Sustainable Architecture
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Lecture – 27
Water Conservation - II

Good morning. Welcome to this new lecture, where we will be talking about Water Conservation as part of this ongoing online course on Sustainable Architecture. And, I am your instructor, Doctor Avlokita Agrawal Assistant Professor at Department of Architecture and Planning, IIT Roorkee.

So, in the previous lecture where we are discussing about water conservation and water management as part of the sustainable architecture. We have discussed about how to reduce the consumption which is the first strategy.

So, we looked at what are the different ways in which the consumption of water can be reduced. So, we talked about the low flow fixtures we talked about, the low flush fixtures, we also talked about some of the design strategies and examples where zero water can be consumed for flushing and other purposes.

Once, we have reduced the amount of water which is required on a daily basis, we have reduced the consumption of water potable water largely. We will then move on to see, what are the various ways in which we can replenish, in which we can reduce the load or municipal supply beyond the consumption part.

So, here we are looking at different strategies to treat the water to reuse the water. Here in today’s lecture, we will be looking at rainwater harvesting.

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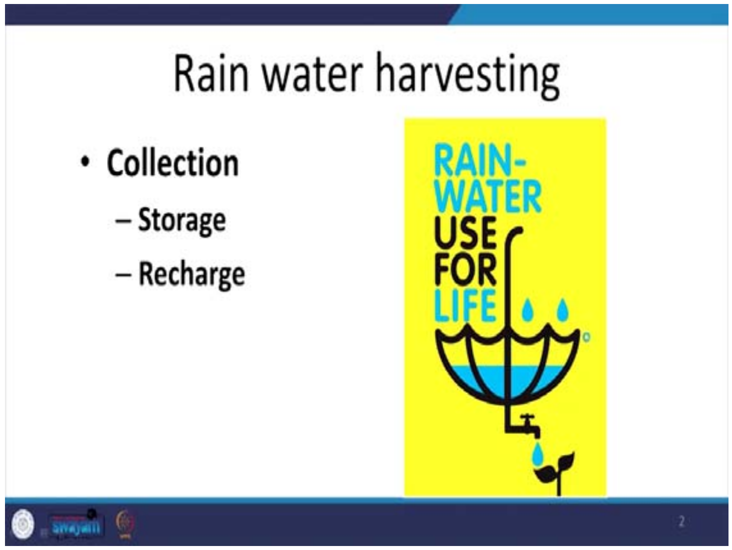

Now, rainwater harvesting is a very common idea as a very common principle is being taught even at schools. Now, couple of years earlier almost 20 years back, when we were studying in schools, we were not discussing rainwater harvesting in as much detail, but gradually as we see all over the country, our country that the ground water resource, which is which was considered to be a perennial source of water has exhausted, we have exhausted that groundwater aquifers.

So, we have the need to replenish the groundwater aquifer as well as use this rain water for our day to day water consumption water needs. This is where, we are talking about rainwater harvesting, how do we do it, what are the different strategies is what we are going to discuss?.

So, when we talking about rainwater harvesting we are discussing about two things; one we are talking about storage; storage of rainwater for later use. And, we are looking at recharge, when I was discussing about this exhaustion of underground aquifer, rainwater can actually be made forced to reach the groundwater, the underground water aquifer and recharge it.

Unfortunately, what has happened as we have seen in the previous one where we were discussing about the storm water management as part of sustainable sites, we saw that most of the materials that we are using on ground are impervious. They do not allow the rainwater to percolate down to the underground aquifer and that is what recharge is.

So, since it is not happening naturally which used to happen as we had a lot of land, which was not paved by impervious materials, we have to force this rain water to reach the ground and to recharge it. These are the two things, which we will largely be looking at in rainwater harvesting. So, it is not that we are talking about it suddenly areas which were parched, which had very scarce rain available the underground water table was very deep in all those places rainwater harvesting has been practiced.

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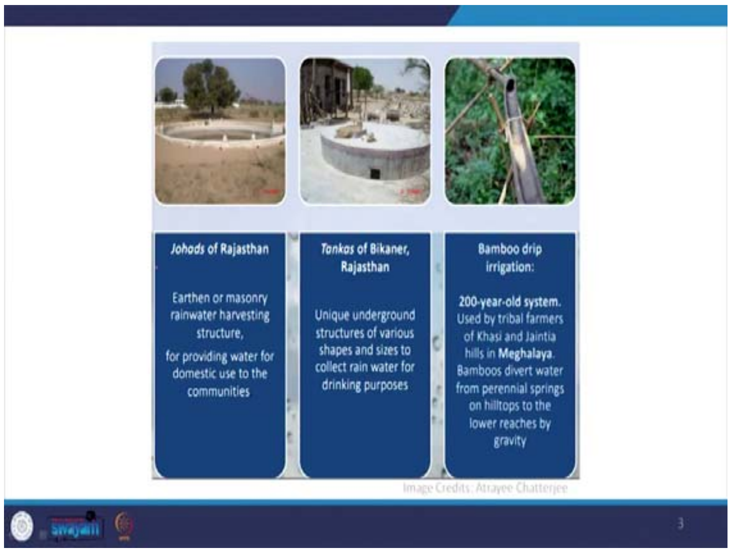

Since centuries so, we are talking about, Rajasthan some areas where Johad has been used. You know Johad is an artificial pond kind of structure, where the rainwater is allowed to collect and people use it throughout the year. There are Tankas, which are like artificially created catchment area around an underground Tank.

Now, this allows all the water to go in and these Tanka's were made with such precision, that the entire rainwater which will be falling on this catchment around the Tanka, will actually be captured in the form of this Tank and this was sufficient to feed them for almost an year throughout the year. However, the primary thing to consider was that the use the consumption itself was very limited.

So, that was where the sensitivity sensibility of people were was. Unfortunately what is happening right now is since we are not connected to the source of water. Right now, what happens? We are getting water from some municipal source.

So, there is a tank municipal Tank's somewhere and the water is being supplied. So, either we just turn on the tap, we have no clue how much water is there in the tank. We are only concerned if the water in my tap is coming and that is the only point of concern for me or in many cases people are drawing directly from the underground aquifers. So, they just turn on the pump submersible pump and it draws water. We do not know, how much of the water is there unlike earlier times, when we would directly go and fetch water from the pond or a lake or surface aquifer or a well or some Bawdi.

So, people would immediately associate that there is less water now. So, I need to reduce my consumption or if there is enough water, I may go on and use it little you know splurge it. So, this is a traditional practice. Unfortunately this was forgotten and we need to revive it.

So, this is what we would see in almost all the traditional settlements across our country. Though at that time the groundwater levels were much higher than what they are today, yet people were very very sensitive about, how to capture this water how to use this water.

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So, this is a Baoli at Abhaneri. And, this Baoli actually goes as deep as the groundwater and when the rains come this water table increases submerging the structure which is below. This structure would remain cool almost throughout the year. So, as the heat goes up as the summers approach the water table goes down and the lower structure becomes visible and the lower parts of the structure are utilized.

As this rains come the water table rises and the upper part of the structure is utilized more. So, this was such a judicious way of using a passive way where we were respecting the resources the water. Some such strategies they need to be used in modern times as well; rainwater harvesting is one such strategy.

So, if we talk about rainwater harvesting, it is broadly classified into two categories. We are either harvesting the surface runoff.

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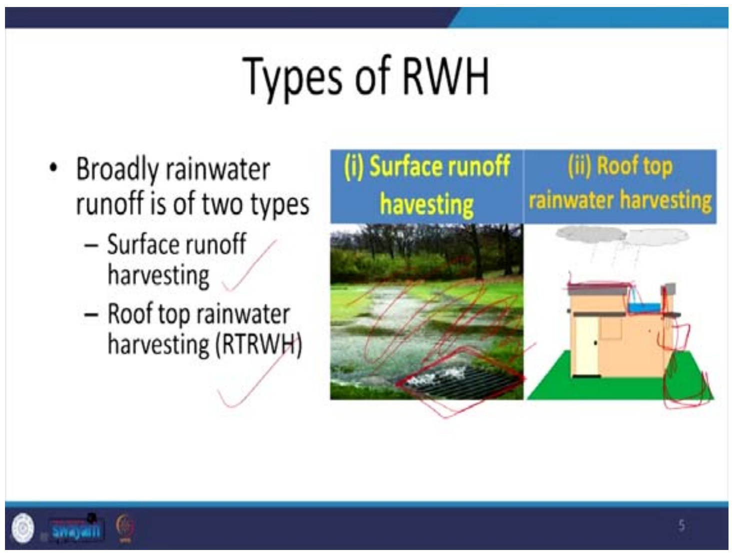

For example, all the water that collects on the ground and with the help of the drains and catchments we collect all this water which is being runoff from the surface. The other one is rooftop rainwater harvesting where all the water which is getting collected on the roof which is being received on the roof is collected on a tank.

Now, this could be anywhere it could also be a tank down on the ground, it could be a tank up there or it could be somewhere else midway as well.

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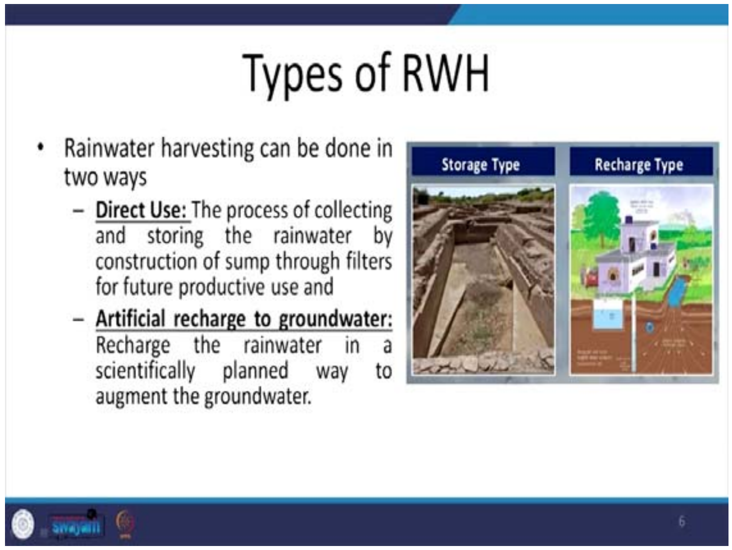

So, these are two types of rainwater harvesting broadly. The water which is collected can also be used for further two purposes one is for direct use. So, we stored the water. So, we store this water and we use it for different purposes in the house that is a direct use.

So, we treat this water it could be passing through multiple filters, we may treat it to bring it to a potable quality where the water is even fit for drinking or we may use it for all other purposes other than potable depending upon the availability of water, and also depending upon the users within a building.

