

Water and Waste Water Management
Prof. Bhanu Prakash
Department of Civil Engineering
Indian Institute of Technology-Roorkee

Module No # 10
Lecture No # 50
Type of Softening Basins and Adsorption

Hello everyone, welcome back to the latest lecture session in the last session we looked at a couple of problems relevant to lime soda softening.

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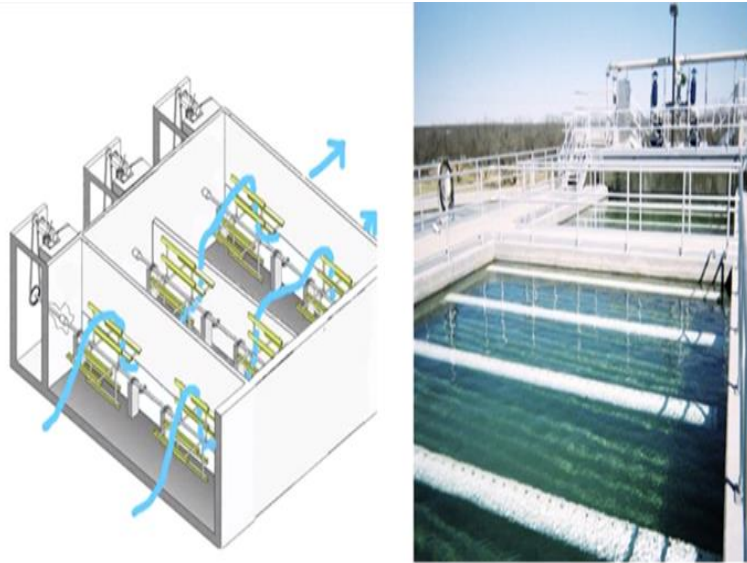
Precip

Conventional Softening Basins

Let us go forth from there, lime soda softening, what is it that we are trying to do? We are trying to remove hardness and what is the principle here? The principle is distribution and precipitation, when does precipitation occur? When you have solids or such or when the relevant compounds being supersaturated, then they will not stay in the solution in the dissolve phase only, but they will also precipitate out. in that context we looked at applying the principle of precipitation.

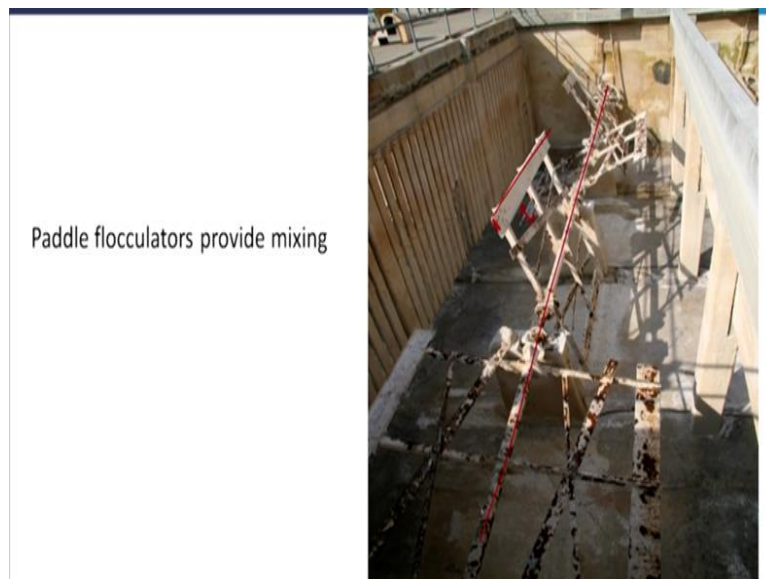
Why I mentioned this now is that while or after we finish discussing this lime soda softening, we will move on to add another aspect. There the principle is going to be different, we have to just understand the principle here, we are trying to remove calcium and magnesium by precipitation following up with what we discussed last time, conventional softening basins.

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This is what they look like, you can see the flow.

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Parallel flocculation, we saw this with respect to flocculation, this is what they look like. And we looked at the design the width, the length, the spacing between them and how many per shaft.

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And yes, this is something we looked at and parallel conventional flow settling basins this is one other way or one other aspect. Typically, rectangular long and narrow is something that you want but then the space beside will be an issue, you cannot really use the space beside it. Different advantages and disadvantages, but with respect to the theory, these rectangular long and narrow, if you can channel them into narrow channels in a way that they are the best for sedimentation.

