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Understanding the Ongoing Nuclear Disaster in Fukushima: A "Two-Headed Dragon" Descends into the Earth's Biosphere

The Japanese original text is available

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The author assesses the Fukushima nuclear disaster in light of Hiroshima and Nagasaki, Hanford, Chernobyl, Three Mile Island and the nexus between nuclear weapons and nuclear power.

This summer, I participated for the seventeenth time in the "Pilgrimage for Peace," traveling to Hiroshima and Nagasaki with a group that included seventeen American students led by Professor Peter Kuznick of American University, seven international students from across Asia, and sixteen students from Japan. During our eleven days together, we had many discussions on the topic of "How to Understand the Relation between the Fukushima Nuclear Disaster and Hiroshima/Nagasaki." Our Canadian coordinator and interpreter Norimatsu Satoko and two students from Fukushima introduced by Gotō Nobuyo made a special contribution to these discussions.

In the midst of this, I was struck by the prescience of something the late Takagi Jinzaburō (Citizens' Nuclear Information Center) once pointed out. The Chernobyl nuclear disaster broke out on April 23, 1986, and shortly after that Takagi wrote the following:

> Nuclear technology is the equivalent of acquiring on earth the technology of the heavens….The deployment here on earth of nuclear reactions, a phenomenon occurring naturally only in heavenly bodies and completely unknown to the natural world here on the earth's surface, is…a matter of deep significance. For all forms of life, radiation is a threat against which they possess no defense; it is an alien intruder disrupting the principles of life on earth. Our world on the surface of this planet, including life, is composed most basically of chemicals…and its cycles take place as processes of combination and dissolution of chemical substances….Nuclear civilization always harbors in its womb a moment of destruction, like a ticking time bomb. The danger it presents…is of a kind completely unlike those we have faced before. And now isn't it the case that the ticking of its timer is growing louder and louder in our ears?[1]

Despite Takagi's words of warning 25 years ago, despite the painful experience of the atomic bombings of Hiroshima and Nagasaki, we failed to cultivate the ability to hear the ticking of the timer throughout the nation. It was against this background, sadly, that March 11, 2011 arrived. Here, I would like to explore the tasks that the present catastrophe presents for social science research.

Breaking Away from the "Celestial Fire" of the Cosmos: The Formation of the Earth's Biosphere

As Takagi emphasized, nuclear reactions taking place inside the nucleus of atoms (nuclear fusion and fission) are the "celestial fire," the original energy source of the cosmos. While chemical reactions (reactions that produce unions of atoms, i.e., molecules, through exchanges of electrons between atoms) were not entirely unknown in interstellar space, nuclear reactions remained the primary energy source, and the cosmos took form as a world swirling with ionizing radiation that they produced.

Some 3.6 billion years ago, on the ocean floor here on planet earth, the conditions necessary to produce a world of more complex, organic chemical reactions appeared, and the first primitive forms of life were born. In other words, the conditions for forming a realm in which life could be transmitted (the biosphere) were born on the ocean floor.

The primitive atmosphere that covered the surface of the earth at the time consisted almost entirely of carbon dioxide and water vapor. It was a harsh world, with high temperatures and harmful ultraviolet rays and ionizing radiation pouring in relentlessly from the sun. Ultraviolet rays damage cells on the body surface of living organisms, while ionizing radiation causes DNA scission in the cells of any living body it passes through. This was why primitive life could only survive at the bottom of deep oceans, where it was beyond the reach of those harmful forms of radiation.

Thanks to the photosynthesis of plants in the ocean, the carbon dioxide absorbed into ocean water was split into carbon and oxygen; the carbon sank to the ocean floor in the form of calcium carbonate, while the oxygen was released into the earth's atmosphere. As the oxygen content of the atmosphere increased, a part of the oxygen entered into an ionic reaction with ultraviolet rays to produce ozone (0_3), and gradually an ozone layer formed between twenty and fifty kilometers above the earth's surface. It shut out the ultraviolet rays and x-rays emitted with energy from the cosmos' nuclear reactions and became a crucial mechanism for protecting the earth's biosphere. In this way, an environment hospitable to life on land took form. As photosynthesis by plants on land increased, the concentration of carbon dioxide in the atmosphere further decreased. Eventually, the concentration of carbon dioxide declined to 0.04%, while the concentration of oxygen reached 21%—an optimal environment for living organisms.

These conditions led to the formation of our atmosphere, capable of blocking nearly all of the ionizing radiation released by the sun. In fact, astronauts living in the international space station orbiting in the upper atmosphere about 400 kilometers above the earth's surface are exposed to roughly one millisievert per day, a potentially lethal dose of ionizing radiation, but only 1/750th of this radiation reaches the planet surface. Nearly all of the radiation coming from space is filtered out by the atmosphere before it can reach the earth's surface.

As I noted above, energy from nuclear reactions is the driving force behind the formation of heavenly bodies. Even now, within the earth's core and mantle, nuclear reactions are occurring, generating geothermal energy. But a thick soil layer formed, blocking emission of radiation from the world of nuclear reactions at the earth's core, creating a mechanism that protects the earth's biosphere from nuclear reactions taking place in the netherworld far below. It is true that in the granite strata formed by hardened magma found in the Kerala region of India and on the southeast coast of Brazil, there are exposed geological layers that include radioactive isotopes. Anyone living in these places would be exposed to about ten millisieverts of natural radiation per year: like

outer space, these regions should be off-limits to human habitation. The lower the amount of ionizing radiation, which causes DNA scission in cells, the healthier it is for living organisms.