The other is where I was talking about the recharge to ground water where this water can actually be used to go down and recharge the underground aquifer or through surface ponds retention ponds as we were discussing in the previous lecture as part of sustainable site development and storm water management.

Storing the water on surface and gradually letting it percolate down to the ground is also a recharge strategy. Both of these here we are using the rainwater to do the purpose, to serve the purpose.

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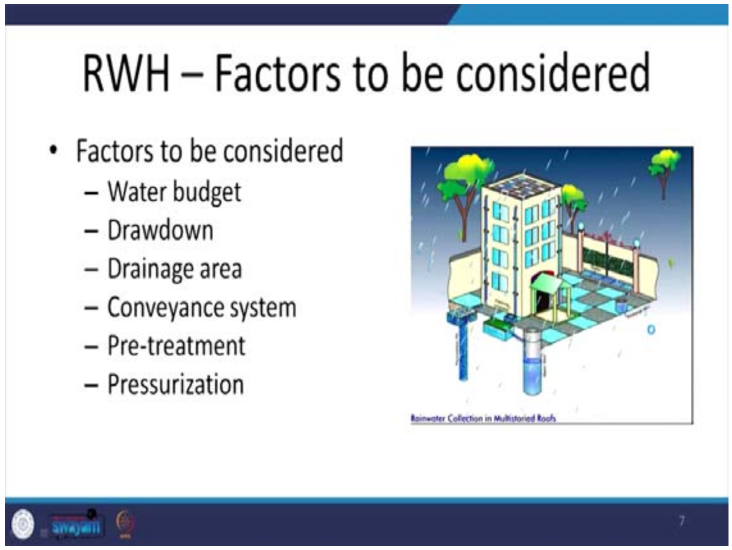

Now, when we are talking about rainwater harvesting and we are talking about the science and the technology of it. We have to look at the quantification of these numbers; so, how much of the rainwater is available, how much can we percolate down to the ground, what is my actual consumption, how much of this water needs to be directly used, how much of it can be recharged and so on.

So, there are multiple factors which need to be kept in mind and which need to be considered. First is water budget. So, we have to know how much of the water is being used, how much is coming that all will become part of the water budget. Second is the drawdown, how much of this overall water which is available will be used and at what rate will we draw it so, that depends upon our consumption pattern.

The next is drainage area. So, how much of the area is available for us to collect this rain water? So, rain will be coming at a certain speed at a certain rate. Now, how much of the area is available will determine how much of water is available to us. Then, we also talked about the conveyance system, collecting this rain water taking it to the storage and then taking this water out of this storage and using it in the building. So, what kind of pipes, what kind of drains are going to be used is what the conveyance system is comprised of.

The next is pretreatment. Now, this pretreatment depends upon what purpose are we collecting the rainwater for? If, we are collecting the rainwater only for managing irrigation suppose then the type of filtration which is required is different. If, we are collecting rainwater for pumping it to the ground, the filtration level is different. If, we want to use it for potable use for human consumption, human use, then the filtration level and the cleaning has to be of a different order all together and then pressurization.

Now, this pressurization will be in case of the recharge. So, the water may need to be pressurized to go into the underground aquifer or the other way around. We could also need pump; we would also need pump to take this water, which is stored in a tank somewhere underground to the overhead tank to be used in the building on an everyday basis.

Let us go over each of these factors in a little more detail.

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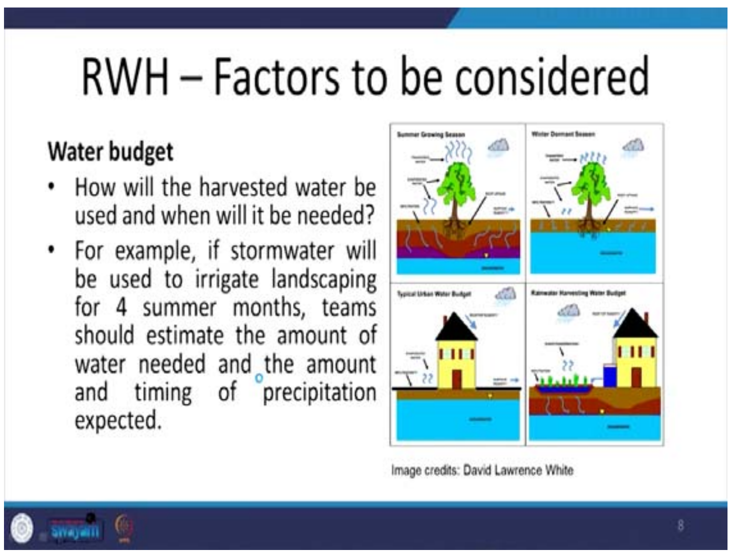

So, when we are talking about water budget, we are talking about how much water will be harvested and when will it be that it will be needed. So, we need to know what is the actual consumption of water in our building and how much of the water can actually be harvested when the rains are there.

So, we can see for example, if the storm water is there, it can be used to irrigate the landscaping around the site for 4 summer months. And, we should estimate the amount of water which will be required for landscaping and simultaneously the amount as well as the timing of the precipitation when the rains will be there.

Based on this, we will be able to estimate we will be able to make a budget. And, this budget will help us to decide what the size of the tank should be, how much water can be stored or should we stored.

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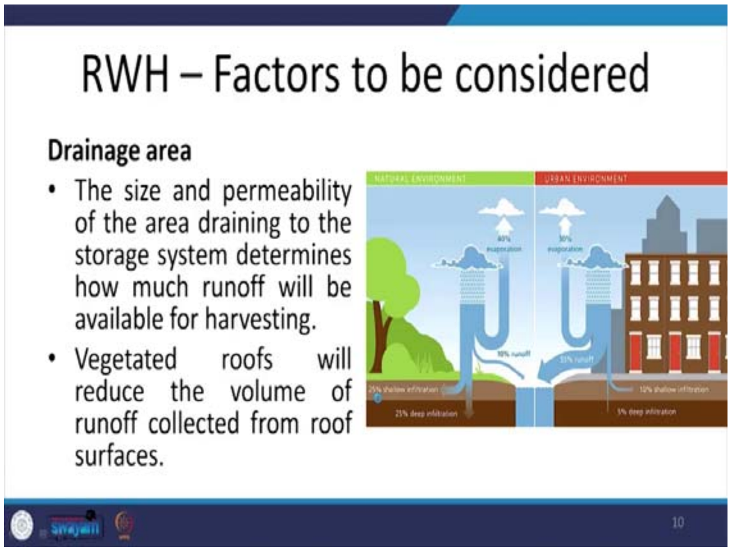

The next is drawdown. So, we have to see at what rate will the water be taken out. Suppose, we have consumption, we have already estimated the amount of water will which will be required. Now, at what rate, how frequently would that water be drawn out? Is it like, once in three days, is it like every day, twice a day and how much, this is the drawdown rate?

The next is drainage area. So, how much of the area is available? Now, if in case we are talking about an area which is vegetated which is not covered by impervious surfaces impervious materials. There is a lot of percolation which is happening and there is very less amount of runoff which is reaching the drain or the correction point.

However, in case of a hard paved building a large percentage of rainwater is actually received as a runoff. So, this is dependent upon how much area is there and what kind of surfaces are provided, what kind of surfaces are there.

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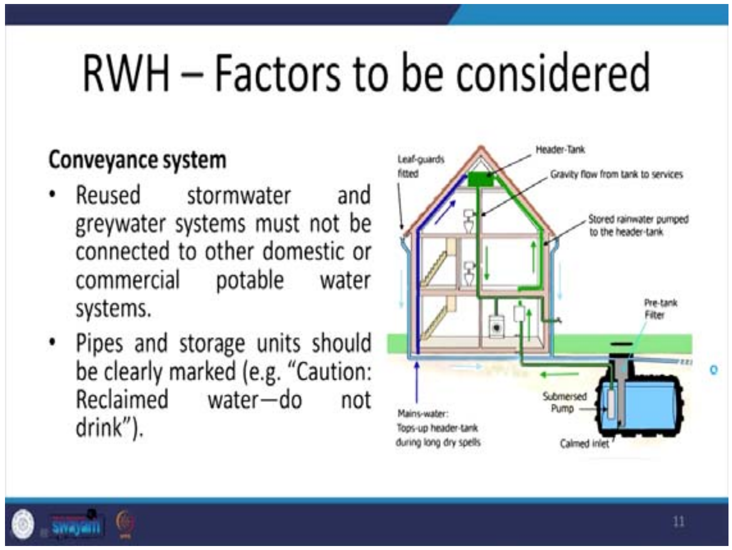

The next is conveyance system. So, we may use this rainwater for all the non-potable purposes. Now, this has to be decided. So, we may be using it for non-potable purposes.

Because, in case we want to use it for potable purposes, then it needs to be filtered appropriately in order to treat the water to potable limits, in in majority of the cases we do not treat the rainwater to reach the potable limit. And, hence we have to have separate conveyance system; one where we use this water we pump this water to use and to serve all the non-potable uses for example, flushing, for example, irrigation.

So, all these purposes will be served. However, there will be a separate line, which will be serving potable water, which will be used for drinking, for bathing. So, there will be two separate conveyance systems which will be installed in the building. Now, when we are talking about all of this, we all so have to see that all this requires a meticulous planning even before the building is conceived.

So, we have to be aware we have to know whether, we are going to do rainwater harvesting or not. When, we are going to do the rainwater harvesting, then what are the purposes for which this rainwater which will be harvested will be used, what is the conveyance system which will be required. So, all that has to be planned right in the initial concept stages and then accordingly designed.

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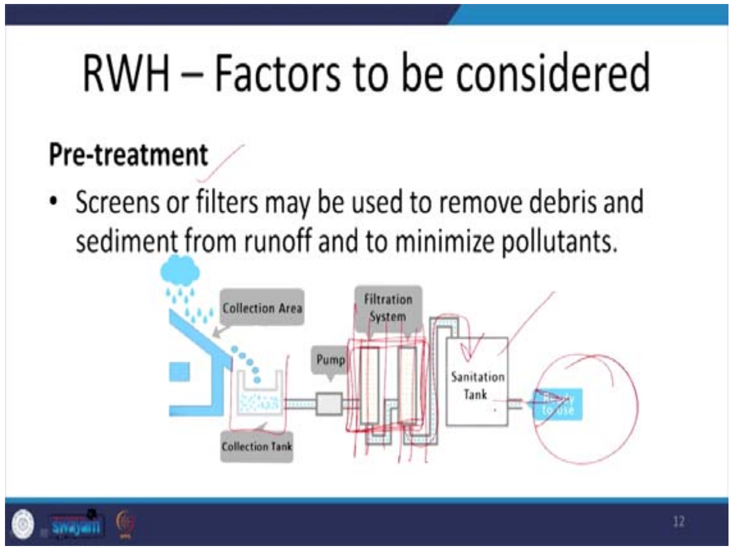

The next is pretreatment. So, different types of filters are available, we will be talking about couple of these in the later slides, but here a very simple flow chart would be that we were have a collection pond a pump to pump it into the filtration system. Now, how complicated this filtration system is depends upon what is the level of what is the quality of water which will be required which is going to be used in the system; so, whether a potable quality or a non-potable quality or what purpose is it going to be used for.

