Nuclear Waste Effects on Human Body

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Abstract: Regarding the fact that fossil fuels are coming to an end soon, the matter of using nuclear energy is getting a big deal of attention. But as using nuclear energy increases matter of waste disposing should be handled more delicately. ill effects of nuclear waste on the human body are a matter of concern which to this day has been investigated repetitively. In this article we wish to extend these investigations with the hope of a day without contamination or at least less contamination. We first illustrate some effects of using nuclear energy and effects of nuclear waste on the human body. Then we investigate some ways of disposing nuclear waste and their advantages and disadvantages. Finally we try to make some suggestions for a better dispose of nuclear waste.

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1. Introduction

1-1 Nuclear energy; a development or a danger

Through last 30 years global need for energy has increased considerably. In 1960 universal energy use was 3.3Gtoe which exceeded 8.8Gtoe by 1990. This means an increase rate of 3.3 per year and altogether it has shown 166 percent of increase and currently the rate of energy use is approximately 10 Gtoe/year. Then it's fair to conclude that in the next century it will increase to a point in which fossil energy could not respond to global need. First 5 Megawatt nuclear power plant was developed in Soviet Union and first commercially used 50 Megawatt nuclear power plant was in Britain. In 2004 nuclear energy was responsible for nearly 6.5 percent of global energy need. It was responsible for 15.7 percent of electrical energy. In 2007 IAEA announced that there are 439 nuclear reactors in 31 countries all around the world. The United States which obviates 20 percent of its need for energy through the use of nuclear energy is in the first place, followed by France in second place.

1-2 How does it work?

The science of atomic radiation, atomic change and nuclear fission was developed from 1895 to 1945, much of it in the last six of those years .

Over the years of 1939-45, most development was focused on the atomic bomb .

From 1945 attention was given to harnessing this energy in a controlled fashion for naval propulsion and for making electricity .

Since 1956 the prime focus has been on the technological evolution of reliable nuclear power plants.

1-3 Exploring the nature of the atom

Uranium was discovered in 1789 by Martin Klaproyhkith, a German chemist, and the element was named after the planet Uranus.

In 1896 Henri Becquerel found that pitchblende (an ore containing radium and uranium) caused a photographic plate to darken. He went on to demonstrate that this was due to beta radiation (electrons) and alpha particles (helium nuclei) being emitted. Paul Villard found a third type of radiation from pitchblende: gamma rays, which were much the same as X-rays.

Then in 1896 Pierre and Marie Curie gave the name 'radioactivity' to this phenomenon and in 1898 isolated polonium and radium from the pitchblende. Radium was later used in medical treatment.

In 1898 Samuel Prescott showed that radiation destroyed bacteria in food. In 1932 James Chadwick discovered the neutron.

Physicist Enrico Fermi, in his experiments, was mostly producing heavier elements from his targets, but also worked with uranium producing some much lighter ones. At the end of 1938 Otto Hahn and Fritz Strassman in Berlin showed that the new lighter elements were barium and others which were about half the mass of uranium, thereby demonstrating the occurrence of atomic fission.

Lise Meitner and her nephew Otto Frisch, working under Niels Bohr, then explained this by suggesting that the neutron was captured by the nucleus, causing severe vibration leading to the nucleus splitting into two not quite equal parts. They calculated the energy release from this fission as about 200 million electron volts. Frisch then confirmed this figure experimentally in January 1939.

This was the first experimental confirmation of Albert Einstein's paper putting forward the equivalence between mass and energy, which had been published in 1905.

1-4 Harnessing nuclear fission

These 1939 developments sparked activity in many laboratories. Hahn and Strassman showed that fission not only released a lot of energy but that it also released additional neutrons which could cause fission in other uranium nuclei and possibly a self-sustaining chain reaction leading to an enormous release of energy. This suggestion was soon confirmed experimentally by Frédéric Joliot and his co-workers in Paris, and Leo Szilard working with Fermi in New York.

Bohr soon proposed that fission was much more likely to occur in the uranium-235 isotope than in U-238 and that fission would occur more effectively with slow-moving neutrons than with fast neutrons, the latter point being confirmed by Leo Szilard and Fermi, who proposed using a 'moderator' to slow down the emitted neutrons and subsequently Szilárd patented the idea of a nuclear reactor with Fermi. Bohr and Wheeler extended these ideas into what became the classical analysis of the fission process, and their paper was published only two days before war broke out in 1939.