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Conventional Softening Basins

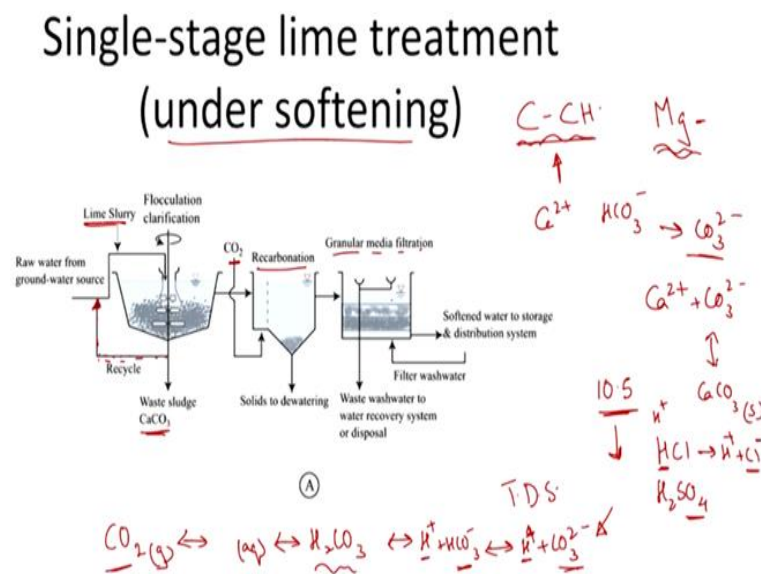
1. Single-stage lime treatment 4 ? Example:
2. Two-stage lime treatment Ca(OH)₂, Mg²⁺, CO₃²⁻, Ca²⁺
3. Split-flow lime treatment

Conventional softening basins, there are 3 kinds- single stage, two-stage lime treatment and split floor treatment. Single stage like lime treatment, we looked at this in the context of the example that we solved in the previous class. Here I am providing the relevant information, some of which was also presented in the previous session. Here it is single stage lime and two-stage lime.

That is pretty much explanatory but what are my objectives here? I am only trying to remove the calcium that to the one that is associated with the carbonate hardness. But here I am also trying to add enough lime such that the magnesium is also removed. If the magnesium is also removed, typically you will add depending upon its association with non-carbonate hardness you will add excess lime or even with carbonate hardness.

For that you will need to be able to add the relevant soda or CO_3^{2-} to precipitate out your calcium, to precipitate out Mg^{2+} you will raise the pH by adding $\text{Ca}(\text{OH})_2$ and if there is not enough carbonate in the system, the Ca^{2+} will now add to the hardness, you are replacing Mg^{2+} hardness with a Ca^{2+} especially. If there is no carbonate in the system so then you are going to add a source of CO_3^{2-} , so that is the relevant aspect. We will look at how to go about it.

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Single stage, so it is under softening, why primarily i am concerned with calcium? That is associated with carbonate hardness. I am not really concerned about magnesium, 2 reasons; one is that the magnesium associated with the non-carbonate hardness could be pretty low. That is why i am going to achieve or try to look at only this aspect, it is under softening.

You will always have some magnesium hardness which we are not even trying to remove, what do we have? We have raw water from the source and we are primarily concerned with the calcium associated with the carbonate hardness. Here what is it that we are trying to do?

Here we know that it sends Ca^{2+} and HCO_3^- . But HCO_3^- , I want to raise the pH such that it transforms to see CO_3^{2-} then Ca^{2+} and CO_3^{2-} , they will precipitate out as CaCO_3 ,

The solid. To be able to achieve this rise in pH, I am going to add lime so that is what I am doing here, lime slurry and then flocculation and clarification and then the relevant sludge which is CaCO_3 . Some of it we recycle as I mentioned to provide the surface area for the particles to or for the relevant crystals to adsorb bond and develop crystals.

You are going to bypass that nucleation step. Which is a pretty late rate limiting step out there let us not bypass you are going to try to force in that, that is one aspect. And then why are we adding carbon dioxide after increasing the pH to 10.5 or such? You cannot distribute this water to the relevant population you need to bring down the pH.

There are different ways to bring down the pH, HCl add strong acids or H_2SO_4 but we are only looking for H^+ so HCl and Cl^- but Cl^- will add to the total dissolved solids. Same case with SO_4^{2-} , so I want to add something that will provide the required H^+ and also the relevant anion is something that I would prefer to be present in the water so what is that it is nothing but adding H_2CO_3 .

