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IMPACT OF CESIUM-CS^{137} AND STRONTIUM- SR^{90} ON ENVIRONMENT

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Abstract

Cesium-137 and Strontium-90 are produced in nuclear reactor as a result of nuclear fission of the fissile elements. The two maxima occur at around mass number of 95 and 140 and hence, these two radionuclides are produced in high yield during fission reaction in the reactor. These radionuclides are also found in environment due to the nuclear fallout from weapon testing or any nuclear activity or by mishandling of radiation sources of these elements. As of 2005, cesium-137 is the principal source of radiation in the zone of alienation around the Chernobyl nuclear power plant. Together with 134Cs, 131I and 90Sr, 137Cs was among the isotopes, distributed by the reactor explosion, which constitute the greatest risk to human health. 137Cs and 90Sr contribute towards major radioactivity and heat output of HLW and hence the removal of 137Cs and 90Sr from the HLW, prior to its disposal, is very important. Out of the various fission products, 137Cs and 90Sr are of significant long half life (137Cs: 30.1 y, 90Sr: 28.5 y). 137Cs emits gamma radiation (Eγ = 661 KeV) while 90Sr emits beta particles and gets converted to 90Y which is a pure beta emitting radionuclide (Ex = 2.28 MeV) ultimately decaying to the stable 90Zr. Chemical similarity of cesium with sodium and that of strontium with calcium may create problem with the biological system of various living beings. Sr (like Ca) is a bone seeker and so, if 90Sr enters in the body, it may ultimately be deposited in the bones and produce un-necessary radiation exposure to the person which may cause bone cancer. Hence, removal of these radionuclides would not only reduce the cost to regular surveillance of waste disposal sites but also reduce the waste volume to be disposed.

Keywords: *Fission, Fusion, Alienation, Isotopes*

Discussion and Results:

In 1787, an unusual rock which had been found in a lead mine at Strontian, Scotland, was investigated by Adair Crawford, an Edinburgh doctor. He realised it was a new mineral containing an unknown 'earth' which he named strontia. In 1791, another Edinburgh man, Thomas Charles Hope, made a fuller investigation of it and proved it was a new element. He also noted that it caused the flame of a candle to burn red.Meanwhile Martin Heinrich Klaproth in Germany was working with the same mineral and he produced both strontium oxide and strontium hydroxide.Strontium metal itself was isolated in 1808 at the Royal Institution in London by Humphry Davy by means of electrolysis, using the method with which he had already isolated sodium and potassium.

Strontium is a soft, silvery metallic element found in rocks, soil, dust, coal and oil. Strontium found in nature is not radioactive and is sometimes called stable strontium. Strontium-90 is a radioactive form of strontium. Strontium-90 is formed in nuclear reactors or during the explosion of nuclear weapons. The half-life of strontium-90 (the time it takes for half of the strontium to give off its radiation and change into another substance) is 29 years. Strontium is best known for the brilliant reds its salts give to fireworks and flares. It is also used in producing ferrite magnets and refining zinc. Modern 'glow-in-the-dark' paints and plastics contain strontium aluminate. They absorb light during the day and release it slowly for hours afterwards.

Strontium-90, a radioactive isotope, is a by-product of nuclear reactors and present in nuclear fallout. It has a half-life of 28 years. It is absorbed by bone tissue instead of calcium and can destroy bone marrow and cause cancer. However, it is also useful as it is one of the best high-energy beta-emitters known. It can be used to generate electricity for space vehicles, remote weather stations and navigation buoys. It can also be used for thickness gauges and to remove static charges from machinery handling paper or plastic. Strontium chloride hexahydrate is an ingredient in toothpaste for sensitive teeth.

Strontium is incorporated into the shells of some deep-sea creatures and is essential to some stony corals. It has no biological role in humans and is non-toxic. Because it is similar to calcium, it can mimic its way into our bodies, ending up in our bones.

Radioactive strontium^{-90}, which is produced in nuclear explosions and released during nuclear plant accidents, is particularly dangerous because it can be absorbed into the bones of young children.

Uses of cesium-137?

Cesium-137 and its decay product, barium-137m, are used for sterilization activities for food products, including wheat, spices, flour, and potatoes. Cesium-137 is also used in a wide variety of industrial instruments such as level and thickness gauges and moisture density gauges. Cesium-137 is also commonly used in hospitals for diagnosis and treatment, as a calibration source, and large sources can be used to sterilize medical equipment.

