Discussion of current topics in radioactive waste management

“Science, great, mighty and in the end, unerring”

—Prof. Von Hardwigg in “Journey to the Center of the Earth” by Jules Verne.
Books and Journals

Books have editors and peer reviewers to make sure that the material is correct and current.

Journal papers must first be peer-reviewed and edited before publication. Submissions may be rejected because the science shown is weak.
Why papers are rejected for publication

No new insights on the topic

Lacked depth and rigor to be a journal paper

The goal(s) and scope of the study were not given

Too qualitative

Too few samples to be representative
Why papers are rejected for publication

Too few (if any) replications of measurements

Previous studies were ignored or not used effectively

Experimental design flawed
What about websites?

The point is that there is a system in place to keep garbage out of the scientific literature.

The same cannot be said for web-based information!

Many website are valid sources of information. Some are biased and misleading.
What about websites?

Almost anyone can create a website.

There is no control on content.
Four criteria to evaluate a website

Currency

It is important, therefore, to determine when the information was created and if it is still of worth.

When was the site originally mounted on the Web?

When was site last updated or revised? If you cannot find a date on the page, click on Page Info under the View menu.

How often is the site updated?

Do the links on the site work?
Authority

Determining the author or source of information for a Web site is important in deciding whether information has credibility.

Is there contact information for the author? (e.g. e-mail address, mailing address or phone number)

What is the author's background? (e.g. experience, credentials, occupation, have they written other publications on the topic?)
Authority

Does the author cite sources?
Is this site linked to other sites?
Do links on this site lead to other reputable sites?
Are there spelling errors or incorrect use of grammar?
What domain does the site belong to? (e.g. edu, gov, or com)?
Reliability

The dependability of a Web site is important if it is going to be cited as a source in other works or recommended for use by others.

Do most of the links on the page work?

From your evaluation of currency and authority, do you think the site will be there next time you visit it?
Occasionally, Web sites pretending to be objective have a hidden agenda and may be trying to persuade, promote, or sell something.

What is the purpose or motive for the site? (e.g. educational, commercial, entertainment, or promotional).

Who is the intended audience and how is this reflected in the organization and presentation of the site?
Example of a questionable website

Greenpeace on radioactive waste

http://www.greenpeace.org/international/en/publications/reports/deadly-legacy/
Radioactive Waste

Nuclear Reactors Create Radioactive Waste That Will Remain Hazardous For 240,000 Years

More than 50 years after splitting the first atom, science has yet to devise a method for adequately handling long lived radioactive wastes. The Nuclear Regulatory Commission separates wastes into two broad classifications: high-level and low-level waste.

High-level radioactive waste is the uranium fuel that fires the nuclear reactor. Once removed from the reactor, the irradiated fuel is considered high-level radioactive waste. Whether in the reactor or in the large pools adjacent, high-level radioactive waste must be cooled by water to prevent it from melting down.

Only after spending more than five years cooling in the fuel pool can the radioactive fuel rods be placed in large dry casks at the reactor site. High-level radioactive waste produced by nuclear power plants accounts for 95% of the radioactivity generated in the last 50 years from all sources, including nuclear weapons production. High-level wastes are hazardous because of their high radiation levels that are capable of producing fatal doses within moments of exposure. Once the uranium atoms begin to split, neutrons are given off and absorbed by fuel which produces plutonium and other long lived radioactive wastes.

Plutonium 239 has a half-life of approximately 24,000 years. That means that after 24,000 years half of the radioactivity contained in the plutonium will have decayed. However, the hazardous life of radioactive waste is at least ten times the half-life, therefore these wastes will have to be isolated from the environment for 240,000.

Because nuclear waste will remain hazardous longer than our ability to contain it, it must be retrievable. Since nuclear waste will remain hazardous for at least 240,000 years it must be monitored in perpetuity. In the short term, nuclear waste should remain at the reactor site or where ever it is currently stored. It is both technologically impossible and scientifically irresponsible to "dispose" of nuclear waste.
Adequately managing these radioactive wastes for 240,000 years is, at best, a daunting proposition. The nuclear industry has already proven itself incapable of keeping track of its high-level nuclear waste for even 30 years. High-level radioactive waste has already gone missing from one, if not several, nuclear reactors. Scientists working on the proposed repository at Yucca Mountain acknowledge that nuclear waste will be hazardous longer than our ability to isolate it from the biosphere.

Even attempts to "dispose" of low-level radioactive waste have been an abysmal failure. The only thing "low level" about low-level radioactive waste is its name. Low-level radioactive waste contains the same long-lived and highly hazardous radioactive materials in high-level waste merely in lesser quantities. The NRC basically defines low-level waste as radioactive wastes other than high-level waste. The government has licensed seven sites in the United States to bury low-level radioactive wastes. However, only three of these low-level waste dumps are in operation. They are located in Hanford, Washington; Clive, Utah; and Barnwell, South Carolina. The four closed dumps located in West Valley New York; Maxey Flats, Kentucky; Beatty, Nevada and Sheffield Illinois have all leaked radiation into the surrounding environment.
Concerned citizens have halted attempts to open other low-level waste dumps throughout the country although the nuclear industry's efforts continue, especially in Texas. Since citizen opposition to this irresponsible dumping has driven up costs on the nuclear industry, the Nuclear Regulatory Commission has repeatedly attempted to de-regulate radioactive waste so that it can be dumped into normal landfills and recycled into consumer products.

