Indian Institute of Technology Madras

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NPTEL

NATIONAL PROGRAMME ON TECHNOLOGY ENHANCED LEARNING

NUCLEAR REACTOR AND SAFETY

AN INTRODUCTORY COURSE

Module 10 Lecture 02

Siting of Nuclear Power plants Cont....

Dr. G. Vaidyanathan

School of Mechanical Engineering

SRM University

Good morning everybody. In today's lecture we will continue discussions on many more siting considerations which we have no doubt brought out but in a little more depth.

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Flooding

- Nuclear power plants require large quantities of water for cooling purposes and are, therefore, suitably located either at coastal sites or at inland sites by the side of a reservoir or a river. It is therefore, imperative that safety of NPP is assessed against flooding. Establishment of design basis flood (DBF) for NPP requires identification of various phenomena relevant to the site conditions, which can result in flooding. This include surface run-off from precipitation, possible upstream dam failure, snow melt, high tide, storm surge, as well as earthquake induced water waves i.e., tsunamis and seiches.

We mentioned that one of the important things could be flooding. How? As I mentioned we take water for condenser cooling from a river or from the sea. It is quite likely that you could have high waves in the sea or in a very large

amount of rain in the river areas you could have a flood. So it is very important that we assess any site for a nuclear power plant from its flooding potential. So before you start designing the plant you setup your design basis flood that means any system which is required for operation should be above that. That is that minimum level above which any structure of a nuclear power plant should be there. And this goes through lot of discussions. Then besides this, it also could include tsunamis. Then as I said snow melt, many times what you call the sea level rises because of snow melting. Then suppose let us say there was a dam which is located well away from the plant. Not well away means not very far but should that dam fail and the water come to the river and that could be flooding. Of course, there could be internal flooding also but there is a part of the design internal design of the plant. This is an external event flooding when we consider.

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- Assessment of design basis flood due to cyclone/extreme precipitation consists of two stages. In the first stage, the historical data on occurrence of cyclones and tornados in the region is collected. In addition, past data concerning wind speed, pressure drop during cyclones, dry and wet bulb temperature and severe precipitation for a period of 50 years (if available) is also collected. This data is then subjected to extreme value analysis to derive the extreme value of each parameter for design along with their corresponding mean recurrence interval. A suitable meteorological and hydrological model is developed to characterize hazard due to surface run-off with due consideration of limitations of available data and past changes in relevant characteristics of the region. Floods caused by failure of upstream dams/barrages or due to possibility of temporary blockage of rivers upstream/downstream caused by landslides/ice are also assessed.

Now how do we go about this assessment? We do it in two stages. First stage what has happened before as a part of history. All the historical data on the cyclones, tornado which have happened in that region we collect. Then we also have the data on the wind speed and all your temperatures; both the dry bulb and the wet bulb temperature, how much has there been any flash floods of a thing in this last 50 years, we collect. Then we subject these data into what is called as an extreme value analysis wherein it looks at the probability of the occurrence and its magnitude both and then finally it tells how what sort of a value we need to consider for the design basis. Normally once this data is analyzed to analyze that we use a model which considers or this meteorological and hydrological parameters and we do this analysis. And you might wonder how do we assure that these models are okay. There are institutions in the country like the Central Water Power Research Station which is located at Khadakwasla, near Pune wherein they do model stories. They really have a scaled model, scaled down model and they really look at the moment of the river,

whether river changes course as a function of time, all sorts of things, different soil conditions everything is done. So we do give a contract to these agencies to do the analysis.

Then as I mentioned the failure of any barrage or dam upstream and should there be a blockage of the river because of landslide very very close hilly area, anything can happen. So all these nice things should be assessed. So this model which ever developed will give us an idea about what is the required design basis flood level.

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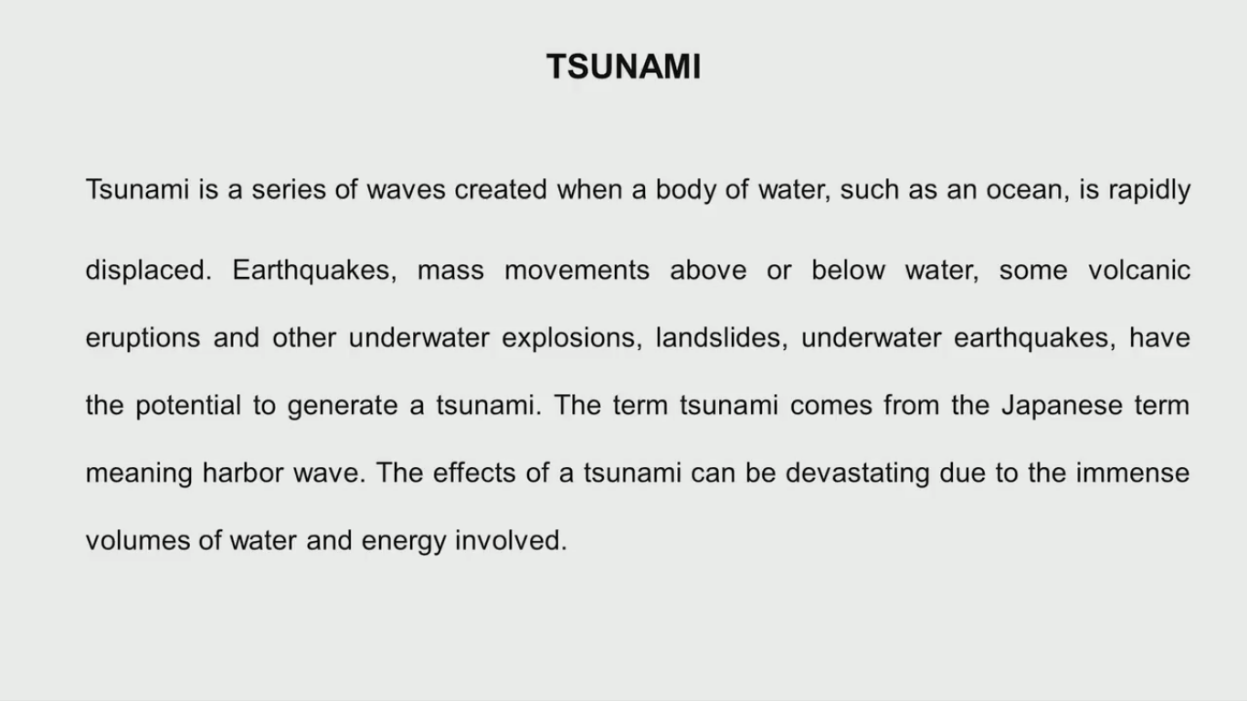