And how are we going to achieve that? By adding carbon dioxide gas, it equilibrates with the carbon oxide in the aqueous phase, it equilibrates with H_2CO_3 . H_2CO_3 is an acid and depending on how much you are going to add it is going to stay as HCO_3^- or while it would not stay a lot as CO_3^{2-} but this is the equilibrium that you can release H^+ depending upon the pH and pKa of the system.

HCO_3^- and CO_3^{2-} that they will add to the relevant alkalinity of your solution. And also, they are good buffers, that is one aspect why we will choose carbon dioxide to bring down the pH. That is why we have re carbonation and then depending upon the relevant suspended solid concentration left after this, you are going to have media filtration. This is what we have under softening.

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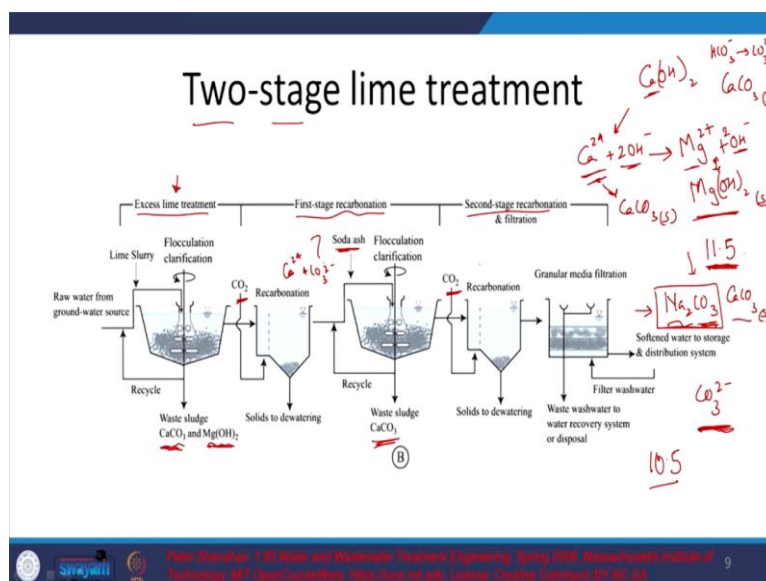
Single-stage lime treatment (undersoftening)

- Used for waters that do not require the removal of magnesium hardness ✓
- Lime is added to the raw water either upstream of the reactor/clarifier in a separate flash mix process or into the reactor/clarifier
- Flash mixers are used because mixing with a conventional mechanical mixer will cause precipitation formation on the blades, resulting in the dislodging and release of CaCO_3 ✓
- Usually softened to a final hardness of about 70 to 100 mg/L as CaCO_3 ✓

As mentioned, we are not looking at magnesium hardness, we are trying to add lime to increase the pH. Flash mixers are used because mixing with a conventional mechanical mixer will cause precipitation on the blades itself and resulting in dislodging and release of CaCO_3 . That is one practical aspect to keep in mind. Usually softened to final hardness, hardness is 70 to 100 as CaCO_3 .

That is something to keep in mind we are not removing magnesium. And also, even after removing most of the calcium, that at equilibrium, you will still always have some calcium. In general, if you are fine with this level of hardness, that is what we are looking at. And this level of hardness is acceptable to most households.

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Two-stage lime treatment, what we have. Here we have excess lime treatment earlier it was only lime treatment. Here we have excess lime, why do we add excess lime? Lime is nothing but at least the form that we wanted $\text{Ca}(\text{OH})_2$ we added to transform HCO_3^- to CO_3^{2-} and then bring about precipitation of CaCO_3 , solid. Why will I add excess? Because if I want to precipitate out magnesium, I can do that in the form of magnesium hydroxide the solid.

For that I need OH^- ? 2OH^- , for that I need to increase the pH and that is what I am going to do. I am going to add the excess lime for that so that is what it refers to, that is why we have precipitation of both CaCO_3 and magnesium hydroxide. As we know to remove magnesium hydroxide, the pH has to be considerably higher on 11, 11.5 depending upon your relevant system.

It is a bit too high and I do not need this high level of pH and also now I am done with removing magnesium but I added calcium because in this lime I have Ca^{2+} and 2OH^- . 2OH^- was consumed by magnesium but I added calcium if there is not enough carbonate in the system, I need to add carbonate so that the Ca^{2+} will precipitate as CaCO_3 the solid.

