Nuclear waste management at Rooppur

No reason to worry about

Handling, storage and disposal of low and medium-level nuclear waste pose no serious problem. Bangladesh Atomic Energy Commission has the necessary expertise and experience to manage such waste and, in fact, has been doing so since the construction of its research reactor in 1986 at the Atomic Energy Research Establishment (AERE) at Savar.

ABDUL MATIN

NUCLEAR fuel that undergoes fission in nuclear reactors consists of heavy elements like uranium-235, available in nature, and uranium 233 and plutonium-239, both produced artificially from thorium-232 and uranium-238, respectively, in nuclear reactors by interaction with neutrons.

The concentration of uranium-235 in natural uranium is very low, only 0.71%. The rest is uranium-238, a heavier isotope of uranium which does not fission in normal reactors. For use in light water reactors, it is necessary to enrich, i.e. increase the concentration of, uranium-235 to 3% to 4%.

Nuclear fuel requires several stages of processing before it can be put inside nuclear reactors in the form of fuel assemblies or bundles. The uranium ore undergoes milling, conversion to uranium hexafluoride, enrichment and again conversion to its final form -- uranium dioxide.

This oxide looks like a black powder, which is compacted to form small pellets about one centimeter in diameter and of the same height. These pellets are put inside metallic tubes called claddings, which are later sealed to prevent leakage of any substance from inside. The tubes form what are known as fuel bundles or assemblies.

Nuclear fuel does not burn like normal fossil fuels, which produce ash and flue gases. Instead, it undergoes fission inside a nuclear reactor and produces energy and fission products, which may be either solids or gases. The fission products are highly radioactive. The energy is carried away by the coolant to produce electricity. The fission products stay inside the fuel or the sealed cladding.

The fuel assemblies can stay inside a reactor for several years before they are replaced with new ones. The used fuel assemblies, after being taken out of the reactors, are called spent fuel. They produce heat even after they are taken out of the reactor, because of the intense gamma radiation, and need cooling. They are, therefore, stored in a pool of circulating water.

The spent fuel contains some unused uranium-235 and plutonium-239 plus uranium-238, which can be recovered by reprocessing the spent fuel, and can be reused in nuclear reactors. After reprocessing, the recovered uranium is sent for further enrichment.

Mixed with uranium dioxide, the plutonium-239 can be used as fuel after conversion into oxides. The highly radioactive fission products are separated from the spent fuel and stored in sealed and shielded canisters in safe depositories.

Nuclear fuel produces waste at different stages of processing. Some of the waste are radioactive and require special treatment for protecting human health and minimising their impact on the environment.

Radioactive waste is normally classified into three categories, namely low-level, medium-level and high-level waste depending on the amount, types and half-lives of radioactivity.

Half-life is the time taken by a radioactive substance or isotope to lose half of its activity. Half-lives vary from a fraction of a second to millions of years. Radioactivity decreases with time as the isotopes decay into stable and non-radioactive ones. Short-lived isotopes decay quickly whereas long-lived ones decay slowly.

Low-level waste contains small amounts of short-lived radioactivity. It is not dangerous to handle but needs to be disposed of carefully. Usually, it is buried underground, only a few feet deep. If necessary, it can be compacted or incinerated in a closed container to reduce the volume before final disposal. By volume, it consists of 90% of all radioactive waste worldwide, but contains only 1% of the total radioactivity.

The residue after mining and milling of uranium contains very low-level radioactivity and is generally buried in the mines. Depleted uranium (the left-over after enrichment), containing mostly uranium-238, is less radioactive than natural uranium.

Medium-level waste contains higher amounts of radioactivity and may require special shielding before disposal. Worldwide, it consists of 7% of the volume and contains 4% of the radioactivity of all radioactive waste. If necessary, it can be solidified through mixing with concrete or bitumen before disposal.

The short-lived waste from nuclear reactors can be buried like low-level waste, but the long-lived waste is disposed of deep underground. Because of shorter half-lives, both low-level and medium-level waste lose their radioactivity in time and become harmless after disposal.

High-level waste includes spent fuel and the main waste from reprocessed fuel. It consists of 3% of the volume of all radioactive waste and contains 95% of the radioactivity. It is comprised of highly radioactive fission products and some heavy elements with long-lived radioactivity. It generates a significant amount of heat and requires cooling and special shielding during handling and transportation.

If the spent fuel is reprocessed, the separated waste is vitrified, i.e. turned into glass by mixing it with borosilicate glass which is sealed inside stainless steel canisters for storage or disposal deep underground. Liquid high-level waste is evaporated to solids, mixed with glass-forming materials, melted, and poured into stainless steel canisters which are sealed by welding, again for storage or disposal.