Now let us look at this tsunami. What is tsunami? It's the Japanese word. It's a series of waves created when a body of water is rapidly displaced. That is is a huge amount of water is displaced. That's why we had the tsunami in 2004, large amount of water came onto the land. So how does it happen? It can be because of movement of the Earth below the sea level. When that happens that just in the land when the earthquake happens it breaks the land and pushes the material out, the plates which break. Here it is the water which is there which comes out. So all of us know that the tsunami can be very devastating. Here if you really look the way we'll be traveling with the speed of hundreds of kilometers per hour and when it comes to the shore where it is stopped, the whole kinetic energy converts the potential energy. It just goes to a right as it happened in the Fukushima in Japan in 2011. The height of the waves went as much as 15 meters whereas still that time only they had had tsunamis of 8 meters. So in Kalpakkam also we had a tsunami of something like 5 to 6 meters. Of course, incidentally I was a witness to the tsunami in 2004 and by a few seconds I escaped. And it can really cause lot of damage to property.

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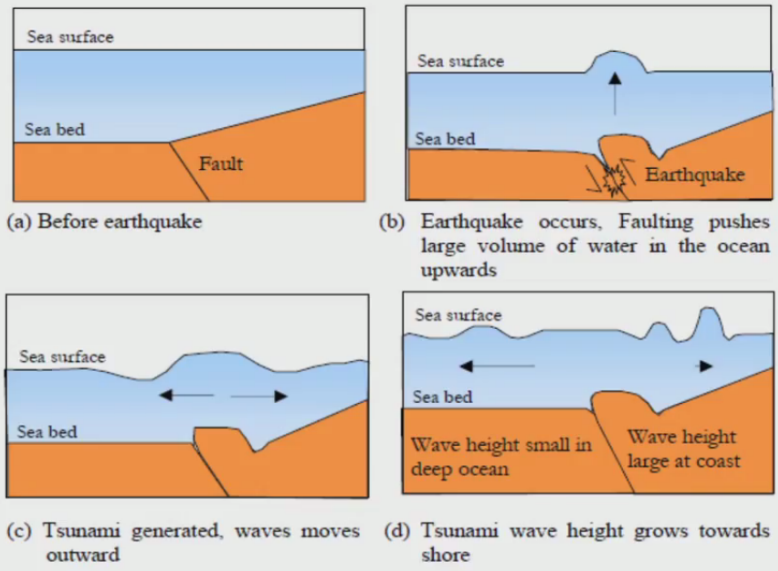

Now look at this figure. How a tsunami happens? Just as we call a fault in the Earth play similarly fault on the base seabed also is possible and let us say this earthquake occurs so this plate moves because there is a crack. This when this pushes this mass comes out and this pushes water on the sea surface. When this pushes the water and then tsunami is generated now now. Now these waves start moving outward and this will be very low where you have a deep ocean but when you come very close to the land where the depth will be very less you are more or less seeing that your land mass is trying to stop this. It is not allowing further. So it rises in height and then grows. That is where we get a large amount of force and the large amount of force.

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SEICHE

- Once the water has been pushed upward, it spreads out horizontally . Once a tsunami gets close to shore, it hits shallower region and velocity of wave decreases. Due to this decrease in velocity, the wave height increases considerably as the compressed energy forces the water upward. This phase is called tsunami wave run-up and is responsible for flooding in the coastal areas.
- “Seiche” is a French word that means “to sway back and forth”. Seismic seiches are waves set up on rivers, reservoirs, ponds, and lakes when seismic waves from an earthquake pass through the area. If the site is found vulnerable, the flood hazard due to these phenomena is assessed based on detailed mathematical models

Then once this water has been pushed up, it spreads out and of course the velocity of the wave decreases and the velocity of the wave decreases, the height increases, and this is actually as a tsunami and just like earthquakes here also there will be a wave. Then it will come back. Then it will be going back and forth. That is sometimes referred to as seiche. It is a French word for to sway back and forth. Of course, this back and forth movement can be even in lakes or rivers when you have the seismic waves. So looking at this we look at a site and all these flood hazard if we feel that these things can cause, require a very large design basis flood level then we may have to think because it's an economics. You can't build all your plant in a very large height. So we have to look at that.