702 H Street, NW, Suite 300, Washington, D.C. 20001 (800) 326-0959

12 Author?

13 Sources of information?
The deadly legacy of radioactive waste

Wasting our time with nuclear power

July 2010

greenpeace.org

Catalysing an energy revolution
Introduction

Would you drive a car if it had no brakes? Probably not. Yet, for the last 50 years, the nuclear industry has driven nuclear power with no concern for the safety of its deadly by-product: nuclear waste.

This briefing illustrates why - for now, and for the coming hundreds of thousands of years - the nuclear waste problem is here to stay and why we should stop wasting our time with nuclear power. It summarises some of the failed ‘solutions’ for radioactive waste over the last 50 years, and illustrates the problems of the current proposals for nuclear waste storage.

For over 50 years the nuclear industry has produced large volumes of hazardous radioactive waste along the whole nuclear chain - from uranium mining and enrichment to reactor operation, waste reprocessing and decommissioning. Today, nuclear energy is being sold to politicians and consumers as one of the options for fighting climate change that will also deliver energy security. However, nuclear energy is a dangerous obstacle on the road to a clean energy future.

On top of other substantial problems related to safety and costs, nuclear waste remains a major flaw of nuclear energy.
The International Atomic Energy Agency (IAEA) estimates that the industry annually produces 1 million barrels (200,000 m³) of what it considers “low and intermediate-level waste” and about 50,000 barrels (10,000 m³) of the even more dangerous “high-level waste.” These numbers do not include spent nuclear fuel, which is also high-level waste.

It takes 240,000 years for radioactive plutonium to decay to a level that is safe for human exposure, which is an even longer period than modern humans have been on the Earth (200,000 years). There is no way to guarantee that these substances can be kept safe for this amount of time. It is senseless to allow the nuclear industry to continue producing more nuclear waste.

‘If a problem is too difficult to solve, one cannot claim that it is solved by pointing to all the efforts made to solve it’

Failed solutions

Billions of euros have been spent over the past half-century on finding a solution to the nuclear waste problem. The attempts have all been unsuccessful.

**Russia, USA, France, UK, Netherlands, Japan and others** Waste dumping at sea banned

For years, low level radioactive waste was dumped at sea, ‘out of sight and out of mind’. Disintegrating barrels brought the waste back into the environment and dangerous substances accumulated in the bodies of animals. After 15 years of campaigning by Greenpeace, an international treaty was signed in 1993 banning all dumping of radioactive waste at sea.

**Germany** Water floods waste dump in salt layers

In Aasee, Germany, an experimental radioactive waste dump was set up in the 1980s in salt formations deep underground. A few years ago it was discovered that it had started leaking water in 1988 and is currently flooding with 12,000 litres of water each day. As a result, all 126,000 barrels of waste already placed in the dump now need to be cleared out. Aasee was envisaged as a pilot project for a final storage solution in the salt layers under Godeben, but there is now serious doubt in Germany about the viability of salt layers as storage for nuclear waste.
New research brings new challenges

Forsmark, Sweden – Olkiluoto, Finland: copper corrosion

Sweden plans to pack waste in cast iron inserts in copper canisters and place them in holes bored in tunnel floors, deep underground (400-500 metres), surrounded by bentonite clay. Water is expected to make the bentonite clay expand so that it fills the cavities in the surrounding granite rock which would reduce groundwater movement.

Finland adopted the same system and Switzerland and the UK are considering this option. But there are already major concerns. The copper canisters were expected to survive corrosion for at least 100,000 years but recent research shows that they can fail in just 1,000 years or less\(^a\). There are also concerns about the build-up of hydrogen produced as a result of corrosion. High temperatures from the canisters could also affect the clay buffer, while groundwater flows could bring contaminants from any compromised containers into the biosphere. Furthermore, Nordic countries will face at least one Ice Age in the coming 100,000 years\(^b\), entailing extremely violent earthquakes, penetration of permafrost to the disposal depth and below, potential intrusion of water and unpredictable changes in groundwater flows.
Bure, France – Dessel, Belgium: uncertainties of clay as a natural barrier

Unlike Sweden and Finland, which rely on man-made barriers to prevent leakage, France and Belgium are exploring clay as a natural barrier. The waste is to be contained in simple stainless steel canisters, which can corrode much faster than the Swedish copper ones. Hence the French/Belgium concept relies on the natural clay formation to contain radioactivity. The crucial question is whether it can be guaranteed – for hundreds of thousands of years – that no cracks or channels will form in the clay layers, which would cause water to leak in and out again, poisoning nearby aquifers.
Human interference

Once placed into final storage, nuclear waste also needs to be monitored and secured from human interference as well as natural events. Stored civilian and military nuclear waste, such as plutonium or uranium, are sources of radioactive material that can be used for the production of nuclear bombs. A few kilograms of these substances would be sufficient to make bombs similar to the ones used on Japan during World War II. Even a very modest amount of radioactive material from waste storage sites would be sufficient to make a ‘dirty bomb’, which could contaminate an entire city. To deal with the problem, the nuclear industry proposes, at the very best, to guard storage sites for 300 years. But there is no proposal to ensure security for the other 239,700 years.