Two ways to add carbonate, one is adding soda ash Na_2CO_3 for the source of CO_3^{2-} but Na^+ you did not want to increase the TDS unnecessarily. Another way is keeping in mind that you did not really need a very high pH of 11.5 to precipitate out CaCO_3 around 10.5 or such is good enough, if I add carbon dioxide, it can achieve 2 purposes; decrease the pH slightly and also add some CO_3^{2-} in the relevant process.

CO_2 well depending on the pH lead release of CO_3^{2-} which will thus cut down on the requirement or the amount Na_2CO_3 required, that is what we are doing here. Here I am removing the calcium carbonate hardness and then the magnesium hardness and then I am adding carbon dioxide to add some CO_3^{2-} and bring down the pH slightly to around 10.5. And then I am going to add soda ash.


First stage recarbonation, why soda ash? Because I have calcium from this excess lime treatment, where this excess lime and so for that I need to add CO_3^{2-} that is why soda ash is being added. Then what do we have? We have CaCO_3 being precipitated out. Even now the pH is around 10.5, is still too high. And I want to bring down the pH to acceptable levels. I am going to have second stage recarbonation.

Here, I am going to bring down the pH and also in the process add the alkalinity or increase the alkalinity of the relevant system. And then you are going to have the obvious granular media filtration.

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Two-stage lime treatment

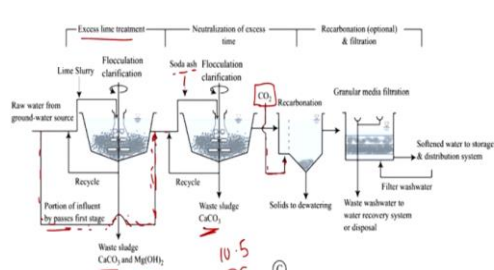
- Usually for excess lime process
- Soda ash is added to precipitate the excess lime added for magnesium removal ←
- Advantages
 - reduces soda ash dose (uses some of CO₂)
 - higher Ca removal



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Let us move on usually for excess lime process. This is something we already looked at. If I added calcium, in the form of lime, I have to remove that. What are the advantages? Because I am using carbon dioxide in the first stage recarbonation, it will reduce some of this soda ash dose higher calcium removal, that is something to keep in mind.

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Split Flow




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Let us move on to split flow. Well, there are different reasons to choose it. But you will need a lot of control on your particular system to be able to achieve the relevant objectives with split flow. Here one aspect to note is that compared to the two stages, here I am not having

two stages of carbonation, I only have one stage. But all others are more or less similar except for this particular bypass portion of influence bypasses the first stage.

Why? Here I added excess lime to remove calcium carbonate and magnesium hydroxide. This is similar to the case of two-stage. And then I want to bring the pH down. I added carbon dioxide in the previous case. But here I am going to use the bypass or the raw water, so that is something to keep in mind.

pH down and also if there is enough carbonate in the relevant raw water that will also add to the relevant alkalinity or the CO_3^{2-} and for the additional required you are going to use soda ash and then the carbonates assuming that the pH is maintained at the condition, CaCO_3 is going to precipitate out, after this stage, you have 10.5.

Carbon dioxide is going to be used to bring down the pH to acceptable levels of 8 or 7.5, split flow that is the major aspect. But simultaneously, you can have other systems like RO or ultra-filtration. We are discussing that now.

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Split-flow lime treatment

- Consist of separating the process water into two or more streams
- Streams are treated to various degrees with different process treatment techniques and then blended to obtain the desired effluent water quality
- Three split-stream configurations that have been practiced are:
 1. parallel softening and coagulation
 2. parallel lime softening and ion exchange or reverse osmosis
 3. split treatment with excess lime
- For surface water, must have other treatment for particle removal

The slide includes a diagram of a split-flow process with arrows indicating the flow of water into two parallel paths and then recombining. The text is annotated with red lines and arrows pointing to specific terms like 'degrees', 'process treatment', 'effluent water quality', and 'split treatment with excess lime'.

Two or more streams, one aspect was it is coming in like this, and there is also a bypass, Bypass to that access lime treatment initially. That is something to keep in mind, to various degrees. They are treated to various degrees with different process treatment techniques. And then you can blend it, for example, I did not need to treat everything to the same extent.

If by mixing 2, 3 different streams, I can achieve my effluent quality that is desired without having to spend a lot, that is the relevant principle here, there are different split stream

configurations, 3 split stream configurations, we can help parallel softening and coagulation, parallel lime softening and ion exchange or reverse osmosis,

Which we are going to discuss later. Split treatment with excess, lime different configurations, but you did not need to mug them up, but I am just mentioning that out to you.