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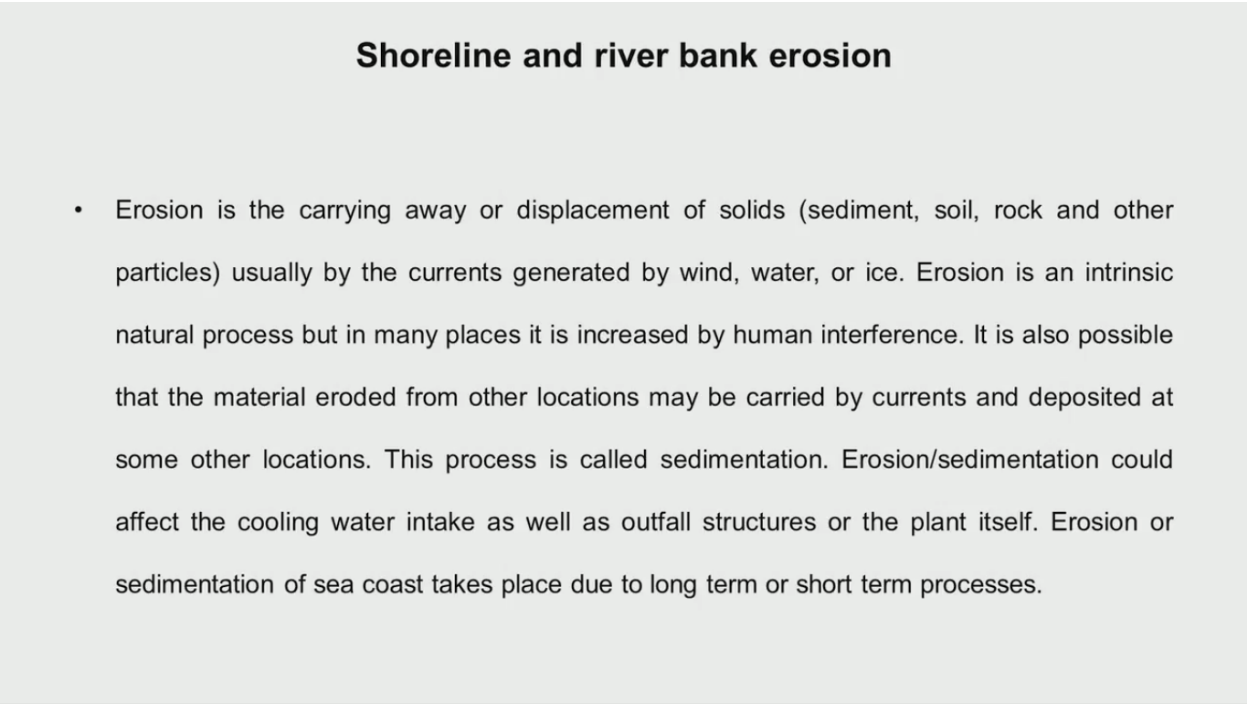

Then shoreline and riverbank erosion. See suppose I have put up my plant very close to a coast and you know the shoreline is never constant. It moves in areas where you have you will find that somewhere the Earth sea is coming in inside, somewhere you may find that the beach portion is growing. This is dependent on the wind directions. This is dependent upon the sand deposition patterns and different things. So this can be observed in the based on the historical observations on the shoreline. So no erosion no – there is a wind it will take the sand and anyway sea water erodes. It's a very common things, and it erode it some place it will deposit in another place. In fact I have seen at Kalpakkam where I lived for 40 years we found that after the construction of some structures very close to in the beach we found that the shoreline had changed. Then we realized that after some years in another place nearby villages somewhere the sea has entered practically inside. That is it has come in. So somewhere protected somewhere. So it has got a natural way of relocating and redeposition. So this needs to be considered before you choose. You should not put your plant in – the distance should be good enough so that you are not going to cost at least in the time of the life of the plant.

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- The long term phenomena include presence of natural structures like river mouth, and sediment transport along the coast. Short term factors include seasonal variations and various human made structures. In case of coastal sites, studies are carried out to establish that there is no potential for shore instability that could affect safety. In case of sites located inland, the instability of lake or river side banks could be caused by erosion of side banks or due to changes in river course (meandering). Due consideration is given to this phenomena during the site assessment.

Now there could be seasonal variations. Sometimes it is called as the they are short-term variations because of the different seasons. So there could be a shore instability which can happen and in case of river banks it can even change the course of the river and it can take another route. So we have to be careful that this doesn't happen. And one more thing which we must consider or keep in mind see many times from the nuclear power plant or the thermal power plant, the water used is let out into the river. The point at which we reach out if it is very low in case of some rivers getting flooded the water might even not the river it may enter through some of the pipes or some of the what we call passages which we are given to for the pipes to go into the river. In fact this happened in the case of the Kakrapar plant in Gujarat where excessive rain and the water increase and the flooding was the plant was flooded because of the spaces gaps in the pipes and the wall which was sending the water back to the river. So this is an important point which needs to be kept in mind. Of course this river course changing is called as meandering. It's a technical term for meandering.

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Human Induced External Events

Aircraft crash : Most of the air crashes occur during takeoff and landing phases of flight. Hence existence of an airport in the site vicinity increases the potential of aircraft crash hazard on NPP. The location of site with respect to the distance to major and minor air fields, including military airports is identified. If these distances are greater than SDVs as defined in the AERB siting code, for respective types of airports, the location of site is considered as acceptable. With the advances made in assessment of the hazards from aircraft impact including the effects of impact, fire and explosion, one can now estimate the consequences of impact also.

So we need to assess this site for all that. Then aircraft location. Now when does aircraft crashed generally take place mostly during takeoff or landing. That is the thing. When it is in the air normally very rarely turbulence happens but nothing -- crashes have not happened because of turbulence per se. So first is it should not be in the vicinity of a what you call, airport so that you can have a crash on the NPP but mind you in spite of all this we still consider in the design of the containment that a plane of course a military plane with a maximum energy can hit and still the containment will not fail. The containment structure concrete structure will not fail. Nevertheless, we still do this because we are reducing one event so that's what why we consider this distant from the airfield. Now this as I said if it is a military airport we need to be still far away.

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- **Chemical explosions :** Plants in the site region involved in handling, processing and storage of chemicals having potential for explosion or for production of gas clouds capable of deflagration/detonation, and the transportation routes for such chemicals are identified and associated hazards in terms of over pressure and toxicity are assessed. A site is considered unacceptable if such activities take place in its vicinity and no practical solutions are available to mitigate their effects. During the site evaluation carried out for prototype fast breeder reactor (PFBR) located at Kalpakkam, Chennai, it was observed that some parts of a highway pass through 3.5km from PFBR site. Among various hazards, the severest incident, i.e., accidental release of LPG from the LPG tanker was analysed in detail. The thermal and explosion effects were considered and it was ensured that the design of plant takes this into account.