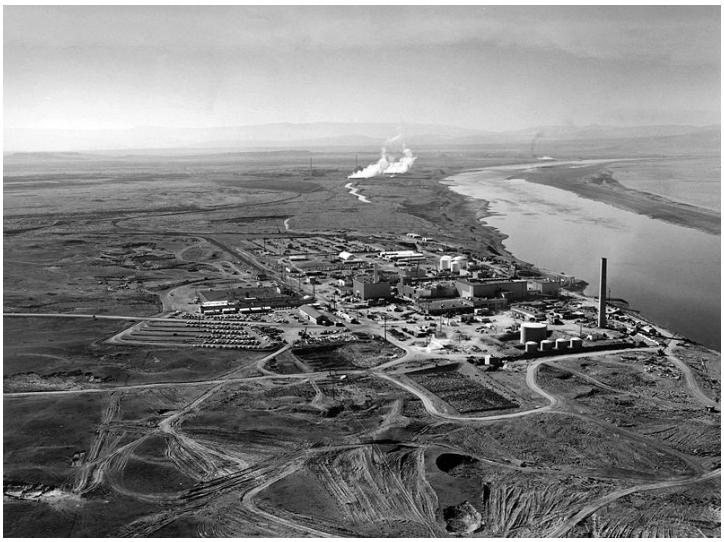
In this way the biosphere formed on the earth's surface. The earth's biosphere extends only to about fifteen kilometers above the ground and to about ten kilometers below the ocean surface. Combining both its upper and lower limits, it consists of a layer that is at best only 25 kilometers wide. In comparative terms, it is thinner and more fragile than the skin on an apple. The earth's biosphere is the precious product of more than three billion years of joint activities by the earth's living creatures. Protecting this world of life and passing it on to future generations is surely the single most meaningful task assigned to humanity.

"Nuclear Civilization": Moving Backward in Cosmic History

During World War Two a massive military research project was launched to collect radioactive uranium (the physical remnant on the earth's surface of nuclear reaction energy from outer space) and to condense it using electricity generated by the Tennessee Valley Authority, thereby anachronistically setting off nuclear reactions within the earth's biosphere. This was the famous Manhattan Project, begun with an investment in then-current values of more than two billion dollars.

Started as a plan by the military-industrial complex to steal the "celestial fire," the Manhattan Project might best be called a modern-day Prometheus. In terms of the history of the cosmos, it represented a turning back against the principles of life, a reactionary project that aimed to turn the earth's clock back some 3.6 billion years.

A reactor for producing plutonium was established at Hanford in the northwestern United States. The greatest waste product generated by this reactor was an enormous quantity of heat. Hanford discharged this heat into the Columbia River, and it was Admiral Hyman Rickover, the "Father of the Nuclear Navy," and the Electric Boat Company who first realized that this heat could be used as a source of engine propulsion power for submarines.



Hanford reactors along the Columbia River, 1960

Next, the American energy industry came into the picture: by moving onto land the reactors built for nuclear submarines and using them to generate electricity for the American economy, it could reduce the cost of nuclear submarine reactors through mass production and assure control over energy resources by the "Free World." The construction of the Fukushima Daiichi Nuclear Plant was part of this effort. The No. 1 reactor at Fukushima was a Mark I model reactor manufactured by General Electric, and the No. 2 and subsequent reactors were similar models.

This descent of the "celestial dragon" into the earth's biosphere led to a double metamorphosis. First, there was the appearance of what we might call the "raging dragon": nuclear weapons. Second was the appearance of what we might call the "sorcerous dragon": nuclear power. The "nuclear dragon" stole the secret of the "celestial dragon," which formerly presided over "celestial fire," and descended to the earth's biosphere, morphing into a "nuclear monster," a beast with two heads that then coiled itself on the earth.

How much of our tax money has this "nuclear monster" devoured, and how fat has it grown? For the U.S., the nuclear arms race cost six trillion dollars and space development one trillion dollars, producing some 50,000 nuclear weapons and warheads. Another 600 billion tax dollars were spent developing nuclear power; 104 nuclear reactors were built domestically, while still others were exported to allied nations. The Eastern bloc, led by the Soviet Union, pursued the development of nuclear power just as enthusiastically, with most of the socialist powers mistakenly seeing it as a progressive undertaking that would increase productive power. Eventually, some 434 reactors were built across the globe.

It was against this backdrop that the March 11 Tōhoku earthquake struck. What happened in Fukushima on March 11 and after? Let us begin by confirming the objective facts.

From Meltdown to Melt-Through

The Tōhoku earthquake made a direct hit on the Fukushima No. 1 Nuclear Power Plant. At 3:00 p.m. on the following day, March 12, a hydrogen explosion took place in the No. 1 reactor, followed by similar explosions in the No. 3 reactor on March 14 and in the No. 2 and No. 4 reactors on March 15. On March 21, there was another mysterious explosion in the No. 3 reactor.

The explosion that took place in the No. 3 reactor on March 14 was accompanied by a violent thundering sound and emitted a mushroom cloud several hundred meters high. This horrifying spectacle was widely reported abroad, including video footage. It was thus foreigners who were first made aware and fully informed that in "the country of Hiroshima" a catastrophe on a par with Chernobyl was taking place. Norimatsu Satoko brought this video to my attention, and when I watched it, I was stunned. Takahashi Tetsuya, who was born and raised in Fukushima, wrote that with the plutonium and uranium mixed fuel used in the No. 3 reactor, "Some people wondered if the uncontrolled reactions had reached a state of criticality and set off a miniature nuclear blast. When you watch the video, you clearly see black smoke pouring out and forming into the shape of a mushroom cloud. Viewing this repeatedly on YouTube, I couldn't help but recall Hiroshima."[2]

But NHK, Japan's public broadcaster, would not permit the airing of this video or others like it. The other major mass media outlets also consistently played down the scope of the ongoing nuclear catastrophe, minimizing the threat it posed. A news blackout was imposed that resembled the days of the Pacific War, when only official bulletins could be reported.