If the spent fuel is not reprocessed, all the highly radioactive isotopes stay inside the fuel assemblies, which become high-level waste. Used fuel assemblies occupy about nine times the volume of equivalent vitrified high-level waste which results from reprocessing.

Whether reprocessed or not, the volume of high-level waste is modest. A typical large reactor produces about 3 cubic meters of vitrified waste or 25-30 tonnes of spent fuel per year. Because of its small volume, it is not difficult to store in isolated locations.

The transuranium elements (heavier than uranium) formed inside the nuclear reactors by absorption of neutrons have longer half-lives (thousands of years) compared with those of fission products (about 30 years or less).

It is possible to solve the problem of management of long-lived heavy elements by converting them into fission products with shorter half-lives by transmutation, i. e. irradiating them with fast neutrons in reactors causing fissions. The resulting fission products have shorter half-lives. Disposal of such short-lived fission products will be much easier than the tranuranium elements with long half-lives.

Final disposal of high-level waste is delayed for 40-50 years to allow its radioactivity to decay, after which less than one-thousandth of its initial radioactivity remains, and it is much easier to handle. Hence, canisters of vitrified waste, or used fuel assemblies, are stored under water in special ponds, or in dry concrete structures or casks for at least this length of time.

The final disposal of vitrified wastes, or of used fuel assemblies without reprocessing, requires their isolation from the environment for long periods. The most acceptable method is to bury them in dry, stable, geological formations deep underground, preferably inside abandoned salt mines.

According to available information, Russia is likely to supply nuclear fuel in the form of fuel assemblies for the proposed nuclear power plant at Rooppur, and take the spent fuel back. If this arrangement can be successfully implemented, Bangladesh will not have to worry about disposal of any high-level nuclear waste as all high-level waste, together with the spent fuel, will be transported back to Russia in properly shielded containers.

Bangladesh has to ensure that it gets back full credit for the unused uranium and plutonium that will be transported to Russia with the spent fuel. Russia may, however, charge Bangladesh the cost of handling, transportation and reprocessing of the spent fuel and that of safe storage of the high-level nuclear waste.

In case the spent fuel is not taken back by Russia, Bangladesh will store the spent fuel in a safe location close to the nuclear power plant for the time being. It is now widely believed that the present share of electricity generation through nuclear power will increase manifold in the near future, mainly because of environmental considerations, since nuclear power is the only alternative to fossil fuels now available in large commercial quantities that does not produce harmful greenhouse gases.

As a result, the demand for nuclear fuel will also increase and, consequently, there will be a market for spent nuclear fuel since it contains valuable unused uranium and fissile plutonium which can be recycled in nuclear reactors. Moreover, several new designs of nuclear reactors, which can be fueled by spent fuel without reprocessing, are now under development. This may further increase the demand for spent fuel in the international market.

Handling, storage and disposal of low and medium-level nuclear waste pose no serious problem. Bangladesh Atomic Energy Commission has the necessary expertise and experience to manage such waste and, in fact, has been doing so since the construction of its research reactor in 1986 at the Atomic Energy Research Establishment (AERE) at Savar. There is, therefore, no reason to worry about the management of nuclear wastes from the Rooppur nuclear power plant.

A nuclear power plant

Dr. Abdul Matin is a former Chief Engineer of Bangladesh Atomic Energy Commission.

BIODIVERSITY

Dewpara Sal forest: Past and present

Dewapara Sal forest is under the Dholapara range of Tangail. Few decades ago it was attached with Madhupur Sal forests as a continuous forest belt. The total area of forest land is 1500-acre, out of which 800-acre has forest coverage. Only 10-acre area has Sal patches and the rest 790-acre is occupied by 10 years long rotational plantation forest.

Conversion of natural forest into agricultural field at Dewpara

DR. MIZANUR RAHMAN

SAL occurs on the southern slopes of the Himalayas in Nepal, India and Bangladesh. In India Sal occupies the northern and central regions separated by the Gangetic plain. Terai (low land) is considered as the main Sal growing region of Nepal. The major portion of Sal forests in Bangladesh is located in the central parts (Mymensingh, Tangail and Gazipur).

Sal forest is the most threatened and vulnerable ecosystem of Bangladesh. Until the beginning of the 20th century, these forests existed as a continuous belt with rich floral and faunal diversity. Gradually increasing population put tremendous pressure on this ecosystem and changed the scenario. These forests at present are under occupation and the remaining stands are of poor stocking. The massive destruction of Sal forests of Bangladesh occurred during the last 40 years. Biodiversity has declined rapidly and many species have disappeared.