Chemical explosions. Now I mentioned to you about chemical explosion maybe in a factory which is close to the plant. So we must but not only that that could be a road or a highway which is by the side of your plant or very close to your plant and let us say there is a explosion of the tanker. Then your chemicals effects will be felt at the plant. So it is very important that not only a chemical factory explosion any movement of chemicals around this thing or let us say you take a gas carrying, cooking gas, liquefied petroleum gas. There are tankers. There are sometimes tankers carrying very hazardous material. So in case that happens whether your site is okay. Here I would like to give a small example with reference to our prototype fast breeder reactor which is under construction at Kalpakkam. Here we found that the East Coast road was going was about 3.5 kilometers from the site. So immediately we decided okay if this is 3.5 kilometers what will be the effect. We considered worst-case scenarios and then satisfied ourselves that okay, our my [Indiscernible] [00:17:08] plant is taken care. There is no effect on the plant because of such explosions. Mind you all these details and studies we need to submit it to the regulatory authorities. Of course, then the Ministry of Environment and Forests everything so that we get the environmental clearance. Environmental clearance is very very important today for practically all industries. We are not following that but luckily for us in the nuclear industry everything is streamlined.

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Other important human-induced events

- Information on blasting operations in the site vicinity and activities related to mining, drilling and sub-surface extraction/injection of fluids are carefully studied to assess their impact on safety of the installation. The region is also investigated for plants/activities either within or outside the installation boundary in which flammable, explosive, asphyxiate, toxic, corrosive or radioactive materials are stored, processed, handled or transported such that if released under normal or accident conditions, could jeopardize safety of the installation. The plants that could give rise to missiles are also assessed with respect to the plant safety. Natural and human induced events that could result in loss of cooling water are identified e.g. blockage or diversion of a river, depletion of a reservoir, blockage of a reservoir or cooling water intake structure by ship collisions, oil spills and fires.

Now what or the other type of events which we think can have effect on the nuclear power plant. Mining. Suppose some mines are there nearby or some drilling operations are going on. Then that drilling can have effect on the plant because continuous vibrations may be transmitted to the plant and this can affect. So we would not like any mines to be nearby. One more thing sometimes in the mines you ought to have explosives to open up and that will cause a vibration to the NPP, Nuclear Power Plant. So one is I should be able to design for that vibration or if I find feel that that going to be higher value I would like to see that I don't locate my plant. I locate it a bit far away such that it

cannot. And these for these again you do lot of studies by really blasting at some places and then noticing how the vibrations are traveling through the land in different places.

Then another thing let us say that there was a warehouse which is storing some flammable material or some toxic material. There may not be factory. It may be a warehouse where it is located and then it may be they may be taking it and transporting it. So that should also not jeopardize. Here again I remember I want to tell you we take care that this should not affect. So we make an assessment. If it is okay. We don't we don't say that okay if it is there I will not. So these are all under the desirable categories. Then last but not the least we should see that cooling water for the plant is always available. You must have a reservoir normally you would find a large reservoir is built very close to your nuclear power plant so that in the worst case when pumping fails you are able to give water to the plant to maintain the shutdown cooling and keep the plant in a safe condition even when power is not available. So this is a very important matter. In some cases we need to see let us take that we have a sea water being used as a coolant. Any ship or any shipwreck happening very close to that weather it can affect the cooling water. All these aspects we need to be look into and see that so we will say no ships should come in that direction like that we put some rules. Now till now we saw what was happening to the plant from the external.

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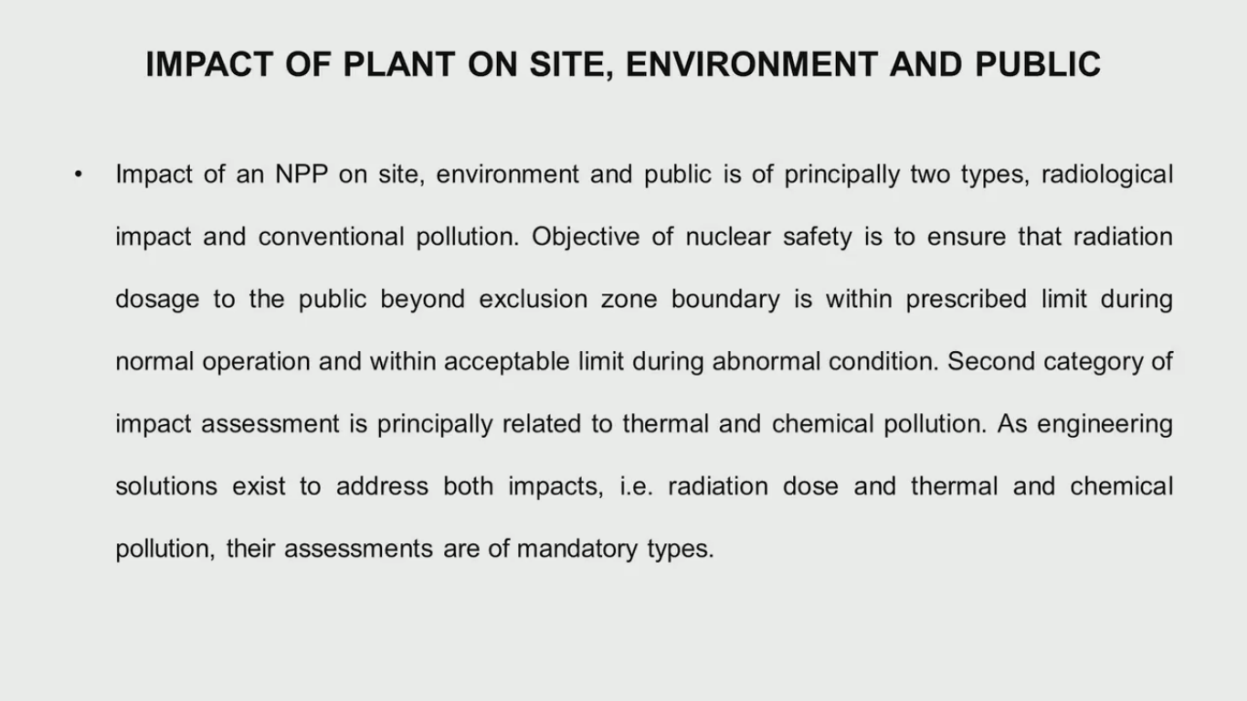