In the first stages of the crisis, its true nature was not fully reported even to the rulers of the U.S. At an early stage, "From data collected by an unmanned Global Hawk spy plane, the U.S. realized that temperatures in the reactors were extraordinarily high. It reached the conclusion that 'the nuclear fuel had already melted down' and pressed its Japanese counterparts for accurate information." In the early morning of March 16, with this information still being withheld from the public, the U.S. issued a threat: "We'll issue an emergence evacuation order for all 90,000 Americans in Tokyo to leave Japan. Do you really want to plunge Tokyo into panic?" In response, the Japanese government finally yielded to a second American Occupation: it permitted the dispatch of a

Fukushima explosion

large number of U.S. specialists to crisis headquarters.[3]

The tight restrictions over information reported to the Japanese public continued even after that. It was not until June 6, three months after the incident, that the Japanese government finally acknowledged that the No. 1 reactor had melted down just five hours after the earthquake, or that several days later the other three reactors had also reached meltdown (the stage at which nuclear fuel rods melt into a pool on the reactor floor) and then melt-through (the stage at which the molten fuel melts through the reactor floor to reach the outside).

March 15: The Largest Release of Radiation

How much radioactive material—in other words, radioactivity—was released into the atmosphere through these explosions and the process of "venting" (the intentional release of radiation from the reactors)? The No.1 reactor exploded on March 12, one day after the earthquake and tsunami, and the No. 3 reactor on March 14. At this stage, the amount of radiation released was still relatively small, and because winds were blowing toward the ocean the extent of onshore ground contamination was limited.

But on the evening of March 14, the core of the No. 2 reactor was fully exposed, and radiation levels around the plant began to rise.

> "The greatest danger arrived on March 15. At around 6:00 a.m., the pressure suppression chamber of the No. 2 reactor was damaged by a hydrogen explosion. A second explosion occurred at the same time in the No. 4 reactor, which was in shutdown mode for a regularly scheduled inspection. The cooling pool for spent fuel rods in the No. 4 reactor contained the maximum possible number of fuel assemblies, and there is a possibility that a considerable number of fuel rods were damaged or melted down, and that radioactive materials were emitted into the atmosphere."[4]

As a result, around 9:00 a.m. on March 15 a radioactive plume formed. The plume first moved in a southerly and then southwesterly direction, spreading radioactivity across across the Nakadōri region of Fukushima Prefecture.

From evening to nighttime of the same day, an "evil wind" struck the village of Iitate and Fukushima City, located northwest of the nuclear plant. Hayakawa Yuki of Gunma University, a specialist in volcanology, described the resulting situation:

> The radioactive material rode the winds a few dozen meters above the ground, brushing against the ground as it moved. This is why its distribution responded to the pattern of such geological features as basins and hillsides….The village of Iitate was exposed to severe contamination around 6:00 p.m. on March 15. That evening, the wind blowing at the Fukushima plant changed from the southeast. For Fukushima prefecture, this was the moment it became an evil wind. A highly radioactive plume reached Fukushima City around 7:00 p.m. and Kōriyama City around 8:00 p.m…. It then crossed over the old Shirakawa barrier and moved into Tochigi prefecture, reaching Nasu and Nikkō.[5]

"It was raining at this time in the northern parts of Gunma and Tochigi prefectures, causing hot spots with high accumulations of radioactive material to form." This is because the particles of radioactive cesium are so small that gravity alone will not make them fall: they typically will descend to the ground only if it rains.[6]

March 21: A Second Massive Release of Radiation

On the morning of March 21 the wind was blowing from the north. In areas downwind from the Fukushima Daiichi Nuclear Plant (including the Fukushima Daini Nuclear Plant and the cities of Kita Ibaraki, Takahagi and Mito), levels of airborne radiation suddenly spiked. What caused this abnormal jump? According to Tanabe Fumiya, an expert in nuclear power, at this same time the air pressure inside the pressure container of the No. 3 reactor, the one that used MOX (a mixed oxide fuel containing both plutonium and uranium), suddenly soared to 110 times the normal level. Because of this extremely high pressure, it was no longer possible to add cooling water from outside; as a result, the damaged fuel rods in the reactor once again went into meltdown, and the resulting build up of steam led to an explosion. The molten remnants of the fuel rods then breached the pressure container and leaked to the floor of the containment vessel. Tanabe concludes that the blast caused some of the radiation to escape the reactor, leading to contamination of the downwind region, an area extending from the interior of Fukushima prefecture to Kita Ibaraki.[7]

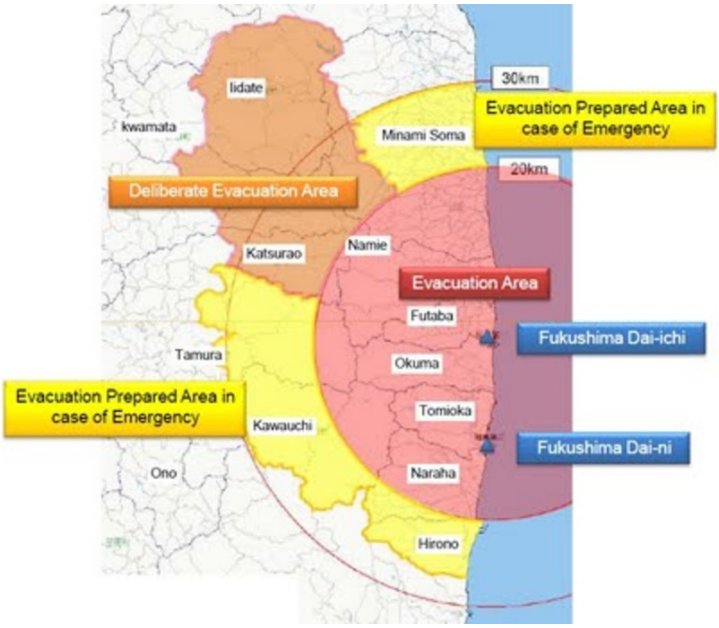
On March 23, a new plume formed, moving southwest from the coastal areas of Ibaraki through Chiba prefecture. During this period, most of the Kantō region saw several days of rain, resulting in accumulations of radioactive materials on the ground across the region.[8]

The Formation of Contaminated "Hot Spots"