And, then we use it we store it in another tank and then it is ready to be used. So, it may be an overhead tank from where the potable water will be supplied into the building. So, this treatment this treatment depends upon the purpose for which the water is intended to be used.

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Now, here a lot of potable systems are available currently. So, we have very simple systems such as these, where the rainwater directly gets accumulated in the tank and then after filtration, this filtered water is available for the human consumption.

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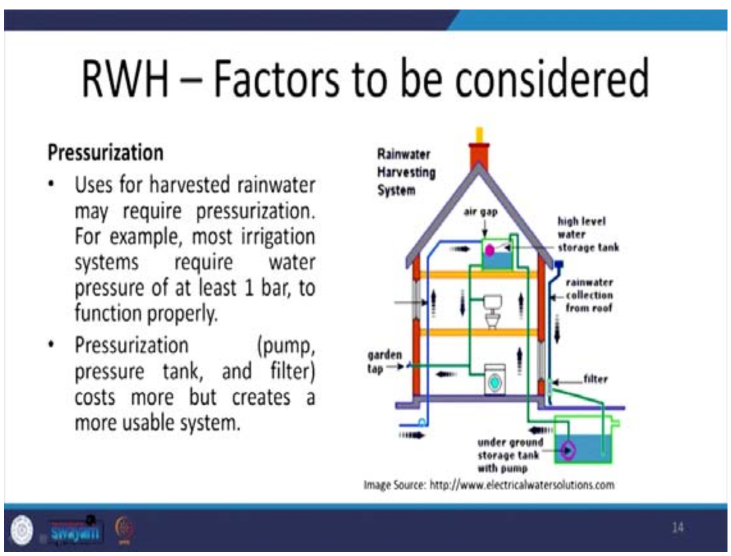

Another one is pressurization. Now, we may actually require the pressurization to put the water underground into the aquifer or to pump it up to an overhead tank. And then to maintain sufficient pressure in the pipeline, which is an, which is the dual pumping plumbing pipeline to serve flushing and all other purposes for irrigation.

So, for this purpose a pressurization mechanism will be required. So, let us look at first the groundwater recharge. Now, all these factors which we have just discussed are going to be present in both the systems, whether we are doing it for groundwater recharge or we are doing it for storage.

So, let us look at the groundwater recharge.

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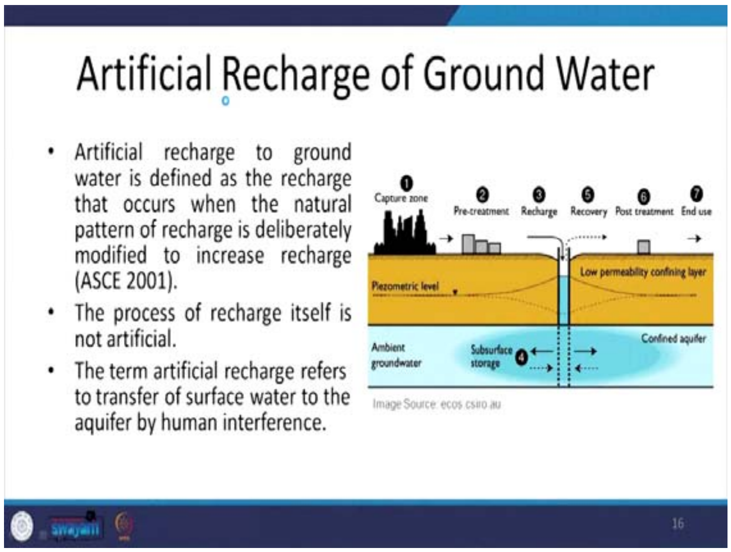

Now, what do we mean by groundwater recharge? Here ideally what should have happened, that it should be naturally recharged. The soil which is available on the surface of the earth is permeable, it allows rainwater to percolate through it and reach the aquifer, the underground aquifer. Now, the aquifer may be an unconfined aquifer or a confined aquifer depending upon the different layers substrata of the ground.

Now, unfortunately since we are paving all of this, we have to artificially recharge. Now, what we do, like we were using the wells, for drawing this water up we are making these wells, for allowing the water to reach the underground aquifer. This is artificially recharging the groundwater.

Now, here what we are doing is there is a capture zone, which from where the rainwater is allowed to pass through, there is a pretreatment. Now, when we are allowing the water to reach the aquifer to reach the confined aquifer, we cannot allow the pollutants to reach that aquifer. We cannot allow the unburned fuel petrol diesel and a lot of other contaminants, which are present in the atmosphere to reach this confined aquifer, because it is absolutely potable water.

So, it has to be treated and then we let it go into the recharge. Now, this is a well, which is connected to this confined aquifer. So, all the layers of earth the substrata, they will be punctured and the well will be created. When the aquifer is full and we require water for consumption the same well may be used to recover the water, treat it again and use it for consumption. This is up till here this is what we mean as artificial recharge of groundwater.

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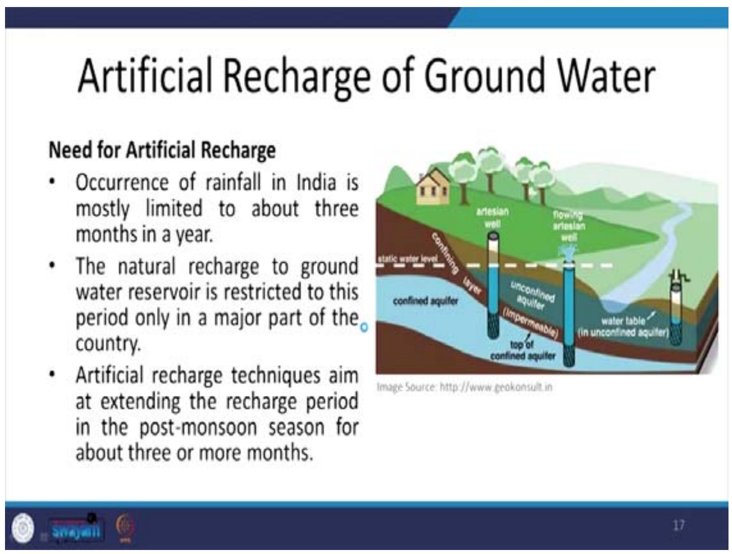

Now, why at all are we needing it simply because all this kind of surfaces these green surfaces, which at one point of time allowed percolation of water. Through them they are gone, there is very less amount of pervious strata which is available. Pervious surfaces which are available in our cities in our urban areas we are paving it all. So, we see roads and then besides them footpaths besides them the buildings. So, there is no space for pervious substrata, for pervious surfaces on the surface of earth.

Now, all this water which was otherwise allowed to percolate down to the ground is now being runoff into the surface aquifers. So, you see that not just in urban areas, but even in villages the ponds which used to retain a lot of water are now captured, they are not taken up, eaten up or the volumes reduced.

So, even the ponds are not sufficient to hold all the surface runoff. It is flooding even in villages unfortunately, that is why we need to pump all this water pressurize it push it down to the ground.

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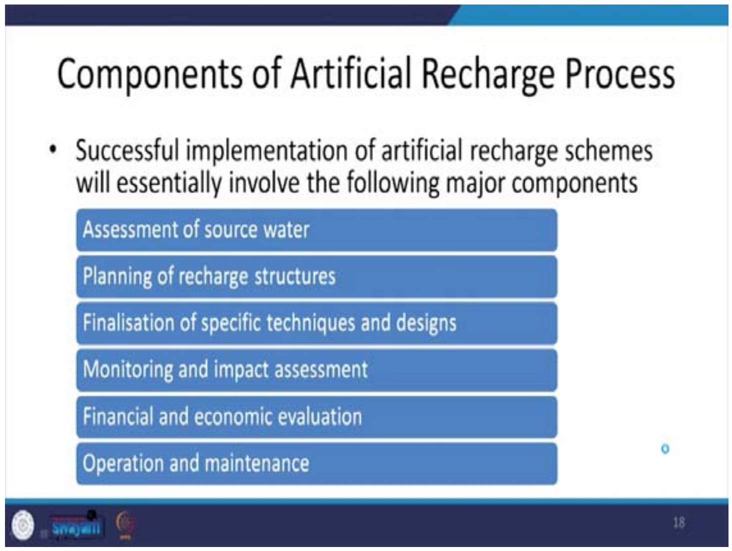

So, if we look at the components of artificial recharge process and how do we do it in a stepwise manner, these are some of these steps. First of all we have to assess the source of water.

So, water is going to be the source. So, the rain may be there, but where is it running off to if there is natural slope available natural topography. So, what is the source of water? It may be rainwater or it may be some other form of water as well which may be used as a source, but then what is the source of water? And, then we plan the recharge structures depending upon many heads: 1. the soil, what type of soil is available. 2. the topography what kind of drain, what kind of slopes are available also the usage pattern.

So, if we have to intercept and use it on the ground itself. So, surface aquifers will be created and then the excess will be pumped to the ground. So, the planning of recharge structures will be done. Once, we have done that we will finalize the specific techniques and designs. So, whether we are going to use a trench, or we are going to use a retention pond, or we are going to use a bore well.

So, how are we going to do this artificial recharging the specific techniques and designs will be finalized? It just does not end there it is a constant process and it requires a lot of monitoring and assessment maybe. Due to some error in the previous two steps, the design does not perform; what do we do, we cannot just leave it like that.

So, it may require improvisations, it most definitely requires a regular maintenance, because there will be soil there will be pollutants who will be choking the filtration media, the filters will be choked, that needs to be cleaned regularly and maintained. So, we have to monitor it is health and we have to maintain it regularly.

The next is we also have to look at the financial and economic evaluation. In majority of the cases this artificial recharge is taken up at a municipality level, at an urban level city level, very rarely would we see that this is happening at a private level, even when there are huge sites.

So, majority of the times if we look at the economic evaluation probably it is more beneficial at the municipality level where the municipality will have to draw the water from a deeper level than a shallower level if proper recharge is happening. And, here it is again this operation and maintenance. So, once we have monitored we are clubbing it with operations and maintenance, because it requires regular maintenance and operations. When we are talking about these groundwater aquifers, there are various methods which are used for recharging it.