Now we will look up what the plant will happen to the site and public and environment because of the plant. What are the effects they can be? Two, one is normally what we call conventional pollution or there is radiological pollution. And our main objective right from beginning is to ensure that the radiological pollution or radiological impact beyond the exclusion boundary is within the prescribed limit not only during normal operation even during abnormal operation and what is the exclusion zone boundary it is 1.5 kilometers, radius that circle you draw within

that okay outside that we should not have that any radioactivity even under normal or during abnormal conditions. This is a very important thing because there is a basic thing for which we are working. Now second category of events is related to the thermal and chemical pollution. In the chemical pollution let us say we are having power plant which has a reprocessing facility and then also in the plant we have chemicals for water treatment and all and after we do the treatment the water we will release it to the sea or river. We should see that this release of chemicals is controlled so that it does not result in the death of the marine organisms including fishes so that our environment on the sea is not affected. So this is very important. So we have limits on what sort of concentrations we should send. So we normally we should dilute and be able to send. Then thermal. Thermal is nothing but what I mentioned to you earlier. We take cooling water for cooling the condenser in thermal power plant or a nuclear power plant. The water it enters at about a room temperature of about 34-35 degree centigrade or about 30 to 32 degree centigrade and will come out after removing the heat in the condenser and if it comes at a very large temperature difference again the marine organisms life would be disturbed. They require a very minimum variation of temperature. So this limit has been set by the Ministry of Environment and Forests. We have a criterion that it should not be more than 7 to 10 degree centigrade. Generally 7 in other cases 10. Now this if that much is not possible we should not – now let us look at, let us look in a design where the temperatures are bit higher. So what we need to do anyway we have to have a higher flow of cooling water. Higher water flow means higher pumping and lot of cost. So in some of the plants basically which are cooled by river they take the water which is coming from the condenser through open ponds so that by the time it reaches the river it cools off. They are ways – see everything can be engineered. Here is one thing which can be engineered. Idea is the temperature should be within 7 degree centigrade which is a quiescent condition for the marine organisms. Here I would like to give you a small flavor of one thing which happened about 20-25 years back. It was near the Ennore thermal power plant which was earlier. Now that Ennore thermal power plant doesn't exist and there was a marine research center by the side of the Ennore thermal power plant somewhere little bit away. They were trying to do research on what conditions this marine organisms can grow. How it is fishers and things like that and once when there were failure in the condenser tubes of the Ennore thermal power plant people were called and this marine scientists also they also went and when the condenser was opened up they found lot of growth of this marine organisms inside the condenser and they saw the fish movement around the water where the water is taken and let off in the nearby sea. It was really enormous. So they concluded that our condenser conditions are the most suitable because it is a constant temperature. So that shows that only thing what the marine organisms require is a constant temperature not much variation in temperature and the condensers prude of course because of the growth of these organisms we had some tube failures.

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Radiological Impact Study

Radio-nuclides released from an NPP during normal operating conditions and under accident conditions eventually reach humans through various pathways. Pathways are routes through which people are exposed to radiation resulting in exposure/radiation dose to different parts of human body. This could be through

- Inhalation, i.e., breathing of the contaminated air,
- Ingestion, i.e., intake of contaminated food
- Immersion, i.e., direct exposure of the body to radioactive material suspended in the atmosphere.

Going on to the radiological impact. Why radiological impact will occur? If radionuclides are released. Now as we saw earlier during normal times we do release very controlled levels basically in the gaseous form after going through filters, and if you whatever anything we send out it has got how it reaches the human. So these are called as pathways. So basically pathways are routes through which people are getting exposed to the radiation. How? This can be through inhalation means breathing. You are in an area where radioactive contamination is there you inhale. Then ingest. Ingest means something could go through into your system of food, food contaminated food you take it could go. If you recall after the Fukushima disaster there is lot of worry asking people not to eat the food, asking people not to eat the fish because they were contaminated. So that could be another route. Of course, as I told you earlier forget about radiological impact, radiological this thing normally itself we are taking lot of potassium-40 with our food radioactive potassium-40 is coming in. So these are all only additional things. Then immersion. It could be a direct exposure to of a person to the radioactive material. This mostly can happen only to the workers, occupational workers or in some establishments which are handling you know sources of radioactivity like X-ray units or irradiation plants like that.

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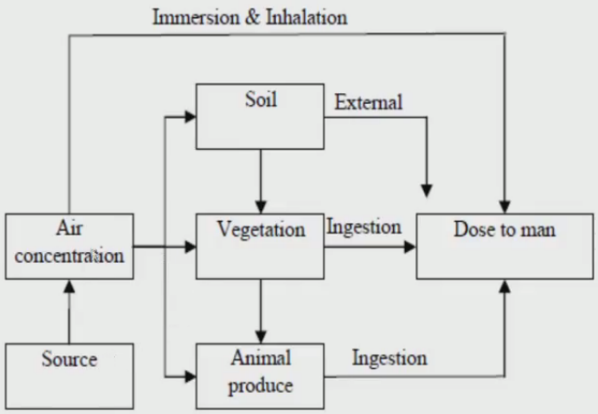
ATMOSPHERIC PATHWAYS TO RADIACTIVITY TO HUMANS



So this sketch shows how it can move. This is a source. So it comes out in the air. This air can affect the vegetation and vegetation eaten by cows. So milk can get or the – it can goats also can get. Then that can slowly get to the man ingestion. This is actually ingestion or it can come through the soil. It can radioactive thing deposit of the soil. That can also go to the vegetation and that also can have an external dose to the man and then of course direct inhalation or immersion whatever, both are possible. So here these are the routes. That is why when I mentioned to you that we do take a environment survey means we do all that. We look at the food. We look at the what you call milk. We look at the vegetables everything we monitor from time to time.