In April, the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT) and the U.S. Department of Energy jointly conducted an extensive survey, measuring levels of soil radiation from elevations of 150-700 meters above the ground. They released a detailed map showing the distribution of contamination. Accumulations of cesium 137 (thirty year half-life) exceeding 600,000 becquerels per square meter indicate a level of contamination equivalent to that of areas subjected to mandatory evacuation during the Chernobyl accident; the April survey revealed that the area reaching this level of contamination covered some 800 square kilometers, mainly in Fukushima prefecture. (In Japan, however, these reports were underplayed out of fears they would

lead to mass evacuations of residents). This is an area equivalent to 40% of the Tokyo metropolitan area—or 1.2 times the size of Lake Biwa, the largest freshwater lake in Japan; it was roughly 10% of the size of the mandatory evacuation zone put into effect after the Chernobyl accident.[9]

On August 19, MEXT released the results of its calculations of the expected annual radiation doses for fifty locations within the restricted area located with twenty kilometers of the Daiichi plant. According to them, at 35 of the 50 locations the estimated annual radiation dose exceeded twenty millisieverts. This estimated annual dose of twenty millisieverts was the standard used in designating regions that would be "planned evacuation zones."



In the town of Ōkuma, home to the Daiichi plant, all twelve locations exceeded twenty millisieverts, with seven of them exceeding 100 millisieverts. The highest recorded level, 508 millisieverts, was recorded in the Koirino district of Ōkuma, about three kilometers southwest of the plant. This level represents the equivalent of a 500-year dose at the estimated maximum tolerable annual radiation exposure for the general population of one millisievert.[10] In contaminated regions, places showing critically high levels of radioactivity are called "hot spots"; these results made it clear that almost the entire area within twenty kilometers of the plants consisted of hot spots.

In late June, Yamauchi Tomoya of the Faculty of Maritime Sciences at Kobe University carried out a survey of radiation contamination in soil from four locations in Fukushima City, finding levels ranging from 16,000 to 46,000 becquerels per kilogram. It became clear that numerous hot spots had formed in Fukushima City, an urban center with a population of 290,000 located 62 kilometers from the nuclear plant.

Hot spots were discovered in many parts of the capital city, too, with its population of thirty million. Kashiwa in Chiba Prefecture is a suburban bedtown of Tokyo. The city is located some 200 kilometers from the Fukushima nuclear plant, but a soil sample taken from a roadside in an upscale residential neighborhood a two-minute walk from the JR Kashiwa commuter train station gave a radiation reading of 53,000 becquerels, exceeding the results found in Fukushima City. In the Chernobyl accident, this figure would have resulted in the location being declared a mandatory evacuation zone.[11]

On June 10, in the largest tea-growing region of Shizuoka prefecture, some 370 kilometers from the nuclear plant, harvested tea leaves were found to be contaminated with radiation, and shipments of Shizuoka tea were halted. Pastures in Ichinoseki in Iwate prefecture, 170 kilometers from the plant, were found to have cesium levels more than three times the provisional limit. In July, widespread contamination of hay being fed to beef cattle was confirmed, and on July 25 radioactive cesium was detected in wheat and rapeseed from Fukushima.[12] Concern mounted about the possibility of contamination spreading to the rice crop.

The leaked radiation quickly crossed international boundaries and drifted across the globe. Radioactive material emitted from the plant March 12-16 was captured in the ascending air currents that accompanied the low pressure system and rode the jet streams to the east at a speed of 3,000 kilometers a day. They reached the U.S. on March 18, and traces of lethal plutonium were detected across the West Coast.[13] Fukushima's nuclear disaster was now a global nuclear disaster.

The Amount of Radiation Released from Fukushima Daiichi

Since the explosions that breached their housing structures, the reactors have been exposed to the open air, and they continue to leak radiation. On March 15, the highest level of emission was recorded: 200 tb/hour (tb=terabecquerel; one terabecquerel = one trillion becquerels). After the initial crisis, levels began to decline on March 21, and the average emission level for May dropped to 0.0002 tb/hour (two billion becquerels) and for June to 0.001 tb (one billion becquerels). By June, the level dropped to 1/200,000th of what it had been on March 15.[14]

Of course, the danger remains that a large aftershock could further compromise the already badly damaged reactors, and any damage to plant pipelines or underground containment structures could also lead to a sudden increase in emissions. The eastern part of Fukushima prefecture was hit with aftershocks of magnitude 6.4 on July 1 and 6.0 on August 12. At roughly the same times, there were incidents of radioactive steam escaping from cracks in the ground inside the plant compound. Professor Robert Jacobs of Hiroshima City University pointed out that the danger was not that the reactors could disintegrate, but that the molten cores might escape the buildings and let off significant radiation.

How much radiation in total has been released into the atmosphere by the Fukushima Daiichi Nuclear Plant since March 11? As of

April, Tokyo Electric (TEPCO) and the government estimated total emissions at 370,000 tb, but at a June 6 press conference they revised this figure substantially upward to 770,000 tb.

How much radiation was released into water (including cooling water in the plant, underground water, and the ocean)? As of July 20, the amount of contaminated water accumulated in the four reactor buildings and turbine structures totaled approximately 96,000 tons. If we add to this the 22,000 tons transferred from the reactor structures to central waste processing facilities at the plant, the total amount of contaminated water now accumulated inside the plant is 117,000 tons.[15] TEPCO estimates the total radiation in this contaminated water at about 800,000 tb; if this figure is close to being correct, it means that the amount of radiation in this on-site water is roughly equal to the total amount released into the atmosphere—a massive contamination of water.

Radioactive Water and Contamination in the Oceans

While both are radiation leaks, there is a significant difference in environmental impact between leaks into the atmosphere and those contained within the plant's cooling water. The 770,000 tb released into the atmosphere immediately spread beyond the plant to contaminate the environment outside the plant.

The situation is different with the 800,000 tb emitted into plant cooling water. From the total of 117,000 tons of contaminated water, it has been reported that 520 tons were discharged into the ocean outside the plant, producing a radiation leak of 4720 tb. If this information is accurate, this means that 99.6% of the contaminated water, including 99.4% of the total radiation that has been emitted into water, remains inside the plant facility and is not believed to present an immediate threat to the environment outside the plant.[16]

But we would be mistaken to conclude from this date that the contamination of the ocean is not a major concern. First, we need to note that compared to normal environmental standards, 4720 tb of radiation is an extraordinarily high figure. The maximum annual limit for radiation emissions into the ocean for the Fukushima Daiichi Nuclear Plant was 0.24 tb. Despite this, contaminated water containing radiation at 20,000 times this limit was discharged into the ocean over a period of four months.