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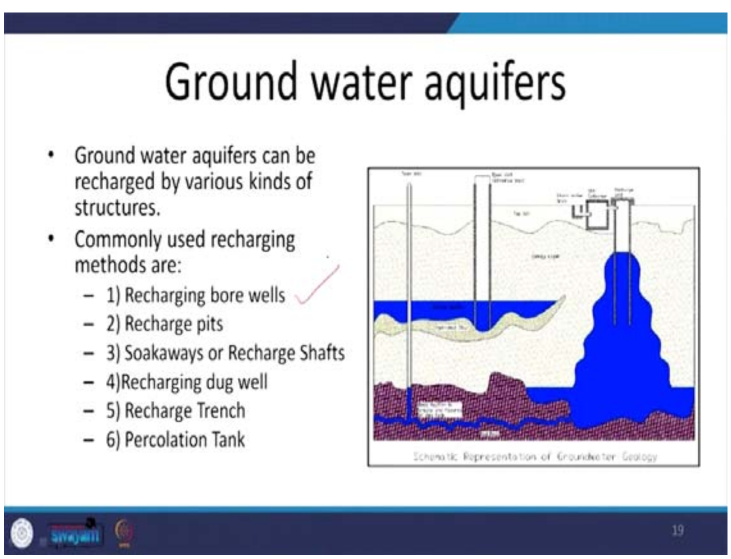

So, we have bore wells, we have pits, we have the Soakaways or recharge shafts, the dug wells, trenches and percolation tanks.

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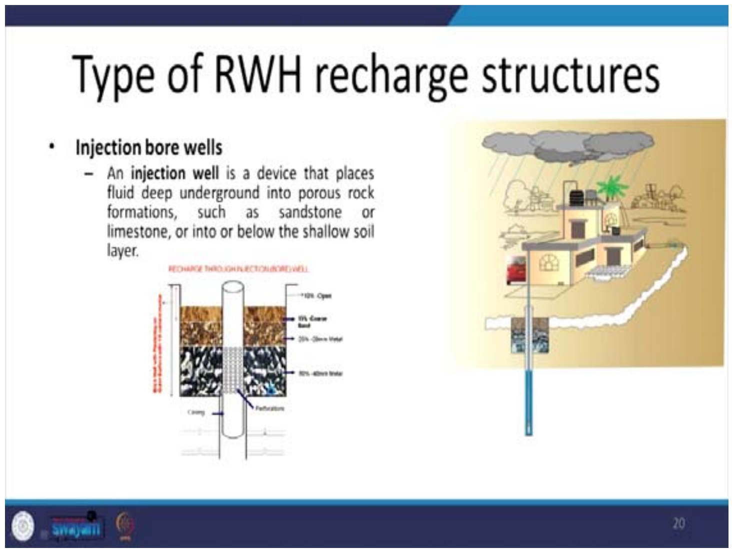

Let us quickly look at each of these structures to quickly give you an idea as to what are these various techniques and designs which are available. So, first is this injection well. Now, what we do in this injection well is that there is a well which is dug in the center and a pipe fitted which is a perforated pipe.

Now, this perforated pipe has a tank around it. So, a larger area is just filled up with the different levels of a gravel and sand the filtration media. So, from finer material, to a coarse material, there are different layers which will be created and the perforations in the pipe are at the bottom most level.

So, that the water which comes gets filtered through it and then through this pipe, it enters and it is directly dug up to the aquifer level. So, this water which is treated through this dug well this bore well will be reaching the underground aquifer.

Now, this may be used to draw the water again from the underground aquifer, it will be used for both the purposes, but this is what the injection bore wells are.

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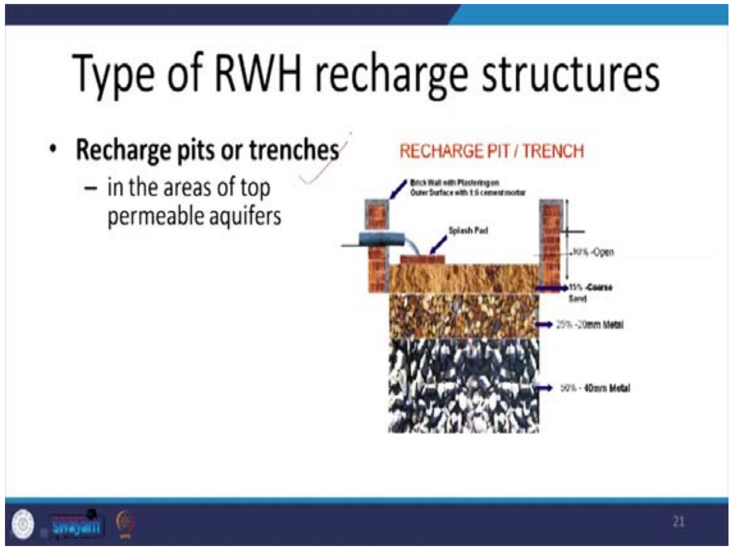

Next is recharge pits or trenches suppose we have we do not have this bore well in the center. The same pit which was filled up with three different media from finer to the coarse level can be used and then there is loose soil all around it, which is naturally occurring. So, the water which will be collecting here will gradually filter and percolate down to the ground.

Now, this is more advisable in areas where the soil is loose. So, it will not be a good strategy to be used in clay soils, which are too tight such a thing will may not work there. Because, we at times during the peak rainfall time, we need to allow a lot of water to percolate down. So, if it is a sandy soil or if it is a normal soil not clay, then the water may percolate down at a speed which is required a rate which is required.

However, if it is a clay soil then it is allows water to percolate at a very slow rate.

So, it may not be a good idea. So, we may just have a pit like this or we may have a trench which has a cross section like this. So, we may have either recharge pits or trenches.

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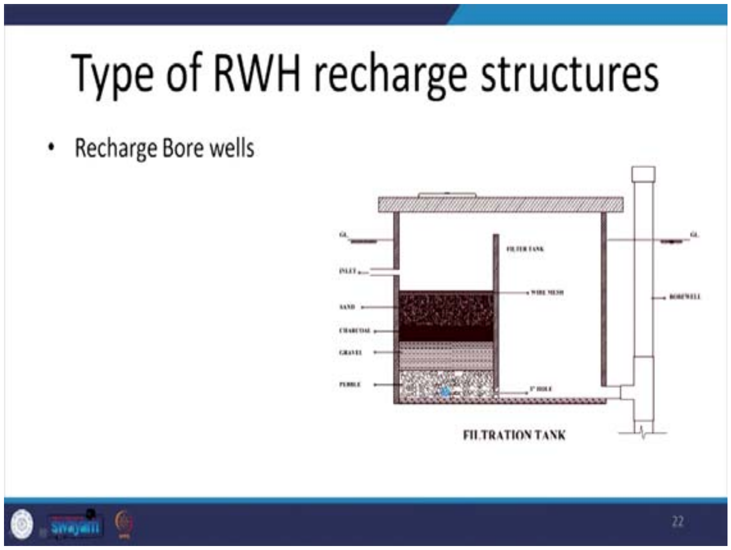

Another one is recharge bore wells after filtration, so the one that we saw was a very simple simplified way of putting a bore well. However, we could also look at a tank form where we after coming into the tank, the water gets filtered.

So, we have a capacity to recharge the water at different times, other than the peak rainfall or the rainfall times as well in this type of structure.

So, we can actually store the water and this water goes through this bore well which is connected to this tank. So, generally what happens that during monsoons even the earth is saturated. So, the water we are not able to pump in a recharge sufficient amount of water to the underground aquifer. Here in this case, if we store this water this water may actually be recharged through this bore even later.

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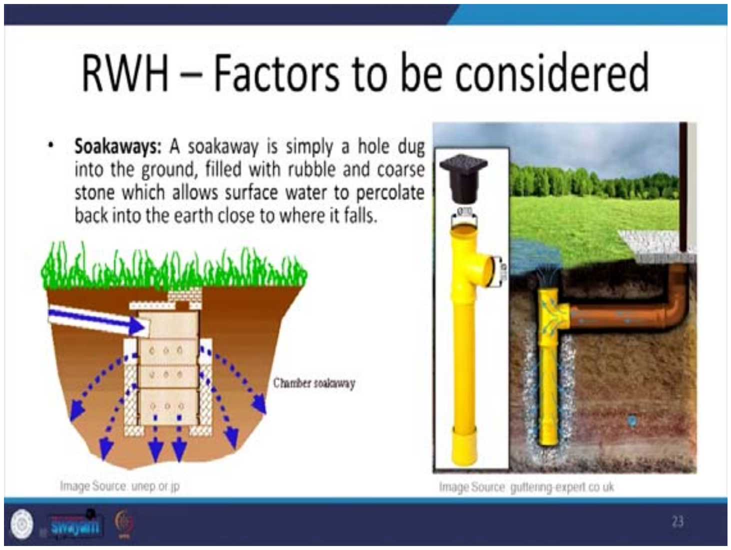

Now, another one is Soakaways. So, this is a very simple recharge pit kind of a strategy, here the sides are not lined and the water directly enters. So, instead of entering from the top the water enters through a channel for example, this one. So, from a paved area the water enters and then this pipe which is also percolated allows it to be soaked up, allows it to be permeated to the ground.

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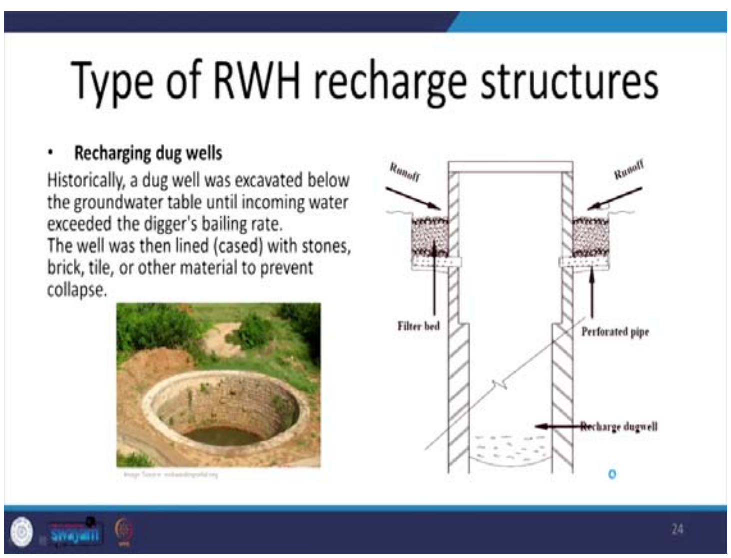

The next is the concept of dug wells.