Change in the environment due to Cesium

Cesium-137 decays in the environment by emitting beta particles. As noted above, cesium-137 decays to a short lived decay product, barium-137m. The latter isotope emits gamma radiation of moderate energy, which further decays to a stable form of barium. Cesium-137 is significant because of its prevalence, relatively long half life (30 years), and its potential effects on human health. Cesium-137 emits beta particles as it decays to the barium isotope, Ba-137m (half life = 2.6 minutes).

Exposure to cesium-137

People may be exposed externally to gamma radiation emitted by cesium-137 decay products. If very high doses are received, skin burns can result. Gamma photons emitted from the barium decay product, Ba-137m, are a form of ionizing radiation that can pass through the human body, delivering doses to internal tissue and organs. People may also be exposed internally if they swallow or inhale cesium-137. Large amounts of cesium-137 were produced during atmospheric nuclear weapons tests conducted in the 1950s and 1960s. As a result of atmospheric testing and radioactive fallout, this cesium was dispersed and deposited world wide. Sources of exposure from cesium-137 include fallout from previous nuclear weapons testing, soils and waste materials at radioactively contaminated sites, radioactive waste associated with the operation of nuclear reactors, spent fuel reprocessing plants, and nuclear accidents. Cesium-137 is also a component of low level radioactive waste at hospitals and research facilities.

Entrance of Cesium-137 Human body

Cesium-137 can enter the body when it is inhaled or ingested. After radioactive cesium is ingested, it is distributed fairly uniformly throughout the body's soft tissues. Slightly higher concentrations are found in muscle; slightly lower concentrations are found in bone and fat. Cesium-137 remains in the body for a relatively short time. It is eliminated more rapidly by infants and children than by adults. Is there a medical test to determine exposure to cesium-137? Generally, levels of cesium in the body are inferred from measurements of urine samples using direct gamma spectrometry (ICRP Publication 54, 1988). Because of the presence of the gamma-emitting barium daughter product, a technique called whole-body counting may also be used; this test relies on detection of gamma photon energy. Skin contamination can be measured directly using a variety of portable instruments. Other techniques that may be used include the taking of blood or fecal samples, then measuring the level of cesium.

ISOTOPES OF CESIUM AND STRONTIUM

The various isotopes of cesium and strontium produced in the nuclear reactor along with their half-lives have been given in Table 1.2. Naturally occurring isotope of cesium is the stable 133Cs while all the other isotopes of cesium are radioactive and are formed in nuclear reactor as a result of fission or other nuclear reaction. 133Cs, 134Cs, 135Cs and 137Cs are major isotopes of cesium produced in the reactor, with 137Cs accounting for almost 43% of the total cesium.

Strontium in freshly discharged spent fuel as a result of nuclear fission consists of stable isotope 88Sr and radioactive isotopes 89Sr, 90Sr and 91Sr, with 90Sr accounting for about 60% of total strontium production by fission. The major heat output of HLW is contributed by 137Cs (0.417 W/g) and 90Sr (0.93 W/g) present in the waste. The removal of these two long-lived isotopes may produce significant cooling to the waste and reduces the risk of matrix deformation, thereby reducing the risk generated by leaching out of the radioactive elements from the repositories.

Various isotopes of Cesium and Strontium

Radio isotopes of Cesium	Half Life Of Cesium isotopes	Radio isotopes of Strontium	Half Life Of Strontium isotopes
Cs^{129}	1.33 Days	Sr^{82}	25.5 D
Cs^{130}	29.2 minutes	Sr^{84}	Stable
Cs^{131}	9.7 Days	Sr^{85}	64.8 D
Cs^{132}	6.5 Days	Sr^{86}	Stable
Cs^{133}	Stable	Sr^{87}	2.8 Hr
Cs^{134}	2.1 Y	Sr^{88}	Stable
Cs^{135}	2.3 Y	Sr^{89}	50.5 D
Cs^{136}	13.2 Days	Sr^{90}	28.5 Y
Cs^{137}	30.1 Y	Sr^{91}	9.63 H
		Sr^{92}	2.71 H

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The presence of 137Cs and 90Sr in the environment may adversely affect the ecological and biological systems. These elements can be adsorbed on the surface of sediments, soils and can enter the food chain. A report on Chernobyl accident states that approximately 5.4x105 Ci of Cs-134 and 1.1x105 Ci of 137Cs along with 2.2x106 Ci of 90Sr activity was found to be dispersed around the Europe region.

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