Moreover, the estimated figures give no information about what will happen with radioactivity released into the atmosphere or ground. Eventually, nearly all of the radiation released into the atmosphere will fall to the surface to be absorbed into the ground or ocean. Radiation that settles on the ground in Japan will be washed away by rain into rivers that ultimately flow into the ocean. Clearly, in the long term most of the radiation released into the atmosphere will end up being absorbed into the ocean. It seems inevitable that through these multiple routes, radiation levels in the ocean will rise, accelerating the biological concentration of radiation, which will in turn gradually move up the food chain to concentrate in the bodies of larger fish and, finally, human beings.[17]

Comparison with Hiroshima

If we combine the 775,000 tb total radiation released outside the facility from the four reactors and fuel storage pools at the Fukushima Daiichi Nuclear Plant with the 800,000 tb contained in the contaminated water accumulated inside the facility, the total emission of radiation amounts to roughly 1,570,000 tb. How does this figure compare to those for previous nuclear weapon blasts and nuclear accidents?

To begin with the uranium-based nuclear bomb dropped on Hiroshima on August 6, 1945, in fact only about 10-15% of the uranium 235 contained in that device achieved fission, with the remainder dispersing. As a result, the total release of radioactivity was limited to 13,000 tb. With the plutonium-based implosion-type weapon dropped on Nagasaki, 15-25% of the plutonium fuel underwent a fission reaction, producing a total radioactivity of about 20,000 tb. In today's nuclear weapons, a hollow space at the center of the fissionable material is filled with a fusion material (tritium or similar materials) called a "booster," allowing a blast that achieves a 100% fission rate. This has made possible the creation of smaller and more efficient weapons. Compared to these, the device used at Hiroshima now seems almost like a toy.

To put this all in comparison, a typical million-kilowatt class nuclear reactor will produce in a single day of operation as much "deadly ash" (spent nuclear fuel) as three explosions of a Hiroshima-class bomb. This means that in a year of operation, a typical reactor produces as much "deadly ash" as a thousand Hiroshima-class detonations. Each day, today's nuclear reactors use as much energy as it would have taken to detonate three Hiroshima-class bombs to heat large amounts of water and drive enormous electricity generators.

The amount of radioactivity emitted to the outside world by the Fukushima Daiichi Nuclear Plant is said to be 775,000 tb. This amounts to a radiation leak equivalent to the detonation of sixty Hiroshima-class, or 39 Nagasaki-class, nuclear bombs.

Cesium is a particularly worrisome radioactive material: with a half-life of thirty years, it produces particularly severe and long-lasting contamination of foodstuffs and soil. If we use only cesium 137 as our comparison point, preliminary figures released by the government indicate that 15,000 tb were emitted from Fukushima; this amount corresponds to the equivalent of 168 Hiroshima nuclear blasts.[18]

Professor Kodama Tatsuhiko, a specialist in nuclear issues at the Isotope Center of the University of Tokyo Research Center for Advanced Science and Technology, testified before the Japanese House of Representatives' Committee on Welfare and Labor on July 27, 2011.

> "Based on our scientific knowledge…at the Isotope Center, we calculated the quantity of heat that has escaped [from the reactors at the Fukushima Daiichi plant] as being equivalent to 29.6 Hiroshima-level nuclear blasts….Even more troubling is [the enormous difference between] the size of the residual effect from radiation due to an atomic bomb and that due to radiation that has leaked from the nuclear reactors. While the residual effect will decrease to a level of 1/1000th after one year for an atomic bomb blast, the radioactive material from the reactors will decrease only to 1/10th in the same period. In sum, the current trouble at the Fukushima plant is similar to Chernobyl in that they both involve the release of radiation in quantities equivalent to those from dozens of atomic bombs, leaving a much higher residual effect than was the case for contamination by atomic bombing."

Not only has Fukushima seen the release of radioactivity equivalent to dozens of Hiroshima-class atomic bombs, but the rate at which that radioactivity will decrease is one hundred times slower, Professor Kodama testified.

Why will it take so much longer for the radiation in Fukushima to decrease than it did for Hiroshima? This is because the radioactive material used in the reactors includes material with a long half-life. A long half-life means that, while it is unlikely to cause acute radiation sickness because the amount of radiation per unit of time is relatively low, it will cause long-term exposure to low-level

radiation. In particular, people who ingest radiation from the nuclear plants by breathing or eating will experience chronic internal exposure to low-level radiation. The result is a determinate increased risk of incidence of cancer and other health problems within as little as five years, or as many as ten to thirty years.

In Hiroshima, by contrast, most of the radioactive material used had a short half-life. In addition, on September 17, soon after the bombing, a typhoon struck the city, leading to floods about a meter deep across the entire blast area; as a result, much of the radioactive material was washed away into the Inland Sea.[19] Within a half year of the bombing, residual radiation levels in the city had decreased to levels enabling safe habitation.

Comparison with Three Mile Island and Atmospheric Nuclear Tests

How does the current disaster compare with the March 28, 1979 nuclear accident at the Three Mile Island Nuclear Plant in suburban Harrisburg, Pennsylvania? At Three Mile Island, the total radiation leak amounted to 91,000 tb. By contrast, already in Fukushima 17.3 times as much radiation has leaked out of the reactors, and 8.6 times as much radiation has been emitted outside the plant facility, as at Three Mile Island.