Reprocessing – the myth of a nuclear ‘cycle’

The nuclear industry talks about the ‘nuclear fuel cycle’ and claims that, after use, nuclear fuel is recycled. In reprocessing facilities, the plutonium and unused uranium are separated out from other waste with the intention to reuse it in nuclear plants. In reality, the term ‘reprocessing’ or ‘recycling’ is misleading, since a lot of the recovered materials are not reused. For example, the UK now has a 100 tonne stockpile of separated plutonium. Thousands of tonnes of reprocessed uranium from France are exported to Russia, where 90% is stored without any further foreseen use. Reprocessing does not get rid of any of the radioactivity in the spent fuel - but the process does spread it about through discharges to the environment and through creating a larger volume of low, intermediate and high-level wastes.
Greenpeace demands

- **A nuclear phase-out**: In order to manage the existing nuclear waste crisis, we should first stop producing more waste and develop clean energy production and energy efficiency. There should be a ban on all new nuclear power reactors and an immediate end to all reprocessing.

- **Storage for existing radioactive waste** must use the best available technology to prevent radioactivity from leaking into the environment and to protect human health. Storage should be managed, monitored and retrievable for an indefinite time period into the future.
nuclear wastes in the United States. Selection by Congress in 1987 of Yucca Mountain in Nevada as the only site to be investigated condemned the United States to pursue a policy that had no backup if Yucca Mountain failed politically or technically.

country will be left with some combination of three basic options: (i) indefinitely store in 35 states and 75 reactor sites, 10 of which have been decommissioned (2–4); (ii) consolidate from at least the decommissioned sites at one or more central storage sites; and (iii) restart the process of locating and developing one or more geologic repositories.
What Went Wrong?

A geologically complex site. Although there is great attraction to isolating nuclear waste in the arid and remote region of Yucca Mountain, there are unresolved scientific and technical issues. The $\text{UO}_2$ in SNF is not stable under the oxidizing conditions in Yucca Mountain and would convert rather rapidly to more soluble higher oxides. Substantial

In contrast, two countries that are currently developing underground SNF repositories, Sweden (10) and Finland (11), have chosen stable granitic host rock permeated with oxygen-depleted water. Their strategy uses copper canisters surrounded by protective bentonite clay, and the estimated failure rate of the canisters is extremely low. France, Belgium, and Switzerland are actively investigating potential repositories in clay. The great age and stability of the granite and clay host rocks increase confidence in long-term predictions of repository performance.
Changing performance standard. There was no U.S. Environmental Protection Agency (EPA) performance standard throughout most of the design process for the Yucca Mountain repository. In September 2008, the belatedly issued new standard extended the proposed regulatory period to 1,000,000 years, a significant change from the earlier proposal of only 10,000 years.

hence (12). The uncertainties in projecting performance over hundreds of thousands of years are real and cannot be avoided. The use of “quantitative” performance assessment for licensing placed an enormous burden on the demonstration of compliance over such long periods. Yet, Congress’s selection of Yucca Mountain was based on the DOE 30-year plan.
Unreliable funding source. The original Nuclear Waste Policy Act of 1982 provided funding for development of a repository by creating the Nuclear Waste Fund from a tax on electricity generated by nuclear power. However, expenditures for repository development were subject to annual congressional appropriations. Indeed, it is that appropriation process that is being used to put the Yucca Mountain repository on hold.

Attempt to override local opposition. The decision to proceed with the Yucca Mountain project in the face of strong public and political opposition in Nevada was a mistake. For
What Should a New Policy Include?

Regional solutions. The DOE should be relieved of the responsibility for management and disposition of used nuclear fuel from commercial nuclear power plants. The states that have the

Local acceptance. In addition to requiring compliance with federal standards and regulations, the local community and state should make the final siting decision. Local commu-

EPA. The EPA should establish a generic, i.e., not site-specific, performance standard for the containment of long-lived radioisotopes in geological repositories.
Performance of a buried radioactive high level waste (HLW) glass after 24 years

Carol M. Jantzen*, Daniel I. Kaplan, Ned E. Bibler, David K. Peeler, M. John Plodinec
Savannah River National Laboratory, Aiken, SC 29808, United States

Defense HLW: Tank 15 waste sludge at SRS in 1978

Calcinated at 350° C

Glass frit added, vitrified at 1150° C

Glass pellet

52-L carboy plus sediment
(pH 6.3, 1.6% iron, 19% clay)
Fig. 1. Schematic of the Tank 15 HLW glass burial lysimeter.
Results

1. Only $^{137}$Cs, $^{90}$Sr, $^{137m}$Ba, and $^{90}$Y were detected in the leachate samples.
2. No alpha radiation detected in leachate samples.
3. Leaching of beta sources was diffusion controlled.
4. Cs and Sr were likely sorbed by the sediments (not verified).