The Sal forests are acutely impacted by over-exploitation, deforestation, excessive litter collection, encroachment, indiscriminate collection of economically important plant species (i.e. medicinal, fodder etc), and other forms of anthropogenic disturbances. Natural Sal forests have been converted into plantation forests, rotational forests, exotic woodlands, rubber gardens, banana gardens, pineapple orchards, rice field, homesteads and other agricultural fields.

Dewapara Sal forest is under the Dholapara range of Tangail. Few decades ago it was attached with Madhupur Sal forests as a continuous forest belt. The total area of forest land is 1500-acre, out of which 800-acre has forest coverage. Only 10-acre area has Sal patches and the rest 790-acre is occupied by 10 years long rotational plantation forest.

The Sal patches are highly degraded, fragmented, mostly denuded and have mono-species based. This area falls under the bio-ecological zone of Madhupur Tract. The soil represents highly oxidized reddish brown clay containing ferruginous nodules and manganese spots. The whole forest areas are fragmented by an intricate network of depressions in honeycomb pattern layout. The depressions are generally cultivated with paddy. Homesteads, cultivable lands and forests are mixed which makes forest boundary demarcation and maintenance extremely difficult.

Biodiversity at present

Flora

Among the natural tree species, Sal is found sporadically in the above mentioned 10-acre area. With few exceptions, the diameter at breast height (DBH) of the Sal trees ranges from 10-30 cm. The height of the mature Sal tree will not exceed 20 m. No other natural Sal associates are present in this forest area. The rotational plantation forests are dominated by Acacia, Mangium and Eucalyptus. The exotic species in the plantation forests are uniformly distributed, where Sal is randomly distributed in patches. Natural regeneration (ephemeral, established seedling and sapling) are totally absent. Few juvenile Sal trees can be found occasionally. Without the continuity of natural regeneration it is not possible to maintain a natural ecosystem. Bhite and Mouhati are the dominant shrubs in both Sal patches and plantation forests. Among the herbs only Basket Grass, Foxtail and Love Thorn are available in this area. Climbers are totally absent in these forests. There is no trace of coarse woody debris and mycorrhizal association. Consequently the species richness, diversity index (Shannon-Wiener index) and evenness (Pielou's index) are very low. Due to poor species richness the concentration of dominance (Simpson index) is very high.

Fauna

Among the bird species, the Common Mayna (Shalik), Spotted Dove (Ghughu) and Oriental Magpie Robin (Doyel) are found occasionally. Fox and Squirrel are rarely distributed in this ecosystem.

Biodiversity in the past

Flora

Tree: Even 40 years back the Sal forest was the richest biodiversity spot of Bangladesh. Sal was the dominant species followed by Bangajari, Gandhigajari, Sindhuri, Datoi, Ajuli, Dud Koroi, Bhutum, Bohera, Haritaki, Arjun, Sonalu, Cheshra, Jiga, Jogini Chakra, Kaika, Sidha, Sajna, Amloki, Roina, Lalmoina, Tamal, Khailadamor, Kakdumur, Faska dumur, Olotkomol, Chatim, Neor, Minjiri, Pakor, Shilabadi, Haldu, Kurchi, Mohuya, Kharajora, Kanaidinga, Kukurchita, Katakhai, Udhal, Sheora, Pahariamra, Awal, Koroch, Bajna, Joina, Debdaru, and Behula.

Shrub: Anaigota was dominant species followed by Fulkhari, Monkata, Chokoi, Piralo, Chutkigota, Chhitki, Bishkanthali, Tagor, Bhite, Nishinda and Mouhati.

Herb: Sungrass was the dominant species followed by Soti, Bishkachu, Fulkori, Basket Grass, Ufatlangra, Foxtail, Carpet Grass and Thankoni.

Climbers: Bidipata was the dominant species followed by Gaza Pipul, Pipul, Shimul Lata, Patilalau, Paniyalata, Dumurlata, Chai, Kumarilata, Harjora, Shotomuli, Natakaranj, Keoyakanthal, Makal, Bishuti, Telakucha, Meta Alu, Bish Alu, Garo Alu, Gachh Alu, Jhum Alu, Shuori Alu and German Lata.

Mycorrhiza: Different genera of mycorrhiza were associated with matured Sal trees. Russula was the most frequent occurring followed by Amanita, Laccari and Scleroderma.