In the 35 years between 1945 and 1980, the U.S., USSR, France and China carried out atmospheric nuclear tests that also released radioactivity. How do these compare to Fukushima? These atmospheric nuclear tests represent the greatest instances of radiation release in human history. The period from 1950 to 1963, in particular, saw a competition between America and the Soviet Union to produce ever larger hydrogen bomb test explosions on the Bikini Atoll and Semipalatinsk sites. The after-effects of radioactive contamination from these linger today. In the 543 atmospheric tests carried out, 3,000,000,000 tb of radiation were released—a total 580 times that released in the Chernobyl accident.[20] This is equivalent to 1900 times the total radiation leak from the reactors in Fukushima. In recent years, global rates for the incidence of cancer have risen sharply, and it seems likely that these past atmospheric tests are one cause. We may still be suffering from the after-effects of the history of atmospheric testing.

Comparison with Chernobyl

In the April 26, 1986 nuclear disaster at Chernobyl, only one reactor (the No. 4 reactor) went into meltdown. A considerable portion of the two hundred tons of radioactive uranium and graphite contained in the reactor was discharged in the explosion, leading to the emission of 5,200,000 tb of radiation into the atmosphere. (The contamination of cooling water, however, remained relatively small scale). An enormous radioactive plume formed and drifted across Ukraine, Belarus and Russia before moving into the countries of northern Europe.

Looking only at total radiation leaked into the atmosphere, Chernobyl was 6.7 times larger than Fukushima. If we include contamination of water, it was 3.3 times larger than Fukushima. In other words, when we use the combined total radiation leaks into the atmosphere and water as point of comparison, total radiation emissions in Fukushima have already reached a level of one-third the size of the Chernobyl accident.

In Chernobyl, more than 400,000 people were evacuated, with over 2,000 villages becoming ghost towns in the process. Even today, 25 years later, the exclusion zone continues to expand and the area remains in a state of paralysis in terms of economic activity.

What was the cost of the Chernobyl disaster in terms of the health of local residents? Alexey Yablokov, an adviser to the Soviet government at the time of the accident, edited *Chernobyl: Consequences of the Catastrophe for People and the Environment* (2007; English translation 2009) a groundbreaking work that surveyed more than 5,000 studies published in Russian and other languages. I will draw here on Sakuma Tomoko's useful summary of its conclusions. Concerning the number of deaths caused directly or indirectly by the nuclear accident,

> "As of 2004 the total has reached 985,000. This figure is hundreds of times greater than estimates produced by the International Atomic Energy Agency….In Belarus, 90% of children were in good health in the year before the accident, but in 2000 this rate decline drastically to less than 20%, and from 1986 to 1994 the infant mortality rate climbed to 9.5%. According to a 1993 survey of two regions exposed to high levels of cesium 137, only 9.5% of children who had been aged 0-4 at the time of the accident were in good health."

According to Sakuma, the levels of contamination for those two regions were on par with those found up to fifty kilometers northwest of the Fukushima power plant.[21]

A significant health cost was also visited on the people of Ukraine. The photographer Hirokawa Ryūichi visited Ukraine in February, 2011, 25 years after the accident, and met with Anatoly Romanenko, Ukrainian Minister of Health at the time of the accident. In his interview with Hirokawa, Romanenko says

> "The 53,000 square kilometer area of Ukraine that was contaminated remains unchanged today. 2.55 million people were evacuated, 500,000 of them children….The results of a study involving more than two million Ukrainian citizens….showed that even among those who were not exposed to high levels of radiation, many had become ill….Among the subjects of the study, 68% were in good health before the accident. But among the people from that category, only 6% are in good health today. In particular, there has been an increase in the incidence of tumors and related conditions."[22]

The Amount of Radiation Lying Dormant in Fukushima Daiichi

What is the total volume of radioactive material (nuclear fuel) accumulated at the Fukushima Daiichi Plant? In the case of Chernobyl, the accident involved only the No. 4 reactor, which contained 200 tons of nuclear fuel. In comparison, at Fukushima the six affected reactors and cooling pools for spent fuel rods contain 2,000 tons, or roughly ten times the amount of nuclear fuel that was involved in Chernobyl.[23]

How does this compare in terms of radiation levels? The 2,000 tons of nuclear fuel at the Fukushima Daiichi Plant is estimated to contain about 20,000,000 tb of radiation. This means that the Fukushima plants holds an accumulated total radiation equivalent to 138 times the amount that leaked from the Chernobyl plant, or 24% of the total radiation released during the history of atmospheric nuclear tests.

At present, only 0.2% of the total radioactivity of the plant's nuclear fuel has leaked into the atmosphere or plant cooling water, but

even at this limited level, the radiation leak has already reached one-third the scale of the Chernobyl disaster. Additional aftershocks, deliberate attacks on the plants (including the possibility of terrorism), or human error could further damage the Fukushima reactors. If only 1% of the accumulated radiation were to escape in such an incident, it would amount to a leak of 7,200,000 tb, making it the worst nuclear accident in history, exceeding even Chernobyl (5,200,000 tb).[24]

The Fate of 2000 Tons of Damaged Nuclear Fuel

On the floors of the Fukushima Daiichi reactors, the "enchanting dragon"—some 2,000 tons of half-melted nuclear fuel—coils itself up and waits. To prevent this enchanting dragon from discharging its toxicity, it will be necessary to continue dumping large amounts of cooling water on it for decades to come.

A "recycled water cooling" system has been set up to avoid having to use large quantities of fresh water. If the system functions as planned, radioactive cooling water will be decontaminated and then recycled to cool the reactors. The system uses equipment from France's Areva and the U.S.'s Kurion companies, and on August 16 this was supplemented with a "Sally" adsorption filter for radioactive cesium produced by Toshiba. But between June 1, when the system was put into operation, and August 9, it was only able to operate at a cumulative 66% of projected capacity. The total volume of contaminated water treated as of August 9 was a mere 42,000 tons, with an additional 120,000 tons sitting untreated underground beneath the turbine housing structures and elsewhere.[25]

Effective decontamination of radioactive water involves an operation in which chemicals are first added to cause it to sediment, after which the remaining radioactive material is removed by adsorbent agents. The radiation level of the contaminated sediment produced through this process is more than 100 times higher than that of highly contaminated cooling water—a substance so dangerous it can only be handled by remote control.[26]

Let's assume the most favorable possible outcome: no massive aftershocks or armed attacks, and the successful production of a reliable cooling water recycling system that is able to fully re-circulate decontaminated water back into the plant. This would mean an end to the nightmarish prospect of unlimited generation of more and more contaminated water. But the decontamination process will also produce a large quantity of highly radioactive sediment day after day. For example, the Toshiba "Sally" operates by running radioactive water through a tower filled with zeolite, which decontaminates water by adsorbing the radioactivity of the cesium in it.[27] But this will result in the daily production of large amounts of dangerously radioactive zeolite.