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Summary of Chemical dosage calculations required

PROCESS	REQUIRED CHEMICAL DOSAGE CALCULATIONS
<p>Single-Stage Lime: For waters with high calcium, low magnesium, & carbonate hardness</p> <p>Figure by MIT OCW. Adapted from: MWH, J. C. Crittenden, R. R. Trussell, D. W. Hand, K. J. Howe, and G. Tchobanoglous. <i>Water Treatment: Principles and Design</i>, 2nd ed. Hoboken, NJ: John Wiley & Sons, 2005, pp. 1610-1611.</p>	<p>Lime addition for softening: $\text{CaO} = \text{carbonic acid concentration} + \text{calcium carbonate hardness}$</p> <p>Soda ash addition for softening: $\text{Na}_2\text{CO}_3 = \text{none}$</p> <p>Carbon dioxide for pH adjustment after softening: $\text{CO}_2 = \left\{ \begin{array}{l} \text{estimated carbonate} \\ \text{alkalinity of softened} \\ \text{water} \end{array} \right\} - \left\{ \begin{array}{l} \text{source water} \\ \text{alkalinity} \end{array} \right\} - \left\{ \begin{array}{l} \text{source water} \\ \text{calcium} \\ \text{hardness} \end{array} \right\}$ + { estimated residual calcium hardness of softened water }</p>
<p>Excess Lime: For waters with high calcium, high magnesium, and carbonate hardness; process may be one or two stages</p>	<p>Lime addition for softening: $\text{CaO} = \left\{ \begin{array}{l} \text{carbonic acid} \\ \text{concentration} \end{array} \right\} + \left\{ \begin{array}{l} \text{total alkalinity} \end{array} \right\} + \left\{ \begin{array}{l} \text{magnesium} \\ \text{hardness} \end{array} \right\} + \left\{ \begin{array}{l} \text{excess lime} \\ \text{dose} \end{array} \right\}$</p> <p>Soda ash addition for softening: $\text{Na}_2\text{CO}_3 = \text{none}$</p> <p>Carbon dioxide for pH adjustment after softening: $\text{CO}_2 = \left\{ \begin{array}{l} \text{source water} \\ \text{alkalinity} \end{array} \right\} - \left\{ \begin{array}{l} \text{source water} \\ \text{total hardness} \end{array} \right\} - \left\{ \begin{array}{l} \text{excess lime} \\ \text{dose} \end{array} \right\} + \left\{ \begin{array}{l} \text{estimated residual} \\ \text{calcium hardness} \\ \text{of softened water} \end{array} \right\}$ + 2 { excess lime dose } + { estimated residual magnesium hardness of softened water }</p>

* All quantities are expressed as mg/L as CaCO₃

Ca(OH)_2

This is something we already looked at in the context of that example in the last session. But we just are going to look at the overview. Single stage and what is it for? When low magnesium and high calcium and carbonate hardness associated with carbonate hardness. I am just going to add the relevant lime, so how much lime should? I add here they are talking about lime in general, when we talk about lime, we are talking about the slaked lime Ca(OH)_2 .

Lately will you directly add CaO which is lime, so carbonic acid and then calcium carbonate hardness, that is it and Na_2CO_3 , now excess lime here we are trying to remove water with high calcium, high magnesium and enough carbonate hardness but not a lot, how much lime are we adding? We are adding enough to remove the relevant H_2CO_3 or carbon dioxide concentration, then the alkalinity to increase the pH and magnesium hardness and excess lime dose.

That is something to keep in mind, so here we are removing the hardness associated with HCO_3^- or the carbonates or the bicarbonates that is what we are achieving here while also

increasing the pH and the magnesium, that is not associated with the carbonate hardness. And then for excess lime dose but depending upon the extent of lime dose,

You are not adding Na_2CO_3 but if it is very high and if you are adding excess, then you will have to add Na_2CO_3 but that is not the case here because we are assuming that there is enough carbonate hardness.