Now, here we actually have a well in the center like a normal traditional well as we understand around this well we will have a filter bed. So, all the water which actually runs off to this well, if it overfills it may directly enter into it, but which is not a good idea because a lot of pollutants suspended particles may then be entering into the well. So, that is why the wall of the well the sides are raised. So, that direct water is not coming into the well and there is a filtration media a percolated pipe or drain, perforated where the water when comes filters through it and then it goes on to recharge the same well, which may then later be used to draw the water up.

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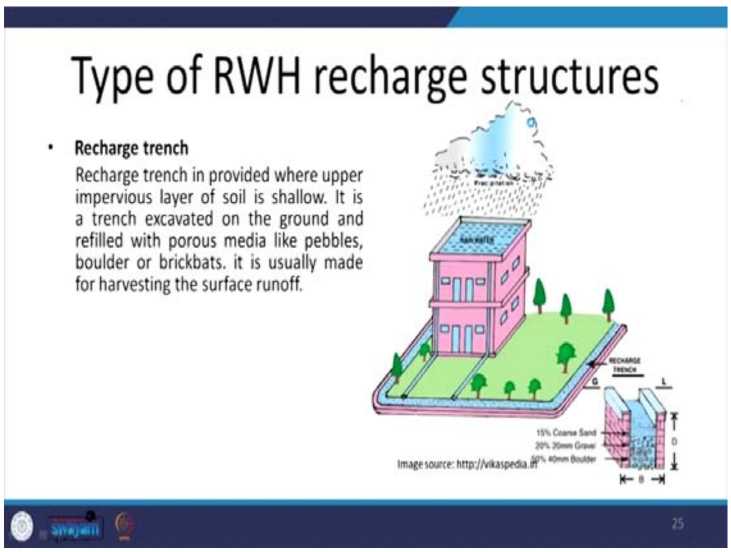

We have also discussed the concept of recharge pit the same when it is in the form of trenches, long trenches, it is called as recharge trench the section cross section almost remains the same.

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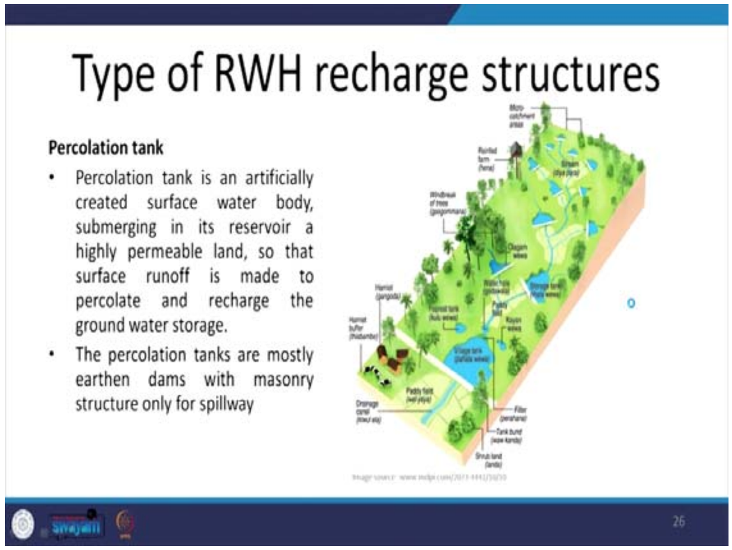

Another one is percolation tank we were discussing about the retention ponds, when we were discussing about this term water management strategies. Now, these retention ponds which are formed with the help of small bunds and these small shallow pits, now these are smaller ones the retation pond will be a huge pond.

So, we can have smaller pits which would be called as percolation tanks and the base of these tanks are these are not lined. So, these are natural strata, this naturally occurring soil and when the water gets filled up here, then it allows it to percolate at the natural rate of percolation, which is for the given type of soil along with it also allows it to evaporate.

So, with the help of this both the water is safe from running off to the surface aquifer into the streams or rivers and go waste. Now, all these factors are not applicable or are not present in all the cases, we have to look at the given context and we have to look at the standards and guidelines.

For example, if you talk about the city of Kolkata, for multiple reasons, one the water table is very high. Since, it is very close to the coast and also the kind of climate it has the amount of rain it receives for all those reasons the water table is already high.

Now, in such a place as per the standards and guidelines rainwater harvesting is prohibited, it is banned. We should not be harvesting the rain water as it is not needed there. If a rainwater harvesting tank is created it has to be created with a lot of precautions, because there will be a lot of pressure from all the sides, because of this underground water which is already there and it may create problems later on. So, before we go on to harvest rainwater we have to look at the standards and guidelines, which are available, which are applicable and then go ahead with it.

Another one is we have to look at the timelines for rainwater harvesting. We have to ideally start conceiving the entire design for rainwater harvesting right before the project is being planned at the concept stage itself, because it requires a lot of design and planning. So, if rainwater harvesting has to be done if it has to be implemented accordingly the designs the building design, the site management, the site layout, landscaping everything will have to be designed.

So, we have to conceive it right in the beginning along with the project and at each step when we are talking about the pre design, the design the construction, during construction, post construction at each of these levels the rainwater harvesting some measure will also come along.

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The next we talk about the rooftop rainwater harvesting, which is becoming very very popular in urban areas, because the surface water. The surface runoff is actually taken by or handled managed by the municipalities.

So, on the site there is a lot of roof area which is available and fortunately. It is also an area which is usually maintained clean. So, there is a potential to harvest the water rainwater which is coming on the rooftops.

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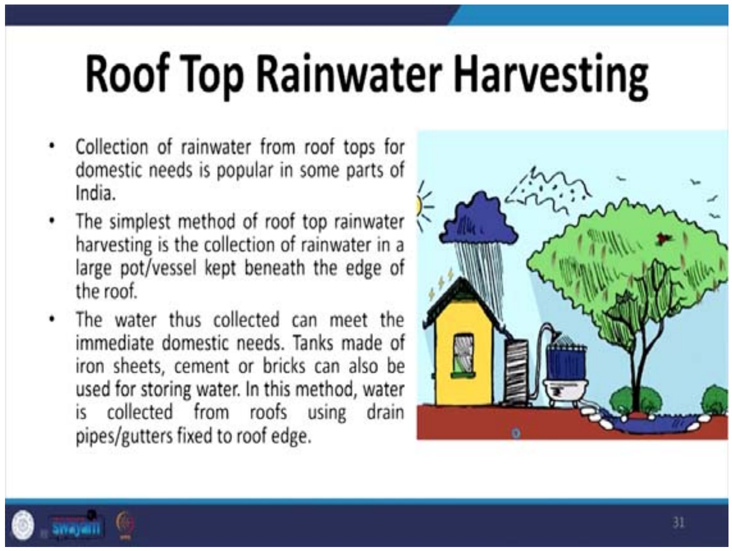

So, what we do actually is we collect the water, which is falling onto the surface of the roof we collect it treat it through a filtration media. And, store it for the later use for multiple purposes again the same factors; it may be potable uses non potable uses.

But, essentially the water which is collected and which is also used is the water, which is essentially falling onto the roof.

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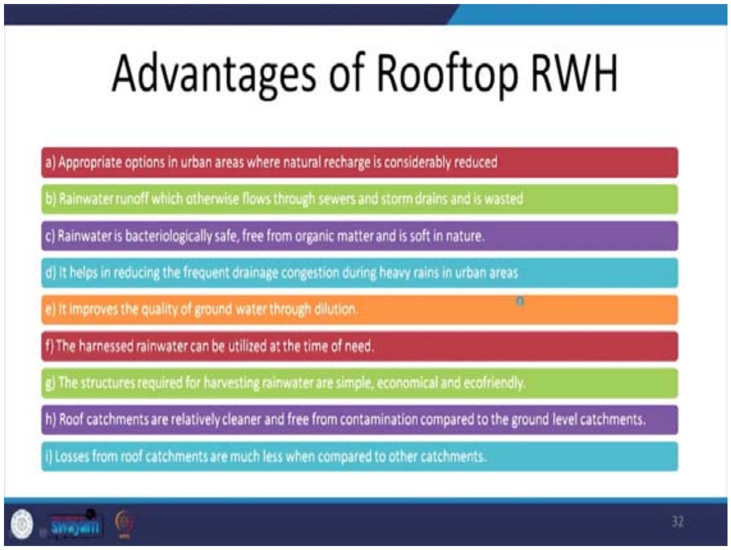

So, there are multiple advantages of rooftop rainwater harvesting. I will quickly list down few of them, which are very common, commonly sensed.

First one is the natural recharge in urban areas which is considerably reduced in such a scenario the collection of rooftop rainwater will help us reduce the burden on the already strained resource of the underground. The next is we are reducing the surface runoff, which if we do not capture and use, it will be running through the sewers and storm water drains. And, it will be wasted it is not going to be utilized in any manner.

Next is rainwater is the cleanest purest form of water, it is not contaminated. It is safe and it is free from any other organic matter which may otherwise be available in the nature. So, it requires very less amount of filtration for it to be fit for human use. The next is it reduces the drainage congestion during the heavy rains. So, when we are reducing the runoff. So, this leads to this. So, when we are reducing the runoff into these storm water drains, it will reduce the congestion in the drains.

Next it improves the quality of groundwater through dilution. Next, we can use the rainwater at the time of need when we have harnessed and stored it. The next is it is a very simple process and we have already seen that people have developed the potable mechanism of harvesting rainwater, where each home can have it is small rainwater harvesting equipment.

So, it is absolutely simple and also economical and very-very eco-friendly, then as we have already discussed that roof catchments are relatively cleaner because they are at a certain level. So, there are less number of solid contaminants the suspended particles and material which are going to be present in the water, which is collected on the roof.

Hence, it requires less amount of filtration as compared to the surface catchment. And, the last is the losses from roof catchments are much lesser as compared to the other catchments. Because, roof is often a very confined area and almost all the water which is which comes onto the roof can be collected filtered and stored.

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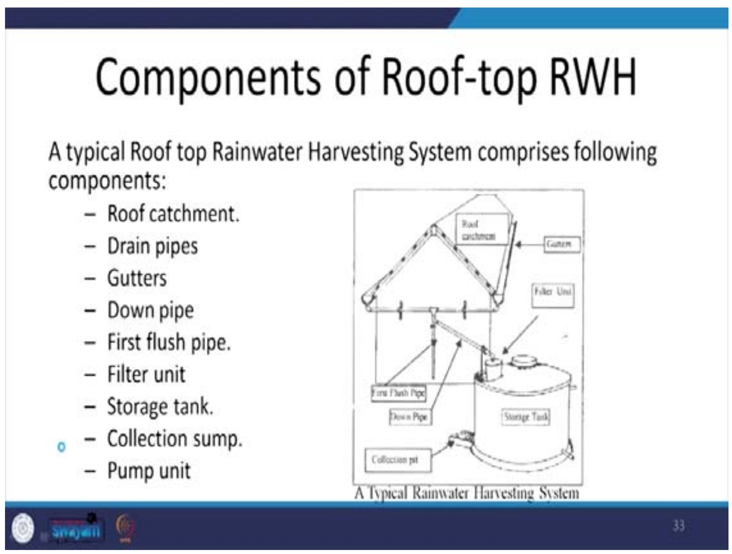

So, when we talk about the different components of a rooftop rainwater harvesting, we have these components. One roof catchments, drain pipes, gutters, down pipe, then we will essentially need a first flush pipe, where all the contaminants which are getting washed off with the first flush they will be taken off.

