[Form 2 (to be reported to Committee on Countermeasures for Contaminated Water Treatment and to be disclosed to public)

Technology Information	
Area	1,3,5,6 (Select the number from “Areas of Technologies Requested”)
Title	**Proposal for controlling ground water and radioactive leakage in Fukushima Daiichi Nuclear Power Station**
Submitted by	World Water and Climate Foundation

1. Overview of Technologies (features, specification, functions, owners, etc.)

1. Introduction

The accident at the Fukushima Daiichi Nuclear Power Station resulting from a large tsunami induced by a magnitude 9.0 earthquake on 11 March 2011 is still causing very serious environmental problems. The leakage of radioactive waste to ground water especially has not been controlled and contaminated water is likely to continue to flush into the Pacific Ocean where local flora and fauna will suffer as well as coastal and even off shore fisheries. Biomagnification of pollutants is well known in both marine and freshwater ecosystems. Tokyo Electric Co. Ltd. announced that these accidental leakages were caused by human mistakes. If this explanation is correct, the workers at the site are becoming exhausted after a long period of hard work and/or most of them are not skilled enough to manage the damaged system. Whatever the cause, we can say that this contamination will or has already reached a critical level for people working in the area of the power plant.

It has been reported that Tokyo Electric Co. Ltd. has a plan to freeze soil around the plant to separate ground water from the radioactive waste leaking from the broken reactors. However, this idea may not be sustainable as it will require enormous amounts of expensive energy to create and maintain the ice shield over the 200-year period that will be required for the reactors to be decommissioned. A frozen wall was only previously used at Oak Ridge National Laboratory (Tennessee) to keep radioactive waste for only six years; this project was more than one order of magnitude smaller than the Fukushima one. Freezing soil is a very costly and problematic solution. The problem with freezing, as we know from lakes and permafrost in the polar regions, is that solutes may be expelled from the ice during the freeze-up process. This can result in extremely concentrated saline solutions that do not freeze even at low temperatures. It is likely that under these conditions radioactive materials could become highly concentrated in dense brines that could then flow as density currents. This will need to be very

Fig. 1 Building deformation as a result of partial thawing of permafrost, Norilsk, Russia (Grebenets 2003).

carefully evaluated (Schmidt et al. 1991, Kudoh et al. 2009). Also, heating and cooling during the four annual seasons in Japan may make the ground of the station site softer and wetter like a swamp, and it could create another risk to the reactors, such as building destruction as shown in Figure 1 (Grebenets 2003). That is why we are proposing an alternative method to control ground water and radioactive waste water more efficiently, effectively and safely.

2. Method

We need to set up three requirements in order to implement our plan: One is to control ground water in the area of the plant and the second is to isolate the radioactive waste. The third requirement is not to use a complicated electronic system dependent upon constant refrigeration but to use a viable method that everyone understands and will have confidence in. If the system is too complicated, we will face a much higher risk of failure. We need, therefore, to put a more natural and more mechanical solution in place. First, as seen in Figure 2, we will construct a canal (blue line) to divert ground water from reaching the plant. As a high mountain area is close to this site, a large amount of ground water could flow continuously toward the power station site. The depth of the canal required will be determined from the depth to the impermeable ground stratum, which will probably be at a depth of about 30 m. The upslope wall of the canal should be permeable for ground water and the downslope wall must be impermeable to both groundwater and the radioactive waste it will contain behind the wall. This means ground water can get into the channel, but waste water cannot get out from around the reactors. From the slope of the canal the uncontaminated ground water will continuously flow into the Pacific Ocean.

Fig. 2 Fukushima Daiichi Nuclear Power Station. Blue line denotes "Canal" and red line does "Inner channel" to be constructed. Those locations are not fixed.

Next, we will construct an inner channel with a depth of 10 m around the reactor buildings. As we do not know the exact situation with the reactor buildings, we leave flexible at this time the specifications for this channel. It is likely that remote controlled equipment will be required for preventing personnel from being exposed to the radiation. Both side walls of the inner channel will need to be permeable. The water level of the channel will always be kept mechanically higher than the water level of the reactors to avoid waste flowing from inside to outside. On the bottom of the channel we will place, an impermeable sheet to collect heavy compound deposits . It will also be necessary to further investigate the applicability of biotechnology to strip the radioactive component from the water, which then could be returned to the environment without a problem. Some phytoplankton and microbial bioreactors are known to absorb radioactive compounds and this might prove useful for concentrating and then removing the radioactivity. In this process some green house gas$_t$ created from power and other industries in Japan could be utilized. These waste sources of CO_2 could be used to sustain higher growth rates in the bioreactors . Our concept would simultaneously create a tool to help solve major environmental contamination: leaking radioactive waste from the damaged nuclear power plant, while at the same time reducing the release of CO_2 to the atmosphere. After removing algae and other microorganisms that would be concentrated and stored to allow for radioactive decay, the water could be recycled and used for cooling the reactors.

3. Evaluation and monitoring

This canal and channel combined system is just like a Japanese castle, which usually has an outer channel and inner channel (Figure 3). In 200 years when the toxic radiation will be gone, this area (a memorial castle of the nuclear power station accident) could become a famous sightseeing spot like the pyramids in Egypt. We believe that in this way our generation may leave something useful to future generations from this terrible accident.

Fig. 3 Castle of Japan with a channel

To evaluate the effectiveness of the system routine monitoring of radioactivity will of course be done both within and outside the barrier wall surrounding the facility . This is now easily acheivable through remote reporting stations located both inside and outside the barrier walls.

Ground water moniroring for water flux and radioactive compounds: (A) around the plant in the terrestrial system [drilling wells], and (B) radioactive monitoring of submarine ground water discharge to the ocean along the coastal line (to detect spatial distribution of possible leakage). Monitoring of marine sediments and migration of radioactive material through trophic (biological) chains (both benthic and planktonic) will be undertaken to determine if radioactive accumulation is occuring in these components of the marine environment.

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References

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2. Notes (Please provide following information if possible.)

- Technology readiness level (including cases of application, not limited to nuclear industry, time line for application)

  Diversion can be often used for lake restoration against eutrophication.

- Challenges

- Others (referential information on patent if any)

【Areas of Technologies Requested】

(1) Accumulation of contaminated water (Storage Tanks, etc.)

(2) Treatment of contaminated water (Tritium, etc.)

(3) Removal of radioactive materials from the seawater in the harbor

(4) Management of contaminated water inside the buildings

(5) Management measures to block groundwater from flowing into the site

(6) Understanding the groundwater flow