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- The main objective of the radiation impact assessment is to determine individual radiation doses as well as total population dose resulting from the plant. For this purpose, details of site characteristics affecting dispersion of radioactive materials, population distribution in the site region including their dietary habits, and use of land and water bodies are examined. There exist many exposure pathways leading to exposure of a member of public, but the dosimetric models indicate only a few of them to be really significant. These are known as critical pathways. A radionuclide which leads to a predominant dose through a pathway is termed as the critical nuclide.

So what is the objective of this radiation impact assessment is what is the individual radiation dose coming to the population from a nuclear power plant. So we need to know the site characteristics. That means we said the wind, the flood everything. The wind comes into picture because let us say some radioactive gases are released which direction the plume will take, which direction it will go, which direction will be more in the winter, which they are actually more in the summer all sorts of data we get. Then the population distribution around the place, which population more, which is less. We get an idea. Suppose I know the direction in this direction I know that means this population is going to be affected. I can do some proper emergency evacuation measures. I might plan for that condition. Then the food we eat, for example the dietary habits. For example when we take Kalpakkam we found that rice is one of the items which is maximum consumed by the public. Maybe if I go to North it might be wheat. So we find out what are the dietary habits and then assess how which are the things. So all this thing we do of course well before the plant is built. Then the we've identified which nuclide is critical which can easily get to the common man and look at that nuclide with more interest.

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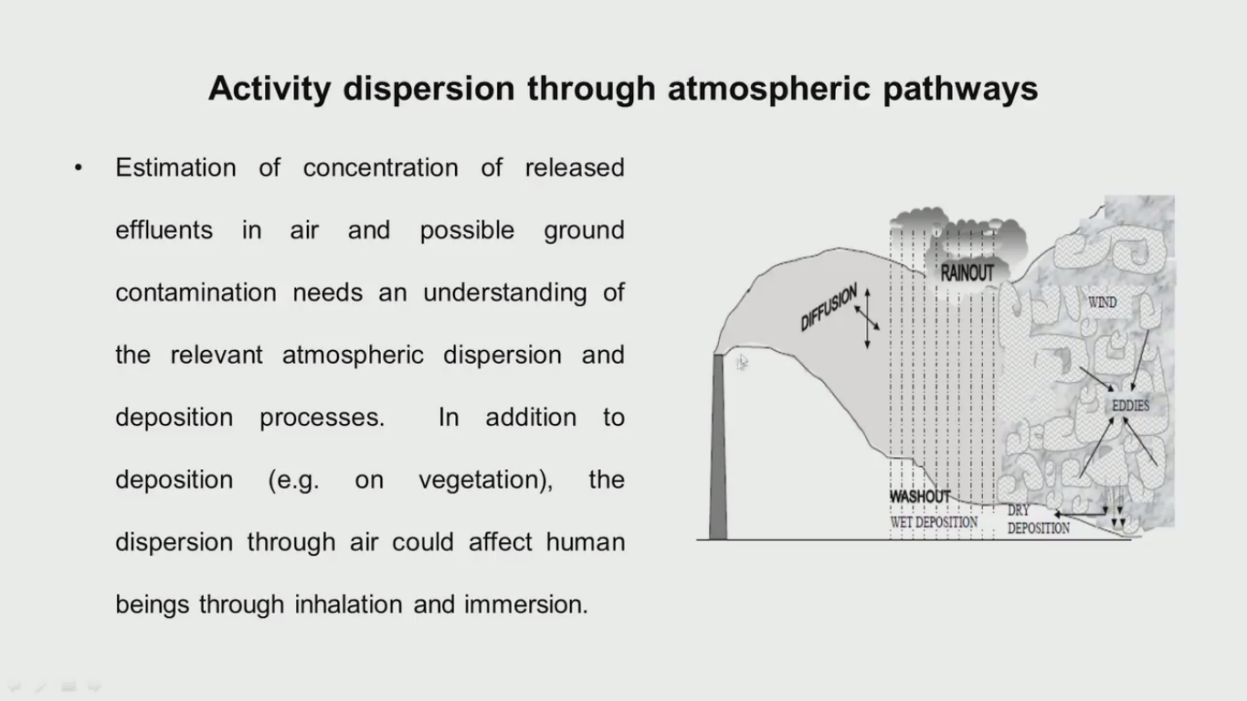

Let us look. We just see this is a plume. Now it will diffuse as distance is there. Suppose you have a rain it might wash out and deposit. Suppose it is not there it may just the plume may go. There maybe eddies everything. Then all these things require a modeling of this taking the weather conditions into account we need to assess how these things go to assess the impact and here we have a continuous weather monitoring station not only at Kalpakkam but at different places along the coast nearby Kalpakkam in a distance of about 20 to 30 kilometers. We have continuous monitoring and continuous data being through wireless transmission being collected at Kalpakkam. In fact many times and we get inputs from the ISRO satellites about the weather conditions, about ensuing weather condition like a cyclone or a storm. So all these data we build it into our assessment of the radiation impact.

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- The nature of release (source height, source strength), the type of sources (specific nuclide released), duration of release (puff/continuous) and the relevant atmospheric parameters could widely differ. The domain of atmospheric flow to be considered (micro, meso or synoptic scale) would be governed by the range of distances over which the assessment is to be made. General meteorological data such as wind speed and direction, air temperature, precipitation, humidity, atmospheric stability parameters, and prolonged inversion conditions are collected from nearby meteorological stations for at least one full year and supplemented with any other relevant data from other sources.