Another important factor was that U-235 was then known to comprise only 0.7% of natural uranium, with the other 99.3% being U-238, with similar chemical properties. Hence the separation of the two to obtain pure U-235 would be difficult and would require the use of their very slightly different physical properties. This increase in the proportion of the U-235 isotope became known as 'enrichment'.

The remaining piece of the fission concept was provided in 1939 by Francis Perrin who introduced the concept of the critical mass of uranium required to produce a self-sustaining release of energy. His theories were extended by Rudolf Peierls at Birmingham University demonstrating that a chain reaction could be sustained in a uranium-water mixture (the water being used to slow down the neutrons) provided external neutrons were injected into the system. They also demonstrated the idea of introducing neutron-absorbing material to limit the multiplication of neutrons and thus control the nuclear reaction which is the basis for the operation of a nuclear power station.

A group of eminent scientists known as the MAUD Committee was set up in Britain and supervised research at the Universities of Birmingham, Bristol, Cambridge, Liverpool and Oxford. A final outcome of the MAUD Committee was two summary reports in July 1941. One was on 'Use of Uranium for a Bomb' and the other was on 'Use of Uranium as a Source of Power'.

The MAUD Report concluded that the controlled fission of uranium could be used to provide energy in the form of heat for use in machines. It concluded that the 'uranium boiler' had considerable promise for future peaceful uses but that it was not worth considering during the present war.

The reports led to a complete reorganization of work on the 'boiler'. The reports also led to high level reviews in the USA, particularly by a Committee of the National Academy of Sciences, initially concentrating on the nuclear power aspect. Little emphasis was given to the bomb concept until 7 December 1941, when the Japanese attacked Pearl Harbor and the Americans entered the war directly. The huge resources of the USA were then applied without reservation to developing atomic bombs.

Revival of the 'nuclear boiler'

By the end of World War II, the project predicted and described in detail only five and a half years before in the Frisch-Peierls Memorandum had been brought to partial fruition, and attention could turn to the peaceful and directly beneficial application of nuclear energy. Post-war, weapons development continued on both sides of the "iron curtain", but a new focus was on harnessing the great atomic power for making steam and electricity.

It was clear that this new form of energy would allow development of compact long-lasting power sources which could have various applications, not least for shipping, and especially in submarines.

The first nuclear reactor to produce electricity (albeit a trivial amount) was the small Experimental Breeder reactor (EBR-1) in Idaho, in the USA, which started up in December 1951.

2. Nuclear waste

- Nuclear waste is irradiated or used nuclear fuel
- Composed of fission products
- Nucleus of atom splits
- Composed of trans uremic elements
- Chemical elements with an atomic number greater than 92-Uranium
- Waste results from using nuclear fuel to produce electricity
- Referred to as high-level waste because it’s very radioactive
- Emits ionizing radiation or ionizing particles which is harmful to humans
- Tissue damage
- Cancer

Nuclear waste disposals; a matter of high importance

Over 1940s the United States has generated 75000 metric tons of waste which is expected to double by 2050. Over 121 facilities over the country are responsible for storing this waste on site.

Geological disposal

Waste should be stored deep in the ground where it would not distribute. Conditions for a safe disposal are:

1. deep coal resources
2. Known hydrocarbon resources
3. Oil shale
4. Aquifer development for groundwater use

Other methods of disposal include:

- Transmutation: Transform one element into another through nuclear reactions or radioactive decay
- Space Disposal

2-1 ill effects on the human body

The main disease caused by nuclear waste is bone cancer. Although it has other effects, bone cancer is in the center of attention. Destroying DNA, causing syndromes, and some kinds of cancer are the main diseases which are caused by nuclear waste. These diseases have long term effects which even affect next generations. The most dangerous radiation amongst three (alpha, beta and gamma) is gamma, penetrating tissues and cells in the body and destroying DNAs. In Gamma radiation particles are just similar to X-rays. The only difference is that they have shorter wavelength. Nuclear wastes contain so many materials which emit radiations of high danger.

Another danger is Americium. 241 isotope of this element was created in 1944 in nuclear reactors. This element is a source of Gamma radiation. It's highly toxic and should be handled very delicately.it can enter the human body through breathing or through skin. It aggregates in bones and disintegrates gradually. Then it starts to emit dangerous radiations. These radiations are an inner cause for all the aforesaid diseases.