Fauna

Once upon a time these forests were very rich in faunal diversity. During the late nineteenth century Elephants and Rhinoceros became extinct from this ecosystem. The Asiatic Black Bear, Sambar Deer, Spotted Deer, Barking Deer and Red Frog disappeared just four decades ago. The Leopard Cat, Fishing Cat, Jungle Cat, Indian Civet and Capped Langur reached extinction in the recent years. This was the paradise of different indigenous birds, many amphibians and reptiles.

Conservation for the future

- Strictly controlling further logging of Sal
- Afforestation and reforestation by early successional Sal species
- Zoning the forest lands into core, buffer and peripheral zones
- Initiating conservation programme at core zone
- Gap filling by Sal associates
- Facilitating natural regeneration in adjacent areas of Sal patches
- Protecting new born seedling or ephemeral from destruction
- Stopping removal of old trees and deadwood from the forest to increase the population of different bird species and to initiate mycorrhizal associations
- Stopping further encroachment
- Rehabilitating the forest people outside the forest areas
- Creating public relations for nature conservation
- Creating alternative livelihoods for the forest people
- Supply of alternative fuel sources in the adjacent areas
- Demarcation of forest land and forest coverage
- Clear felling of all exotic trees after maturing into merchantable timber size
- Stopping further plantations of exotic species as they adversely affect the natural ecosystem
- Initiating income generating activities through microcredit programme to minimise the tremendous human pressure on forest

Dr. Md. Mizanur Rahman, a biodiversity specialist, is Assistant Commissioner, Jhalakathi Collectorate (mizan_peroj @yahoo.com).

Human interference and species extinction

Governments are gradually moving to give wider areas protected status, but progress is slow. Globally, in 1997, only 6.4 percent of the land area was protected. To protect the full range of species, large areas are needed, but 88 percent of protected areas in 1997 were smaller than 100,000 hectares -- a square with sides of about 32 kilometers.

KHALID MD BAHAUDDIN

BIODIVERSITY is a term applied to describe the complexity of life. It is generally measured at three levels: the variety of species; the genetic diversity found within members of the same species (what makes you different from your neighbour); and the diversity of the ecosystems within which species live. These three levels are intimately connected. Genetic diversity is essential to the prosperity of the species, giving it the resources to adapt. And the number of species within an ecosystem is closely tied to the health and size of the ecosystem itself.

However it is defined, biodiversity is the stuff of life. However far we may be removed from "wild" biodiversity in our daily lives, it remains the source of our food and most of our medicines. In addition, 15 percent of our energy is derived from burning plant materials. Even in the United States, wild species contribute around 4.5 percent of GDP. Due to agricultural modernisation, changes in diets and population density, humankind increasingly depends on a reduced amount of agricultural biological diversity for its food supplies.

A dozen species of animals provide 90% of the animal protein consumed globally and just four crop species provide half of plant-based calories in the human diet. FAO estimates that about three-quarters of the genetic diversity found in agricultural crops have been lost over the last century. Of 6, 300 animal breeds, 1,350 are endangered or already extinct. This rapidly diminishing gene pool is cause for concern.

Nobody knows how many species there are in the world -- or how fast they are disappearing. Fewer than 2 million have been catalogued and estimates of the total vary wildly, ranging from 7 million to as many as 80 million. The currently accepted working estimate is 13.6 million.

At least 40 per cent of the world's economy and 80 per cent of the needs of the poor are derived from biological resources. In addition, the richer the diversity of life, the greater the opportunity for medical discoveries, economic development, and adaptive responses to such new challenges as climate change.

Biodiversity is an immense resource, built up over 3.5 billion years of evolution. It embraces not only the number of species on Earth, but the range of habitats and genetic diversity within species as well. It is of enormous importance to humans. Of the 270,000 known plants, some 3,000 are exploited for food, and between 25,000 and 50,000 more are used in traditional medicine. Wild plants are potential sources of new medicines and of material for genetic engineering. Biodiversity is a major attraction for tourism, and not least a lasting source of human aesthetic pleasure.

Around 1.75 million species have been scientifically described. More than half of these are insects, while vertebrates -- including fish, birds, mammals, reptiles and amphibians -- make up only 2.5 percent. But the real number is certainly far higher. Most recent estimates fall in the 7 to 20 million ranges, though a widely acceptable working estimate, used by the United Nations Environment Programme's Global Biodiversity Assessment of 1995, is 13.6 million.