So first what is the source strength, how much is the source, how many becquerels of activity it has got, and then at what height it is being put out. You always see a chimney of course no smoke comes out near a nuclear power plant but that chimney height is decided such that the plume which is generated by the time it reaches the ground it would have dispersed a lot so the effective per unit volume activity would have come down a lot. So the stack height is decided that way. Then what sort of nuclide you are going to release Odin, Krypton, Xenon what sort of things you are going to release and what is the duration of your release and how they will change with the atmospheric condition. So all this data as I mentioned the wind speed, the air temperature, the humidity and all parameters we get current and the past and we are able to decide when I should release the valve. So even this is also possible.

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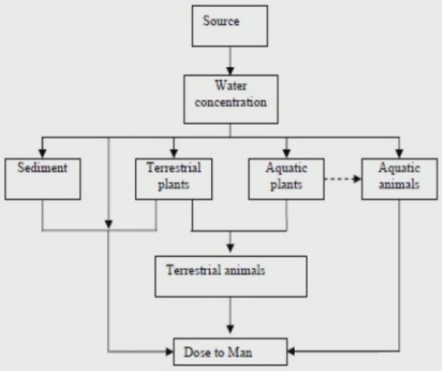
Activity dispersion through surface water

- The hydro-sphere represents an important pathway. This includes both surface and subsurface water. Surface water refers to open bodies of water on the earth's surface including sea. Although these water bodies form a continuum with ground water, a distinction has been made for purpose of dispersion analysis and dose assessment as the radio-nuclides are transported rapidly in surface waters.



Then let us take the other route of water route. Source where we are using and let us say we are in a waste treatment plant so we have lot of water which is having activity or let us say there could be a surface or a subsurface which has got this activated water. In the case of your Fukushima we had to discharge active water. So that can go to sediments. It can go to the plants both the terrestrial and the aquatic plants and again the aquatic animals officious they will take. Then finally the dose will come to the man from both sides. So how the groundwater dispersion is very important so that's why wherever we have this waste treatment and waste immobilization plants we continuously monitor the ground around the area we look for activity and again these are we decide our siting based on the soil conditions, the ground water movement, etcetera. but still nevertheless we continuously monitor. So we want to ensure that the radionuclides will not be transported very fast.

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- Low level radioactive wastes generated during plant operation are stored in the sub-surface locations, like trenches within the plant area. The postulated sources for the radionuclide migration through sub-surface water are earth trenches, Reinforced Cement Concrete (RCC) trenches and tile holes storing low and intermediate level radioactive wastes. Rain fall, run off, surface storage and ground water recharge, porosity and permeability of the soil and rock formations are significant factors responsible for giving rise to different types of aquifers which control the sub-surface dispersion. Hydro-geological investigations are carried out to study migration and retention characteristics of soils, dilution and dispersion characteristics of aquifers, and physical and physicochemical properties of underground materials, mainly related to radio-nuclides transfer mechanisms in ground water and their exposure pathways.

Now low-level radioactive waste as I mentioned we store it in trenches or within the plant area. So there is always this is a source for through subsurface water and suppose there is trenches there is a leak. It is possible. So we use normally reinforced concrete cement concrete trenches. Then sometimes rainfall and seepage through the trenches can happen because of the permeability of the rock and soil in that area. So that also can lead to dispersion. So we really understand all these pathways. We do lot of studies by examining the dispersion by simulation with some other sources when the plant has not been built and then later we find out, use these models to validate experimental model to validate our theoretical model and then use it for the analysis.

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Population distribution

- Population distribution is one of the several characteristics that are considered in the radiological impact assessment. The main aim is to assess the radiological impact resulting from releases of radioactive materials during normal operation and under accident conditions with a view to minimize the collective dose to the population. Another reason for conducting population distribution study is preparation of emergency preparedness plans. . It is desirable to locate the plants in the regions of relatively low population density.

Then population distribution. It's a very important input as I mentioned. Suppose on the day when I had my leak or when I want to release something to the atmosphere I must know in which direction the wind is which population. If the population is going to be very large in that area then I would like to think twice and this population distribution analysis helps you even during emergency preparedness. You know that okay today this emergency has happened in this direction okay how many people are there. I need to evacuate about 1 lakh people. So how many buses I require all this goes into the emergency planning. Of course, when we come to emergency preparedness we will see how these are done. So the population distribution we saw is very important for us to know which population – how much population is getting that dose so that the average dose should not cross any of the allowable limits.

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Environmental Impact Study

- For meeting the cooling requirements of turbine condenser, water is drawn from sea, lake or river using intake structures. While passing through the condenser, temperature of the condenser cooling water rises and the heat is discharged to the ultimate heat sink. This is achieved by either discharging the hot water to the sea/lake/rivers though the outfall system or by rejecting heat to the open atmosphere through cooling tower. It is ensured that with the given arrangement of intake and outfall structures, the temperature difference between the two legs at specified locations are within the limits stipulated by the State/Central Pollution Control Board or any other appropriate authority. Appropriate numerical or experimental model studies are generally conducted for this purpose.

Then let us look at the environmental impact study. Of course environmental impact study as I mentioned is conducted by an independent agency. We do consider the cooling water, the condenser cooling water requirements and things like that. We do consider but the study what we do study will not be acceptable. It should be done by an independent agency. That independent agency consultants they have data of so many plants, thermal power plants and all. So they do have an idea how to go about it and they also would give us solutions to the different types of problems. So we use their expertise. So as I mentioned this cooling, the intake structure, intake structure means where we take the cooling water from the river or sea and the outfall is where we put the outfall. Now the temperature difference needs to be maintained and this is again indicated for different areas which is the local, the state or the central pollution control board has put limit and for this studies have to be need to be done to say that this is appropriate. This will not happen. We do a lot of experimental modeling also for this.