Then a filtration unit a storage tank a collection sump and a pump unit, because we need to use the same water.

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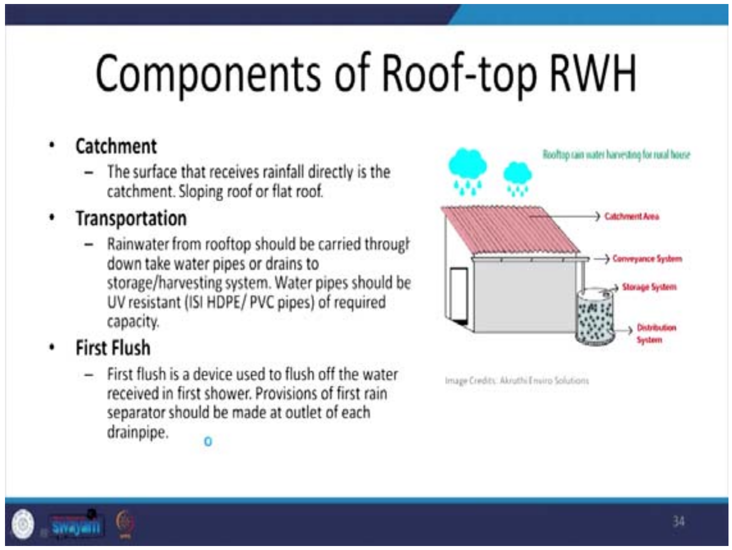

So, catchment is actually this roof area where which is the area which we are using to catch the rainwater.

So, first it is catchment, second is transportation. So, this gutter which is going to collect this water from the catchment and then the pipe, which is going to bring all this water to a filtration or a storage tank is the part of conveyance system. So, how water is getting transported to this system is what this transportation and conveyance system is.

Now, first flush as I was just mentioning is a device which is used to flush of the water which is received in the first shower. Now, all of us receive rains in our areas and we know that before the first rains it is all dusty. So, the roof is completely covered with dust there may also be some solid matter like leaves or something's. So, this first flush first rain needs to be flushed out.

So, there is a very simple device which is attached to this pipe which collects the rainwater and it flushes off the first rain, which is received the next and very important part is filtration.

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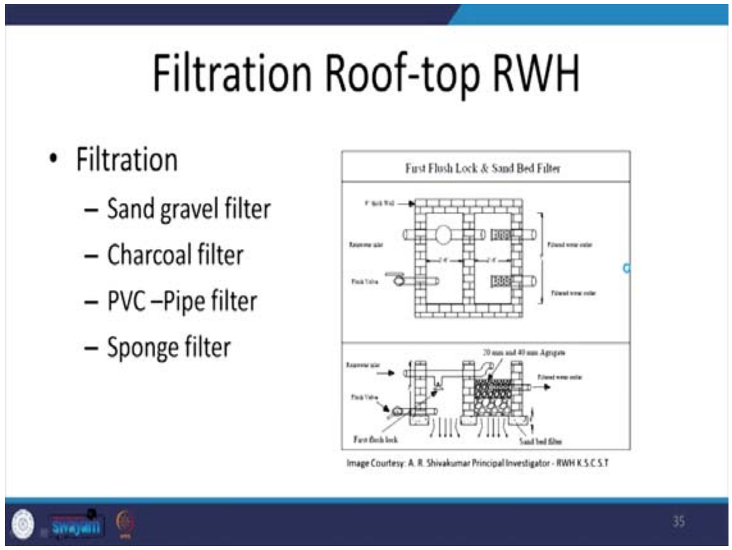

So, there are different types of filters which are available, we have sand gravel filter now these ones that I am talking about are the passive filters. So, we just install it and they continue to work, they need to be maintained, there is active filtration which is also there, but it requires energy to filter.

So, like arrow or some other filtration processes may also be used, but that may be used only when we have to treat the water to the potable levels. So, we have Sand gravel filter, we have charcoal filter, PVC-Pipe filter and Sponge filter.

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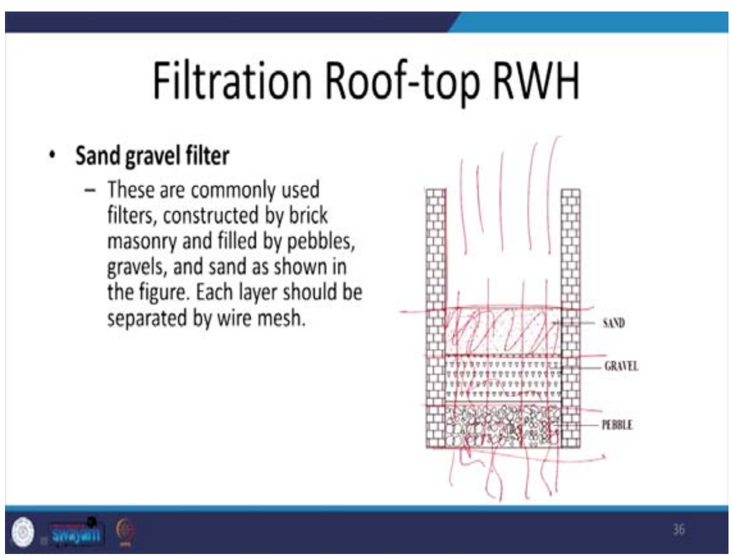

So, in sand gravel filter we have the filtration tank almost half of it is used for collecting the water. The first layer is the fine media of sand followed by gravel and pebble. So, there are three levels of filtration through it the water gradually percolates and all the impurities are held, in these different layers.

And, once it passes through it we get filtered water.

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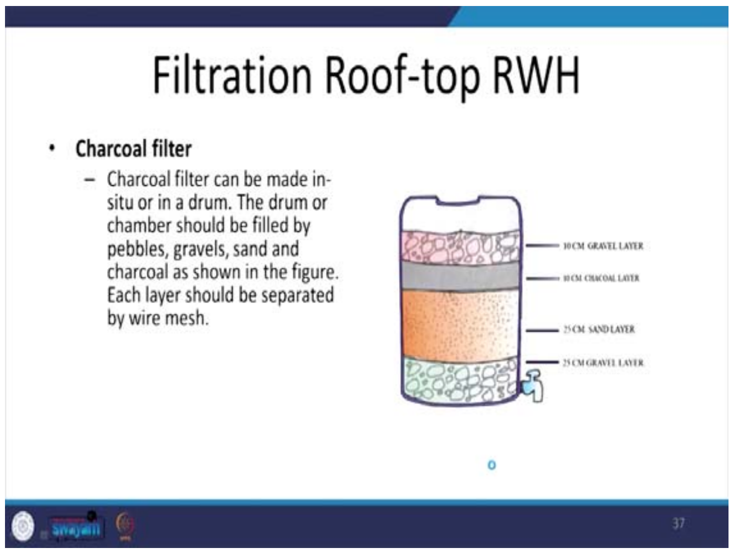

In charcoal filter we have slightly reversed layers. So, first we have a gravel layer, which is a coarse layer, then we have charcoal layer. Now, a charcoal is a purifier. So, this charcoal purifies the water and then it let us it pass through the sand and further gravel and then it is ready to be used.

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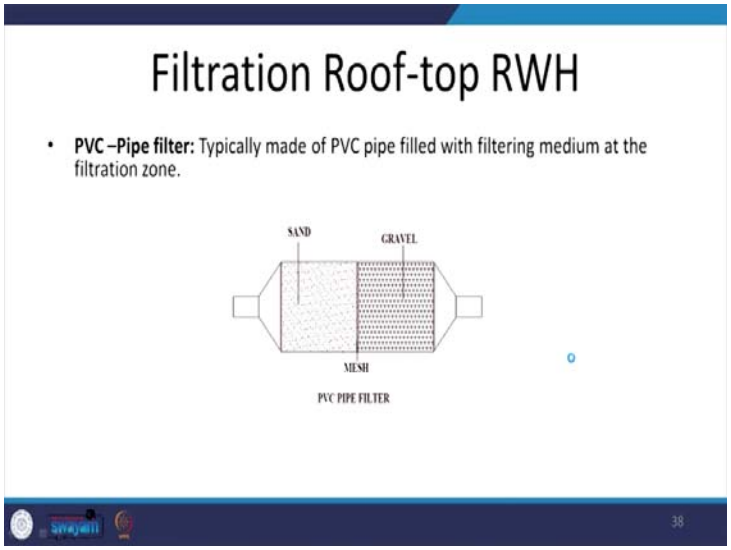

Now, both these methods with both these methods, the water may qualify to the potable limit, potable quality or may not qualify to the potable quality depending upon the quality of water which is being taken in.

The next is we have a PVC-Pipe filter. So, it is a very small kind of filter, but also fit for small volumes. So, within the pipe we have this these meshes and we have in one chamber the sand filled up and the gravel filled up. So, from one side the inflow of the rainwater will be there and from the other side clean water will be taken out. So, this type of filter is good for small volumes not for holding large volumes, because there is no point no way no place where the water can be held. Unlike the previous two chambers where we could hold sufficient amount of water and let it percolate slowly.

So, here it will percolate, but at a slow rate and hence only smaller volumes may be cleaned through this.

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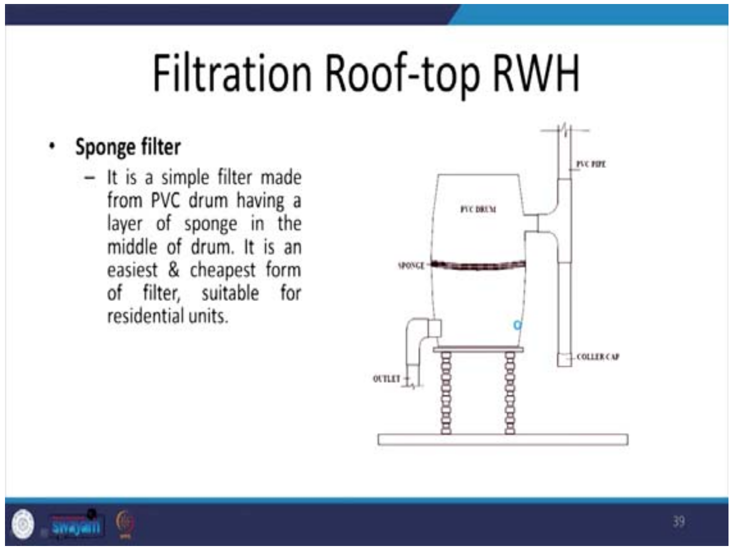

The next is a sponge filter, now this is also very common the sponge filter. Here, we get the rainwater there is a sponge layer in between we filter it and then this water is available for non-potable uses.