The total rubble left behind by the earthquake and tsunami in the three most affected prefectures is estimated at 22,630,000 tons. Much of this is radioactive, and high levels of radiation have also been detected in incinerator residue from household waste and sewage. We somehow need not only to separate out and secure this radioactive waste, but also to store safely the large amounts of contaminated zeolite that are now going to be produced at the plant.

That is not all: we also face the enormous task of figuring out how to reduce and finally extinguish the 2,000 ton enchanting dragon that still occupies the plant. It seems the only way to do this is to keep pouring in vast quantities of water, as if to wash away the dragon's scales one thin layer at a time, dissolving the radioactive materials into the water and then adsorbing it into zeolite. If this in fact turns out to be the case, how much radioactive water will need to be decontaminated until the dragon finally disappears? How much contaminated zeolite and other highly radioactive materials will be generated in the process? How much time and money will be needed to store and secure these contaminated byproducts? Today nobody can answer these questions with any degree of certainty.

Prospects for Resident Health in Five Years and Beyond

According to data released by the Ministry of Internal Affairs and Communications on July 27, as of October, 2010—that is, before the disaster—Fukushima prefecture had a population of 2.3 million. After the nuclear accident, earthquake and tsunami, 46,000 persons evacuated to locations outside the prefecture.[28] If we included those who evacuated to areas within the prefecture this figure would of course be larger, but for the present it represents about 10% of the number evacuated after Chernobyl. Fukushima will likely follow not the path of Hiroshima, but rather of Chernobyl: ongoing contamination of ground and seas over the long term, with chronic low-level exposure to internal radiation.

ECCR scientific secretary Christopher Busby, whom I have already cited several times, included the following two clauses in the conclusion to "The Health Outcome of the Fukushima Catastrophe," a paper he published three weeks after the accident:

> 1. The ECRR risk model has been applied to the 3 million people living in the 100km radius of the Fukushima catastrophe. Assuming these people remain living there for one year the number of excess cancers predicted by the method is approximately 200,000 in the next 50 years with 100,000 being diagnosed in the next 10 years. If they are evacuated immediately, the number will fall by a significant amount. For those 7 million living between 100km and 200km from the site, the predicted number of cancers is slightly greater with 220,000 extra cancers in the next 50 years and about 100,000 being expressed in the next ten years. These predictions are based on the ECRR risk model and also the findings of cancer risk on Sweden after the Chernobyl accident.
>
> 5. It is recommended that populations living within the 100km zone to the North West of the site are immediately evacuated and the zone is made an exclusion zone.[29]

Sasaki Sadako was two years old at the time of Hiroshima; she did not develop leukemia until 1954, nine years after the atomic blast. Following Chernobyl, too, it was not until five years had passed that rates of thyroid cancer among children suddenly spiked. The world waits to see what health problems the people of Fukushima, especially the children, will face in five years and beyond.

In Place of a Conclusion

Through the collective efforts of primitive life forms starting some 3.6 billion years ago, the ozone layer and atmosphere took shape, and hospitable lands and oceans capable of sustaining the earth's biosphere slowly emerged. By contrast, in this "Nuclear Age," the "celestial dragon" bearing the "celestial fire" has suddenly descended to the earth's biosphere, transforming into a monster with two heads: the raging dragon (nuclear weapons) and the enchanting dragon (nuclear power),

I once had the opportunity to visit in America the artist Mayumi Oda, known for using goddess imagery in her depictions of mother earth. I would like to conclude by thinking about a painting of hers that portrays a two-headed dragon. Promoters of nuclear energy looked only at the heads of the dragon and declared that we could distinguish between "atoms for war" and "atoms for peace" and keep them separate. But under the harsh realities of capitalism, it is nearly impossible to separate cleanly the two heads of the

dragon. The French oceanographer Jacques Cousteau, addressing the United Nations General Assembly in May, 1975, correctly warned that "We are far too nationalistic in spirit to succeed in holding peaceful atoms and war-like atoms apart for long; we have not conquered our fierce aggressiveness. We are unable to embrace atoms for peace while rejecting atoms for war. If we want to preserve human life, we must learn to abandon both."

The danger of building nuclear plants in regions susceptible to earthquakes is frequently pointed out, but we should also have paid closer attention to and sounded alarm bells about the danger of building nuclear plants in areas susceptible to outbreaks of war. Nuclear power was trumpeted as the model for the "peaceful use of nuclear energy," but in reality this was the "delusion of peaceful use." Under the U.S. Japan Mutual Security Pact (AMPO), all of Japan was turned into a U.S. military base, the "unsinkable aircraft carrier" at the heart of America's new strategic plan for warfare on an unprecedented scale. At the same time, based on the foolishly optimistic and baseless "assumption" that war would never break out, we eagerly pursued the construction of nuclear plants on the cheap.[30] Why? Because keeping up this "delusion of peaceful use" allowed the production cost of electricity to drop, leading to increased profits, which in turn underwrote the bribes known euphemistically as "political contributions."

What would happen if the Korean War, paused now under the terms of a still temporary ceasefire, were to erupt back into open combat? "Nuclear plants cannot be defended militarily from armed attack. Accordingly, the nuclear plants spread along Japan's coastline are in effect nuclear weapons in the hands of a hypothetical enemy....Once its nuclear plants come under armed attack, the land of Japan will become permanently uninhabitable," declared retired nuclear engineer Ogura Shirō, who concludes, "The presence of nuclear plants render it impossible for us to defend ourselves in case of war."[31] This is a crucial fact: if the Korean War were to explode into open combat again, the utterly vulnerable Fukushima Daiichi Plant would inevitably present an ideal target; this state of utter vulnerability will continue for decades into the future.