Also radioactive dusts generated around exploratory drillings are really hazardous for the human body. It can be disseminated through streams and creeks to the cities and start a disaster.

At last let's don't forget the Chernobyl and the pregnant mothers who were forced to an unwanted abortion because of the radioactive radiations.

2-2 how to prevent these effects

Using appropriate methods of disposal for nuclear waste is the best way to prevent bad effects of nuclear waste. Concentrating and isolating, diluting and discharging, and letting the waste to decrease radioactivity naturally are some ways of disposing safely. There are rules to be followed on this matter. Rules of GSR 125 atomic energy rules govern the transfer and disposal of these certain kinds of waste.

2-3 Different types of nuclear wastes

1. **Low-level**

Low-level wastes are the least dangerous radioactive materials which aren't able to radiate for a long time. The garment which is used by the people involving with these material, tools they use and filters are low-level wastes. This type doesn't need any special treat and these wastes are treated as normal wastes. They are usually burnt and buried under sea or in dry lands.

2. **Intermediate-Level**

This type includes chemical sewage, metal coats in fuels and most of the wastes from nuclear reactors. These types aren't able to radiate for a long time but they need to be covered carefully since in their short life period they have a considerable amount of radiate. So, they are usually kept in concrete blocks or in special warehouses.

3. **High-level**

One of the examples of this type is the waste from the nuclear reactor's fuel, maintenance of which is way harder and more expensive. They should be covered in a special coat and kept in stores at least 1.5 km under the ground and in temperatures below zero.

2-4 Steps to manage these wastes

The steps to manage these wastes are

1. **Temporary store keeping**

The fuel used up in a reactor is very hot and radioactive and radiates a lot of radiances and ions. So, not only they should be cooled but also they should be stopped from radiating radioactive radiances. There are pools beside each reactor for storing used up fuel. These pools are full of water. They are made of concrete reinforced with stainless steel with 8 meters of depth. Water not only cools down the bar of used fuel but also acts like a screen in front of radioactive radiates. As the time goes by the radiation decreases to one tenth of the amount it was at time it came out of the reactor and also the temperature cools down too.

2. **Reprocess final storage**

After separation high-level nuclear wastes are heated to change into powder. After this process which is called calcification, powder is mixed with glass to be stored in a container. This process id called glassifization. Liquid glass is stored in a container made of stainless steel and kept in a stable (geographically) place. After one thousand years the radiation goes back to normal. To this day this point has been the end of a nuclear fuels cycle.

2-5. Some ways to remove pollution

Characteristics of nuclear wastes at the time of quench are:

1. Appropriate heat conduction
2. Resistance to any chemical breakdown
3. Being solid
4. Leakage control and the least solvency in water
5. Having the least mass possible
6. Resistance to pressure and impact

Gathering and transporting radioactive wastes

International Atomic Energy Agency (IAEA) has categorized solid radioactive wastes to four categories:

First degree- wastes with radiance below 0.2 rad per hour which generate Gamma and Beta rays. These wastes could be transported or buried without any special regulation.

Second degree- wastes with radiation from 0.2 to 2 rad per hour which generate Gamma and Beta rays. These wastes must be transported in special containers with cement or lead shell.

Third degree- wastes which generate Gamma and Beta rays but the amount of Gamma ray is not considerable. Radioactivity in these wastes is more than 2 rad per hour. These wastes must be transported exactly as regulations of IAEA say. Bases for these regulations are: using coated containers and carefully eliminating any danger for living creatures while and after burial. Burying these wastes under oceans or in vast deserts has been protested hardly. Sending these wastes to outer space with missiles was another way which has lots problems and is considered as being irrational.

Fourth degree- these types of wastes generate Alpha ray which has a long half-life. Their radiation is usually measured by Kory in m^3.

2-6. Different methods of burying solid nuclear wastes

1. Temporary storing
2. Final storing so that they are reachable
3. Expulsion to natural frigid lands (e.g. North Pole)
4. Expulsion to seas or oceans (the Illegal way)
5. Expulsion to space (the Illegal way)

Different methods of burying atomic wastes:

a. Temporary storing

b. Final storing so that they are reachable:

Although final storing and final removal is economical, it has some disadvantages like:

These wastes aren't reachable, so they cannot be removed by better ways which are found through time

To store this type first steel cylinders with 30 meters of diameter and 3 meters of height are sent to the place. For temperature exchange, around these cylinders are air or cool water. In burial process vicinity of those cylinders are covered by soil around 10 ft. and probably using spaces between soil particles the heat will be conducted out.