Now, this sponge filter sometimes is also available on the top of this drum, where the rainwater, which is coming directly falls onto this and then the sponge cleans and filters this and the water is available to be used.

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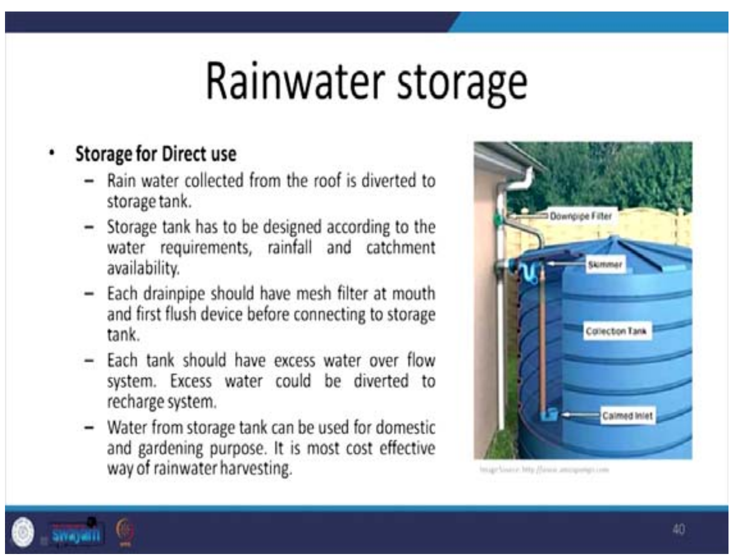

So, when we are storing this rainwater the filtration media could be different the transportation mechanism, the conveyance mechanism could be different, when we are storing it is it could be stored it could be used directly for all the purposes as we have discussed non potable.

In case the quality of water is really good the rainwater, then it may also be used directly for potable purposes, even for drinking. These are the different factors which we have discussed qualitatively. Let us look at the quantitative aspects of it.

First of all whenever we are going to design rainwater harvesting systems, whether it is for ground recharge or it is for storage, we have to know the volume of captured water.

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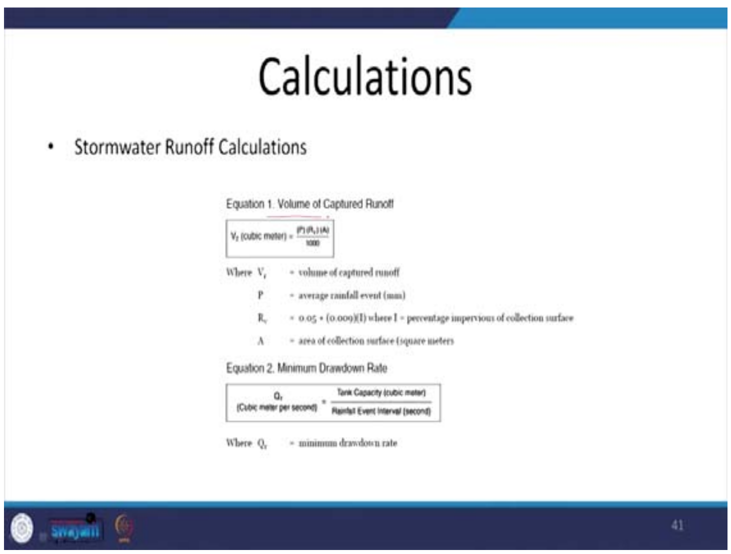

This we have also calculated when we were discussing about the storm water management. So, how much of the water is going to be available is the first question, is the first point. The second is minimum drawdown rate so, at what rate are we going to draw the water, from the storage tank or wherever the water is going to be stored. May not be rain water it could be any form of water, but what is that drawdown rate, at which the water will be taken out.

So, once we know these two we have to further move ahead with our calculations.

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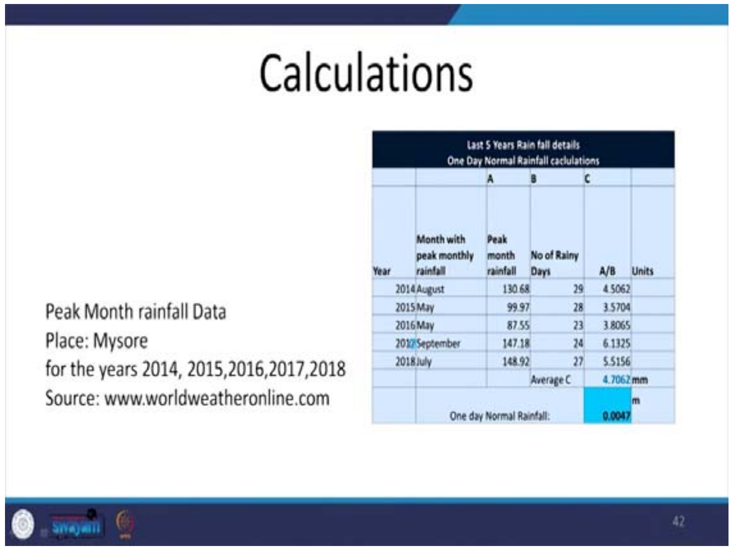

. So, what we will here see is we have to look at the peak month rainfall data. So, we have to look at how much of the rainfall is available for a given place. We have also used the same data for calculating the average surface runoff.

Here before we do that we are calculating how much of the rain is available? So, for different years and different peak monthly rainfalls we calculate the amount of rainfall which is available the total number of days and then we calculate the average normal rainfall for one day.

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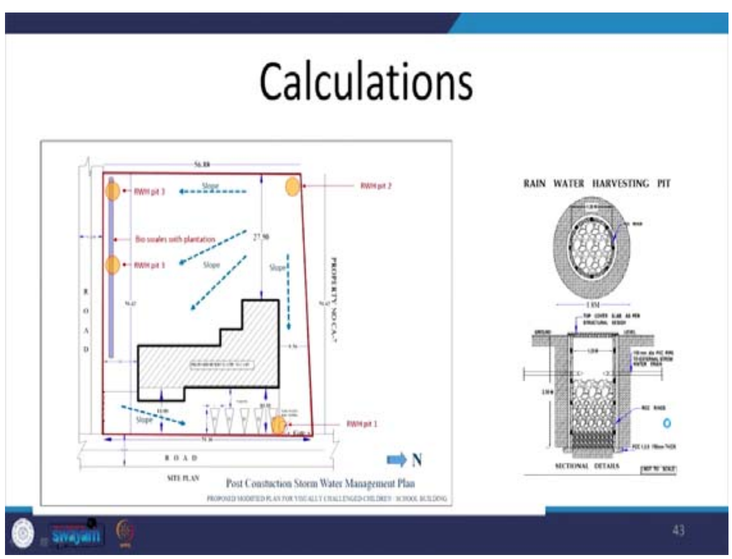

Once we have done this we will decide upon the type of recharging structure. For example, or rainwater harvesting pit, where there is a tank in the center and there is a coarse media around it which allows it to percolate. So, this is say the kind of structure that we are using and this is available, this is being planned in four places and all the rainwater, which is available on the site is going to run off to these 4 pits.

So, once we already know how much is the total amount of water which is going to come and we design upon decide upon the design strategies, we move on to the next set of building calculations.

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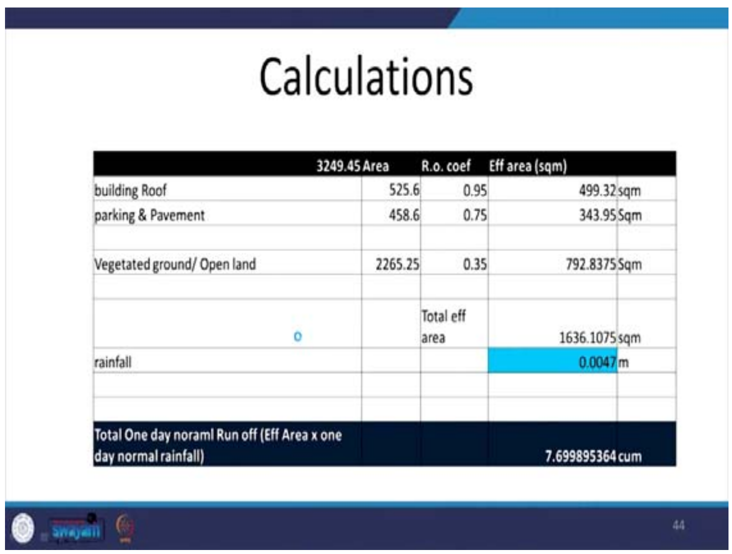

3249.45	Area	R.o. coef	Eff area (sqm)	
building Roof	525.6	0.95	499.32	sqm
parking & Pavement	458.6	0.75	343.95	Sqm
Vegetated ground/ Open land	2265.25	0.35	792.8375	Sqm
0		Total eff area	1636.1075	sqm
rainfall			0.0047	m
Total One day noraml Run off (Eff Area x one day normal rainfall)			7.699895364	cum

So, we calculate the total building roof area, we already have discussed the concept of runoff coefficient. So, we calculate the effective area. So, with the help of 95 percent runoff here, the effective area is this, this is a product of the total roof total area available with it is runoff coefficient.

So, we take the different areas different types of surfaces which are there and we calculate the total effective area. We also know the rainfall from the previous calculations. So, multiplying these together we would know the total amount of water volume which will be available per day. So, this is the one they normal run off from the given site, which we just saw in the previous slide.

Once we have that we will then move on to calculate the capacity of these structures. So, we have decided that we will have a recharge tank, which will be covered on all the sides with the coarse media.