If we can muster the political will, there is one task that we can readily accomplish: bring the Korean War to a permanent conclusion and transform East Asia into a completely war-free zone. This is clearly the most important task facing Japanese diplomacy post-March 11, and if it can be achieved, AMPO will start to lose its seemingly supernatural powers.

Takahashi Tetsuya, a native of Fukushima, puts the problem in the following terms: "If it is true that emperor-system militarism was the core of Japan's wartime political order, then isn't it just as true that the doctrines of AMPO and nuclear power have formed the core of Japan's postwar political order?"[32] This is a very sharp observation. AMPO and the nuclear plant network of public works that supports it: this system permits electric utilities to push onto the market relatively high electricity prices that cover their costs and provide a fixed profit, and it is also the basis of political fundraising for both the Liberal Democratic Party and the Democratic Party of Japan.

The present crisis surrounding Japan's nuclear plants has made it clear that the key to guaranteeing peace lies not with AMPO, but with concluding a peace treaty to end the Korean War and the establishment of a war-free region. Moreover, if we can root out the politics-by-bribery of the electricity utilities, sustained by their nuclear plants, there is a possibility we could dismantle the hidebound structure of politics in Japan. If we can simultaneously free ourselves from AMPO and the nuclear plants, the pillars of the whole corrupt postwar Japanese establishment will crumble.

Fukushima continues even now to be visited by frequent, ominous aftershocks. The 2,000-ton enchanting dragon, with its 720,000,000 tb of radiation, writhes and coils in the land of Fukushima. As we keep a watchful eye on this enchanting dragon descended from the heavens, trying to keep it from discharging its poison, how can we drive it out from the earth's biosphere and back into the heavens (or into the netherworld at the earth's core)? We will be wrestling with this problem for decades to come.

In the Old Testament, the following passage appears: "Then the Lord answered Job out of the whirlwind, and said, Who is this that darkeneth counsel by words without knowledge?.... Hast thou commanded the morning since thy days; and caused the dayspring to know his place?"[33] In the coming years, this question will be our own cross to bear, as we seek to find a new way of life.

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See other articles on Fukushima in the What's Hot section on Asia-Pacific Journal: Japan Focus

And a complete list of articles on 3.11 Earthquake, Tsunami and Atomic Meltdown.

Notes

[1] Takagi Jinzaburō, *Cherunobuiru genpatsu jiko shinsōban* (Tokyo: Nanatsu Mori Shokan, 1986).

[2] Ko Sanmyon and Takahashi Tetsuya, "Nihon no ariyō ga towarete iru," *Sekai* (August, 2011), p. 112.

[3] *Yomiuri Shinbun* (August 17, 2011).

[4] *Asahi Shinbun* (July 10, 2011).

[5] Hayakawa Yuki, "Hōshanōgumo wa kono yō ni zujō wo tsūka shita!," *Shūkan Kinyōbi* (July 8, 2011), p. 22.

[6] *Nihon Keizai Shinbun* (July 25, 2011).

[7] *Asahi Shinbun* (August 8, 2011).

[8] *Asahi Shinbun* (August 8, 2011).

[9] *Asahi Shinbun* (May 11, 2011).

[10] *Asahi Shinbun*, evening edition (August 20, 2011).

[11] *Shūkan Gendai* (August 6, 2011), pp. 64-65. See also the interview published in the July 30 issue of the same magazine with the University of Ulster's Christopher Busby, scientific secretary of the European Committee on Radiation Risks (ECRR).

[12] *Mainichi Shinbun* (July 26, 2011).

[13] "Beikoku made hirogatta purutoniumu," Norimatsu Satoko's interview with Christopher Busby, *Shūkan Kinyōbi* (July 8, 2011), pp. 24-25.

[14] *Asahi Shinbun* (July 29, 2011).

[15] *Asahi Shinbun* (July 21, 2011).

[16] *Asahi Shinbun* (July 10, 2011).

[17] Nakachi Shigeharu, "Suisan no osendo wo yomitoku," *Shūkan Kinyōbi* (July 29, 2011), p. 18.

[18] *Nihon Keizai Shinbun* (August 27, 2011).

[19] Yagasaki Katsuma, "Naibu hibaku kakushi ha hōshasen giseisha kakushi," *Nihon no Kagakusha*, Vol. 46, No. 8 (August 2011), p. 6.

[20] *Kakuheiki Kakujikken Monitaa*, Vol. 373, No. 4 (April 15, 2011).

[21] "Sakuma Tomoko Shabekurihōdai," *Oruta*, No. 429 (August 2011), p. 38.

[22] Hirokawa Ryūichi, "Cherunobuiru no nazo no ame," *DAYS JAPAN* (July 2011), p. 43.

[23] This estimate comes from the ECCR's Christopher Busby. See *Shūkan Kinyōbi* (July 8, 2011), p. 25.

[24] *Ashahi Shinbun* (June 11, 2011).

[25] *Nihon Keizai Shinbun* (August 17, 2011).

[26] *Asahi Shinbun* (June 10, 2011).

[27] *Akahata* (August 24, 2011).

[28] *DAYS JAPAN* (September 2011), p. 18.

[29] Christopher Busby, "The Health Outcome of the Fukushima Catastrophe." A Japanese translation is also available.

[30] Tanaka Toshiyuki, "'Genshiryoku heiwa riyō' to Hiroshima: Senden kōsaku no tāgetto ni sareta hibakushatachi," *Sekai* (August, 2011).

[31] Ogura Shirō, "Genpatsu wo narabete jiei sensō wa dekinai," *Kikan Ribureiza*, No. 3 (Summer 2007).

[32] *Mainichi Shinbun* (June 17, 2011).

[33] King James Version, Job 38:1-2, 12, and the source of the title for Pearl S. Buck, *Command the Morning* (1959).