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SUMMARY

- These 2 lectures have shown the degree of safety consciousness right from the site selection stage of a nuclear power plant. Such an approach is absent in many industrial activities. From this you would have got to know the amount of work that is carried out by different agencies before a site for NPP is selected. It is carried out as a scientific activity based on regulations which are international in nature. The environmental impact study is conducted by an independent consultancy organization, as in other countries.

In summary I would say what we have looked at in the last lecture and this lecture we see a huge amount of effort which goes into the site selection. So why? I repeat we are conscious of the safety to the person. Industrial safety sure. We are conscious of that. In addition to that we are very much conscious of the radiological impact which it can cause, not that radiation per se is bad nevertheless, we would like to see that the normal radiation levels which are persisting we should not add too much into that. We want to that additional value we want to limit as low as possible. One can say take one viewpoint very I should say drastic viewpoint this can cause radiation so why we go for it. Not correct. Everywhere there is a risk. So that we have to see that the risk is acceptable and here when the operation of so many plants has shown the risk is not high. I can just tell you one very very important thing which people normally get scared sir radiation if it happens today okay I am okay but it can genetically affect somebody. There could be mutations and cancer some could be some other and it could have different problems for my future

generations. Yes that was what was thought in the 40s and 50s but now we have data on all the people who were exposed to the Hiroshima, Nagasaki bombings in Japan in 1945. All their survivors and their children, their grandchildren everybody now it is something like about 55 plus 14, 69 years of data we have and the most surprising thing is they say if we take the cancers which have happened in that sample population, maximum but not sure you can attribute only two cancers could be because of radiation not yes because it could be there are so many other causes. So what I can tell you there is there nothing to fear radiation but nevertheless we should take every effort to say that the impact is minimal. Too much of anything is bad even if it is like drinking you know nectar too much of anything is bad. So you see that the amount of safety consciousness in a nuclear power plant is unlike any other industrial activity like a chemical plant or anything. There may be revelations. Here we have a regulation. We have a regulating authority and the regulating authority its performance over the last 30-40 years has been so good that we have had practically no events which have released large-scale reactivity to the environment. Now this environmental impact study is a very important part before we make a decision on the site and as I mentioned environmental impact along with the all data and the then only we get the environmental clearance from the Ministry of Environment and Forest. Then only we can think about constructing the plant. Thank you.

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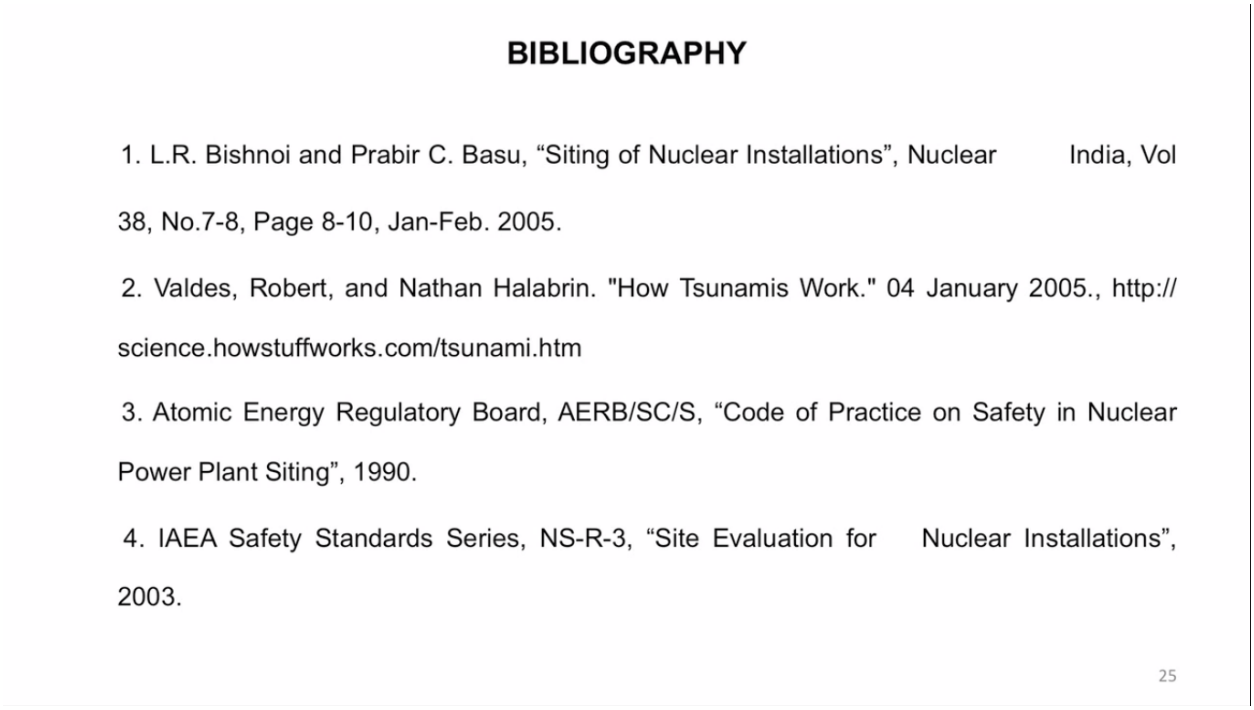

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ASSIGNMENTS

- List the important factors affecting the selection of site for a nuclear power plant? Are any of these common to thermal power plants?
- What are the mandatory and desirable requirements in the selection of site for NPP. Give examples.
- What do you understand by rejection criteria in site selection? List 5 such criteria adopted by AERB, India.
- Write short notes on the following with reference to site selection: a) Geological hazards b) Meteorological events c)Flooding d) Tsunami.
- What do you understand by Environmental impact study? What are the requirements to be fulfilled in such a study?

S Subash

F Soju

S Pradeepa

M Karthikeyan

T Ramkumar

R Sathiaraj

Video Producers

K R Ravindranath

Kannan Krishnamurty

IIT Madras Production

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