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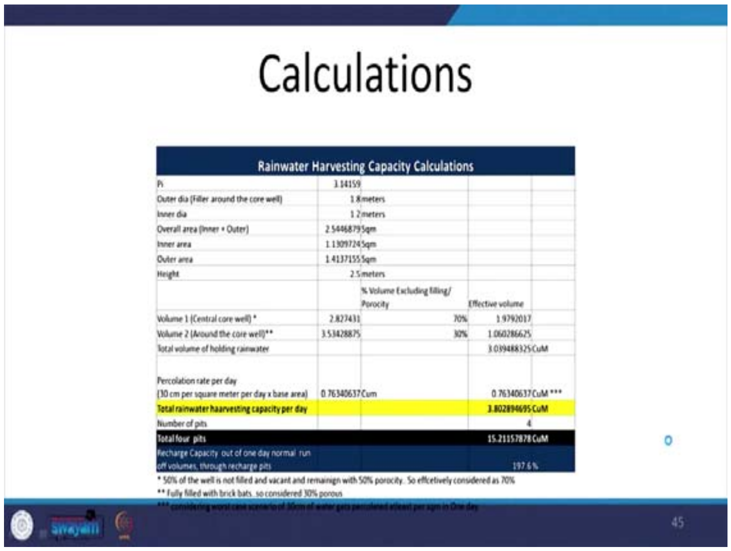

Rainwater Harvesting Capacity Calculations				
Pi	3.14159			
Outer dia (Filler around the core well)	1.8	meters		
Inner dia	1.2	meters		
Overall area (Inner + Outer)	2.5446879	Sqm		
Inner area	1.1309724	Sqm		
Outer area	1.4137155	Sqm		
Height	2.5	meters		
		% Volume Excluding filling/ Porocity	Effective volume	
Volume 1 (Central core well) *	2.827431	70%	1.9792017	
Volume 2 (Around the core well)**	3.53428875	30%	1.060286625	
Total volume of holding rainwater			3.039488325	CuM
Percolation rate per day (30 cm per square meter per day x base area)	0.76340637	Cum	0.76340637	CuM ***
Total rainwater haarvesting capacity per day			3.802894695	CuM
Number of pits			4	
Total four pits			15.21157878	CuM
Recharge Capacity out of one day normal run off volumes, through recharge pits			197.6%	

* 50% of the well is not filled and vacant and remainign with 50% porocity. So effcetively considered as 70%

** Fully filled with brick bats, so considered 30% porous

So, water comes into it so we have the Inner dia we have the Outer dia and we have the overall area of this recharge pit.

Now, we will calculate the volume of the central core the inner core and we will calculate the volume of the outer core. On the basis of these volumes that are available for the inner core, which is the central core, which is going to be an empty tank around 70 percent of it will be used to store the water. So, here it will be holding it. The core will be allowing the water to percolate through it. So, around 30 percent of the water, 30 percent of the volume will actually be used to hold the water, because it is a porous media.

Total we get the amount of volume which can be held by this entire structure. In addition to that we also have the percolation rate, because the base of this pit is actually not impervious. So, it allows a lot of percolation through the base itself. So, based upon the rate of percolation which is on the basis of the soil and the substrata which is available, we will calculate that how much of the water can be percolated through the base itself?.

On the basis of this we know that each pit can actually hold and take in 3.8 cubic meter of rainwater. Now, we have from the site, plan, we saw that there are four such pits. So, overall around 15.2 cubic meter of rainwater can be managed per day now this is for one day. And, if you remember the total amount of rainwater the normal runoff which was available was around 6 7.8.

So, we know that they have very well exceeded the amount of water, which is actually going to be available per day and the capacity which is available with us. So, in this manner we can actually handle the peak rainfall, in case there is a sudden heavy rainfall and the peak rainfall is coming even that can be handled with the help of this volume. I will also quickly take you to this file.

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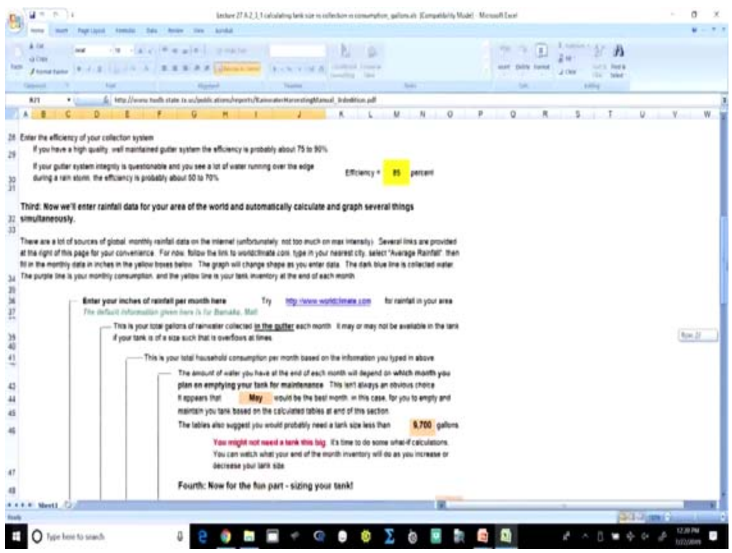

So, there are a lot of excels, which are available to put all that we have just discussed in a simplified calculation format.

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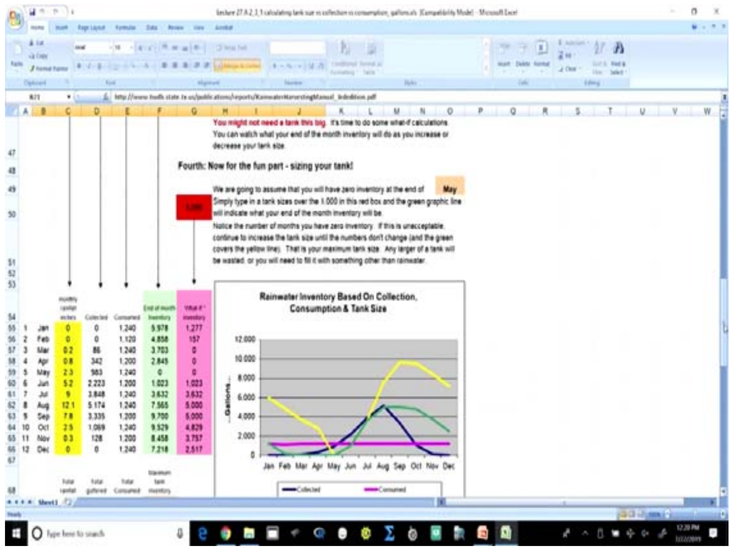

So, here if you look at we have certain data and now this data in yellow we can edit. So, here we are talking about the monthly rainfall data it is given in inches, but it would also be in millimeter, we have to change the units and then the correlations.

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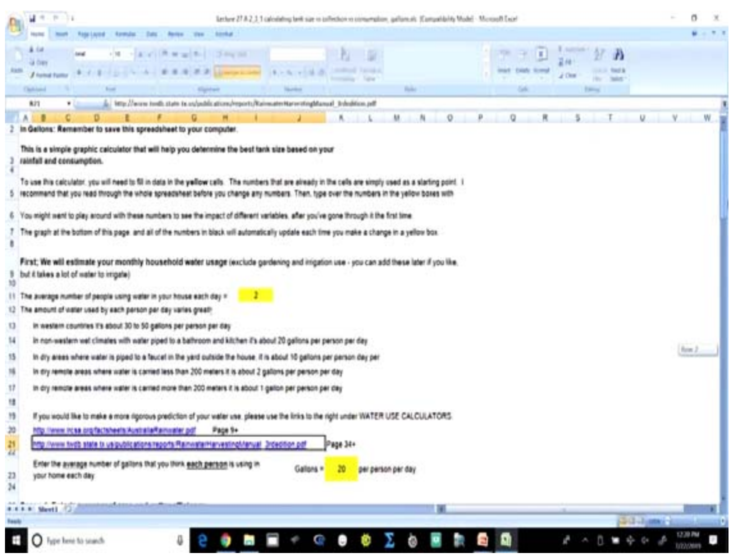

On the basis of this it will give us how much of the volume is collected on the basis of the total surface area which is available.

So, we have the surface area given, we can have the efficiency of which depending upon the surface they runoff coefficient. So, this will give us the amount of the rainwater which we which can be collected in a month for a given place. So, we are not doing it only for the normalized one day rainfall. We are doing it separately for each month and this becomes quite detailed. The next we have is how much of it will be consumed.

So, what is the consumption? Per capita per day after the reduced flows and fixtures that have been used, we will calculate the total amount which will be consumed per month. Once, we know that it will automatically give us the end of month inventory. Now, here in May we see it as 0. So, we see that before June the end of the May the tank will be cleaned and it will be ready for the next month's use.

So, we see that at the end of the month May it will be maintained as 0, it could be changed depending upon when the monsoons are going to arrive in different parts. So, for your context you could also change it. Now, if I decide upon this tank size. So, I may have this tank size here I have fixed it to 5000, if we change it if we have 5000 we see that almost all the volume, which is going to be received in each month will be stored in this and if we harvest, if we have a large enough tank as this, then rainwater will be sufficient to meet the demands for almost 8 months of an year.

So, for 8 months only the rainwater can be used to have to supply for the consumption for the demand. So, suppose we change this number from 5000 to say 2000 and let us see how it changes? So, now, if we have a smaller tank, we can very clearly see that we are able to provide for only 6 months of consumption and even in the sixth month, it will not be sufficient to provide for the amount which is required, which is to be consumed.

Suppose we increase it to 3000.

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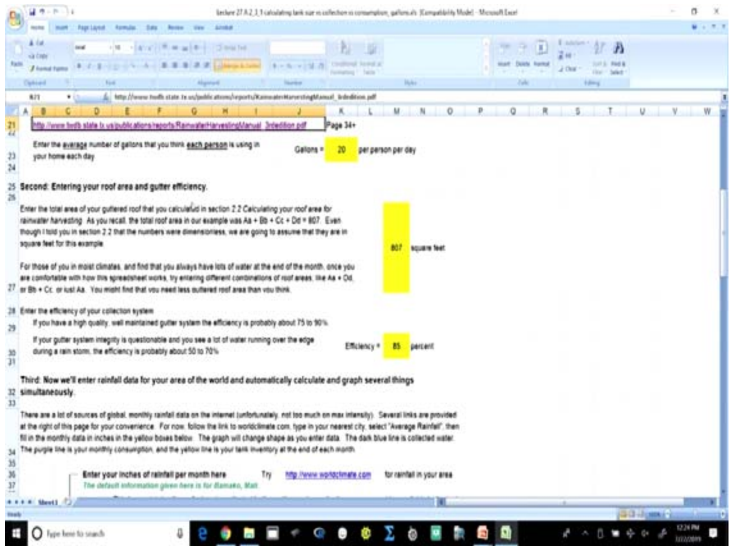

We see that it is able to provide us for 7 months of the water which is going to be required. So, we can estimate that and this will the size of the tank will actually affect the amount of resources which are going to be consumed, the economic resources, it requires finances it requires area also.

So, depending upon a combination of all these we can decide upon what is going to be the storage tank size and how are we going to use this rain water. So, we will stop here and see you in the next lecture, where we will be discussing about the more concepts on the water conservation for sustainable architecture.

Thank you for being with us see you again.