous street washing and cleanup. However, this has caused the secondary contamination of sewage systems and sludge storage.

Contamination of the agricultural areas:

Agricultural plants, grazing animals during the 10 days post the accident and after were severely contaminated, as a consequence of which the milk produced in parts of Belarus, Russia, Ukraine and some other parts of Europe also came under contamination and were banned. Another increasingly important concern was regarding the issue of plant contamination from the soil through their roots.

Even today the problems persist in some of the rural areas of former Soviet Union with small private farms where cows are grazing in pastures are neither ploughed nor fertilized. Also, the milk produced in some parts of Belarus, Russia and Ukraine may still have high levels of caesium-137.

Contamination of the forest lands:

The animals and vegetation in affected forests and mountains are particularly contaminated since the radioactive particles are continuously taken up by winds and rains and are being passed on by organisms in the forest. Food products such as mushrooms, berries still now contain the highest recorded levels of contamination. The doses of radioactivity being received by the habitants from forest products are expected to remain high for decades to come. The accident led to high contamination of reindeer meat in Finland, Norway, Russia and Sweden.

Contamination of water bodies:

The radioactive materials deposited on rivers, lakes and some water reservoirs as well. The amount of radioactive materials present in water bodies decreased rapidly during the first weeks after the initial deposition because the radioactive materials decayed. Fishes

⁶ UNSCEAR, <http://www.unscear.org>

absorbed radioactive iodine very quickly. the bioaccumulation of radioactive caesium among the aquatic food chain quickly resulted in high concentrations in fish in some lakes as far away as Scandinavia and Germany. Water bodies are still being contaminated by runoff of the long lived caesium-137 and strontium-90 both released from contaminated soils. Contamination levels of the Black and Baltic seas were much lower than those in fresh water because of greater dilution and distance from Chernobyl.

Observations:

In 1989, WHO was the first to raise concerns that the local medical scientists had incorrectly linked several biological and health effects to the radiation. The Government of the USSR then requested the International Atomic Energy Agency (IAEA)⁷ to coordinate an international experts' assessment of the Chernobyl accident's radiological, environmental and health consequences in selected towns of the most heavily contaminated areas in Belarus, Russia, and Ukraine.

Between March 1990 and June 1991, a total of 50 field missions were conducted by experts from 25 different countries. It showed some significant health disorders were evident in both the controlled as well as the exposed groups, but, at that stage, none of them was radiation related.

In 2003, the International Atomic Energy Agency established the Chernobyl Forum⁸, in cooperation with other United Nations organisations along with the competent Authorities of Belarus, the Russian Federation, and Ukraine. The reports prepared by two expert groups the "Environment", coordinated by the IAEA, and the "Health", coordinated by WHO, were intensively discussed by the Forum and eventually approved by consensus. The conclusions of this 2005 Chernobyl Forum study stated that even after 14 years of the accident thyroid cancer increase remained as a major public health impact attributable to the radiation exposure. There, were evidences even after 5 to 6 years of the accident, of increase in radiation-induced leukaemia.

The Report:

The Report Provided by the State Committee Stated⁹:

The 1991 report by the State Committee on the Supervision of Safety in Industry and Nuclear Power on the cause of the accident ignored the operator actions. It stated that although it was

⁷ The Chernobyl Accident www.pub.iaea.org

⁸ Chernobyl's Legacy - A report by The Chernobyl Forum: www.hps.org

⁹ Three Decades after Chernobyl: Technical or Human Causes? Nikolaus Muellner

true that the operators placed their reactor in a dangerously unstable condition, it was on the other hand also true that in doing so they had not violated any vital operating policies and principles, since no such policies and principles had been articulated. Besides this, the operating organisation had not been made aware either of the specific vital safety significance of maintaining a minimum operating reactivity margin, nor regarding the general reactivity characteristics of the RBMK which made low power operation extremely hazardous.

Thus, it is very much clear that the major mistakes on the part of the operators and particularly that by Mr. Anatoly Dyatlov who was the deputy chief engineer and the supervisor of the entire experiment which was being conducted at the reactor during the accident, were looked past only due to the lack of proper environmental guidelines and regulations relating to the operations of nuclear atomic power plants. Since no such laws related to maintaining any minimum level of reactivity margin was present and no such particular and strict legislations are yet present in today's day.

All these facts of the Chernobyl case thus leads to the urgency of putting more importance to the issues relating to the world environment and for drafting more stricter and modified international environmental laws.

IV. THE AFTERMATH:

The catastrophic accident at Chernobyl, the suffering of the people and the animals, the tragic end of the ones who were into immediate rescue and fire control process on site, all made it clear before the international community how poor the legal framework was when it came to nuclear disasters, especially since such issues were taken to be national and not something international or trans-boundary in nature. All these realisations led to a number of agreements, conventions and rules all guiding the subject matters related to nuclear power plants, their installation procedures, the principles of liability and safety issues, compensation in case of future instances and so on, in the upcoming years to be signed by countries at large.

V. CONCLUSION

To conclude, let us finally take a look upon the present scenario and discuss two points, the conventions and the non-convention states.

The International Atomic Energy Agency (IAEA)

Way before the Chernobyl disaster, right after the Three Mile Island accident in 1979 the IAEA had initiated the process of structuring some multilateral agreements on the issue of international cooperation or emergency assistance in case of a nuclear accident.

The Chernobyl incident added another crucial reason for implementing them at a hurry and thus, The Convention on Early Notification of a Nuclear Accident or the Early Notification Convention and, the Convention on Assistance in the case of a Nuclear Accident or Radiological Emergency or the Assistance Convention came into being.

The Joint protocol with regards to the Application of the Vienna and Paris Convention, the Convention on Nuclear Safety, the Joint Convention on the Safety of Spent Fuel management and on the Safety of Radioactive Waste Management, the Protocol to amend the Convention on Third Party liability in the Field of Nuclear Energy and many more were ratified, signed and agreed upon by a vast majority of the international community.

Position of the Non-Convention States Regarding Their Absence

The most important objection as pointed out by the non-convention states including some of the major nuclear power generating states like India, China, Japan and even the USA has been the principle of limited liability on which the conventions are based. Since this principal limit or restricts the liability to compensate the victims it somehow aids the ones responsible.

Thus, it is time now to have some reasonable approach by the international community and the United Nations in order to try and negotiate between the non-convention states in order to make the conventions and guidelines applicable to each and every nation, making some important up to date amendments keeping in mind the changing nature of warfare, terrorism, complex scientific approaches so that no “Chernobyl” be born in the future.