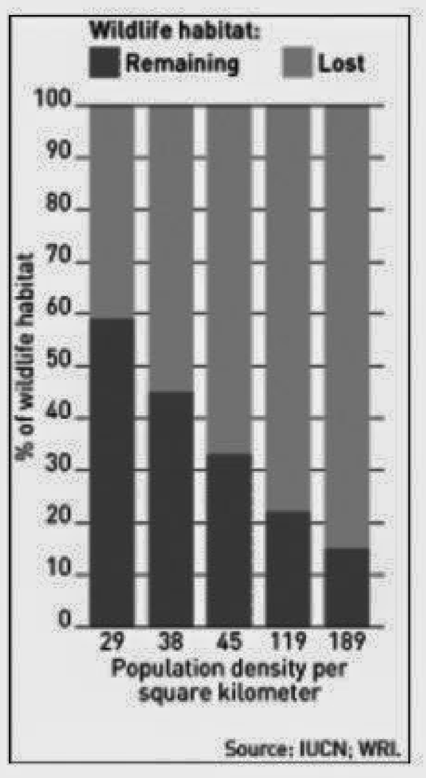
Most ecologists believe that we are currently undergoing a mass extinction driven by human activities. Since 1600, 484 animal and 654 plant species are known to have become extinct through human actions. But these are only the tip of a vast iceberg. Since most species are as yet undescribed, the majority of current extinctions are going unrecorded -- species are dying out before we even learn of their existence. Projections of future losses vary widely, from 2 to 25 percent of all species over the next 25 years. But even the low end of this range is 1,000 times the background rate of extinction.

The total extinction of a species is drastic and at present irreversible. But local extinctions are serious, and far more common. Data on species are far from complete, but countries and taxonomic groups with more complete information have a higher share of species threatened, so it is quite likely that as more data become available, the percentage judged to be under threat will rise. The prospects for the coming decades look gloomy. Forests are the home of between 50 and 90 percent of all land species in the world. If tropical deforestation continues at present rate for the next 30 years, it is estimated that 5 to 11 percent of forest species will eventually be lost.

Wildlife habitat is becoming increasingly fragmented by human activities -- making way for cities, farms and roads. Fragmentation lowers the size of individual populations, reducing their genetic variability, and making them more vulnerable to extinction. Human barriers also make it difficult for animals and plants to migrate in response to environmental change.

At the same time, global warming will be shifting present temperature zones generally polewards and uphill. Species will have a greater need to migrate but will encounter human barriers blocking their way. Some species which prefer cold temperatures will see their natural habitats disappear completely. Meanwhile genetic engineering -- unless it is rigorously controlled -- may introduce new genes which could spread to wildlife with unforeseeable consequences. There is no doubt that genes from existing commercial crops can pass to wild relatives, and even with rigorous control measures, it is unlikely that accidental transfers could be prevented indefinitely. The extent to which this is likely to have negative impacts on the environment and biological diversity is still not known.

The Global Biodiversity Assessment found that the major threat to biodiversity was habitat loss, fragmentation and degradation, due to the need for land for farms, dwellings, industry, services, transport and leisure. Of those species that are threatened, habitat loss affects 44 percent of the bird species, 55 percent of the fishes, 68 percent of the reptiles, and 75 percent of the mammals. Other direct pressures are overexploitation of species for commercial gain, for subsistence or for sport. The introduction of alien species, pollution and climate change are all major threats. Population is a major indirect cause underlying most of these threats.



Population density is closely linked with most forms of habitat loss. A sample of 50 non-desert countries in Asia and Africa where wildlife habitat loss has been estimated showed that the percentage loss tends to be highest where population density is highest. The top 20 percent of countries, ranked in terms of habitat loss, had lost an average of 85 percent of their original wildlife habitat. Their average population density was 189 people per square kilometer. The 20 percent with lowest population density had lost an average of only 41 percent of their wildlife habitat -- and their average population density was only 29 people per square kilometer.

Governments are gradually moving to give wider areas protected status, but progress is slow. Globally, in 1997, only 6.4 percent of the land area was protected. To protect the full range of species, large areas are needed, but 88 percent of protected areas in 1997 were smaller than 100,000 hectares -- a square with sides of about 32 kilometers.

Biodiversity is integral part of our life as different aspects of our activities. For our survival, we must be aware about biodiversity and take measures to check its the mass extinction. It is high time for sustainable use and conservation of biodiversity otherwise our own extinction will also come soon.

Khalid Md. Bahauddin is Member, Bangladesh Society of Environmental Scientists, Jahangirnagar University, Email: khalid_mbuddin@yahoo.com