2-7. Suitable places to bury solid wastes

Some suitable places to bury solid wastes are:

1. Salt marshes with thick beds
2. Clay rocks formed from sedimentation of under pressure clay
3. Hard crystal rocks like granite rock formed in high temperature

Two major methods in permanent storing

1. Temporary storing is done carefully in an appropriate place regarding rules and regulations. First a well with 3000 meters of depth is dig and then tools are transmitted to the bottom of the well. After this step, channels of 1000 meters deep are dig horizontally and wastes are placed in them. Finally 3/4 of their height is filled with soil and the remaining part is filled with protective material. So digging and loading will be done one by one regarding the amount of waste.
2. Wells of 6000 deep are dig and 2000 meters of them is filled with waste and the rest with protective material considering the radioactivity of wastes.

Other methods

Burial in North Pole

Ice layers in North Pole are of a good thickness. These areas are suitable places to bury wastes because their far away from human beings but only if they are not a danger of earthquake. Another advantage is low temperature which conducts heat out of reservoirs.

Disadvantages:

For example the possibility of movement for ice and also increase in earth temperature is a big problem. On the other hand, if the shields undergo damage wastes spread in a vast area.

Burial in North Pole is done in two ways:

Gradual penetration in ice

Some deep wells are dig in ice and reservoirs are put into them, the ice around the reservoirs are melt and reservoirs start to go down and settle at the bottom of ice. The reservoirs go 3 to 4.5 km where they hit rock beds and stop.

Using wiry cables

Reservoirs are put in holes with a specified height by cables so that the connection with reservoirs is held. So, a complete protection takes place through ice layers and wastes are buried in a known place and they can be controlled. Temperature decrease is one of the advantages of this method. Burying wastes under the oceans and sending them to space are other methods that fortunately are prohibited now.

In another method wastes are put in a reservoir under the ground which is dig among a cairn. This cairn must be a final dam against leakage so that any possibility of a crack in the system is decreased to a minimum. It's less probable that to reserve these wastes neutral metals like gold or platinum which have a high resistance to depreciation are used, so to ensure the protection via other metals that undergo depreciation some steps should be taken. Nowadays this method is being used some European countries specially Germany.

Throwing wastes into seas is also considered because it's assumed that finally due to sub duction this wastes will go under the surface. Although in Pakistan this method is being used, we cannot be sure that through time these wastes won't go any further because our information about these areas is not enough.

Other method which is being used is throwing wastes to space. Radiant materials are placed in a missile and lunched to space, so that the danger is clear.

This method is very expensive and dangerous if the missile explodes while taking off it will be a disaster.

2-8 Best methods in some countries

The best method which is being used by countries like America, Britain and France is reserving these wastes in stone reservoirs. In this method, wastes are kept in a reservoir on the ground which makes it easier to reach and control the waste. Although this method needs a good care, in comparison with other methods it's more reliable. According to EPA's (environment protection agency) regulations areas which are used to remove wastes must be able to quarantine and keep away wastes for 10 thousand years, because this is the period in which wastes are still dangerous, for instance American congress has chosen Yoka Mountains in Nevada as the best place to bury the wastes. However, Texas and Washington have some places to bury the wastes too.

Conclusion

The area for removing nuclear wastes is studied for many years, and now the attention is toward removing them in stones where they came from first not oceans and ice lands of Poles. Stone reservoirs are better because they have a better chance to stay untouched for thousands of years and so wastes are insulated and the radiation will go back to a normal level. These stone reservoirs must have little holes and breathing spaces and they must be far away from earthquakes or natural disasters. Studies on UraniumRachlo reservoirs in Gabon shoe that this place is a good place for this purpose. The ratio of U 235 to the amount of Cans a Rachlo is much more less than normal Uranium. The reason probably is that nearly 2 billion years ago when it still was in a high depth, natural reactions of gap happened and used U 235. A big amount of Plutonium in wastes produced in America's defense department is recycled. However, America and Canada still keep their wastes, from business reactors, in water reservoirs, waiting for further decision about final removal, how to and where. In France some Silicate glasses are used to remove wastes. In Sweden wastes are kept in copper barrels because ancient handcrafts stayed intact for thousands of years in copper covers, although there's a possibility that in the future societies without mineral resources will attend to use copper and it would dangerous.

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