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<p>Single-Stage Lime Soda Ash: For water with high calcium, low magnesium, & carbonate and noncarbonate hardness</p>	<p>Lime addition for softening: $\text{CaO} = \text{carbonic acid concentration} + \text{calcium carbonate hardness}$</p> <p>Soda ash addition for softening: $\text{Na}_2\text{CO}_3 = \text{calcium noncarbonate hardness}$ and/or $\text{magnesium noncarbonate hardness}$</p> <p>Carbon dioxide for pH adjustment after softening: $\text{CO}_2 = \left\{ \begin{array}{l} \text{source water} \\ \text{alkalinity} \end{array} \right\} + \left\{ \begin{array}{l} \text{soda ash} \\ \text{dose} \end{array} \right\} - \left\{ \begin{array}{l} \text{source water} \\ \text{calcium} \\ \text{hardness} \end{array} \right\} + \left\{ \begin{array}{l} \text{estimated residual} \\ \text{calcium hardness} \\ \text{of softened water} \end{array} \right\}$</p>
<p>Excess Lime - Soda Ash: For waters with high calcium, high magnesium, and carbonate and noncarbonate hardness; process may be one or two stages</p>	<p>Lime addition for softening: $\text{CaO} = \left\{ \begin{array}{l} \text{carbonic acid} \\ \text{concentration} \end{array} \right\} + \left\{ \begin{array}{l} \text{calcium carbonate} \\ \text{concentration} \end{array} \right\} + 2 \left\{ \begin{array}{l} \text{magnesium} \\ \text{carbonate} \\ \text{hardness} \end{array} \right\} + \left\{ \begin{array}{l} \text{magnesium} \\ \text{noncarbonate} \\ \text{hardness} \end{array} \right\}$</p> <p>+ excess lime requirement</p> <p>Soda ash addition for softening: $\text{Na}_2\text{CO}_3 = \left\{ \begin{array}{l} \text{calcium} \\ \text{noncarbonate} \\ \text{hardness} \end{array} \right\} + \left\{ \begin{array}{l} \text{magnesium} \\ \text{noncarbonate} \\ \text{hardness} \end{array} \right\}$</p> <p>Carbon dioxide for pH adjustment after softening: $\text{CO}_2, \text{ first stage} = \left\{ \begin{array}{l} \text{estimated hydroxide} \\ \text{alkalinity of softened} \\ \text{water} \end{array} \right\} - \left\{ \begin{array}{l} \text{excess lime} \\ \text{dose} \end{array} \right\} + \left\{ \begin{array}{l} \text{estimated residual} \\ \text{magnesium hardness} \\ \text{of softened water} \end{array} \right\}$</p> <p>$\text{CO}_2, \text{ second stage} = \left\{ \begin{array}{l} \text{estimated hydroxide} \\ \text{alkalinity of softened} \\ \text{water} \end{array} \right\} - \left\{ \begin{array}{l} \text{source water} \\ \text{alkalinity} \end{array} \right\} + \left\{ \begin{array}{l} \text{soda ash} \\ \text{dose} \end{array} \right\} - \left\{ \begin{array}{l} \text{source} \\ \text{water total} \\ \text{hardness} \end{array} \right\}$</p> <p>+ estimated residual hardness of softened water</p>

* All quantities are expressed as mg/L as CaCO_3

Figure by MIT OCW. Adapted from: MWH, J. C. Crittenden, R. R. Trussell, D. W. Hand, K. J. Howe, and G. Tchobanoglous. *Water Treatment: Principles and Design*. 2nd ed. Hoboken, NJ: John Wiley & Sons, 2005, pp. 1610-1611.

Same case here, single stage lime soda. This is just single stage lime this is excess lime. Single stage lime soda here. We are also adding what soda one set of lime or fraction of lime to remove the carbonic acid, the other for removing the calcium carbonate hardness then Na_2CO_3 for removing the calcium non carbonate hardness and or magnesium non-carbonate hardness, this is just getting repeated to but this is one way for you to look at it.

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Equipment

- Conventional (generally reliable, but more costly; typical in older plants)
 - rapid mix \downarrow
 - flocculation basin
 - (a) $\theta = 30-45$ min
 - (b) mixing ($G = 10$ to 50 s⁻¹)
 - (i) horizontal paddle wheels
 - (ii) vertical turbine common
 - sedimentation basin
 - $\theta = 4$ to 8 hr
 - solids recycle from sedimentation effective, increase particle size, improve dewaterability, increase removal kinetics

Recipⁿ

1) Nucleation $S > 1000$

2) 'a' 's'

\uparrow

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Let us look at the equipment, conventional which is reliable but typically more costly we looked at it in the context of the sedimentation basins, with respect to the wastewater and even with respect to water treatment, what do we have? We have a rapid mix, initially you want to mix the relevant coagulant or floc lime coagulant pretty well.

And then you have flocculation basin where you have relatively gentle mixing for a relatively higher or more time compared to the coagulation basin or the rapid mix basin. And we looked at this horizontal paddle wheels or vertical turbine are common and then we will look at sedimentation basin where we need to give much more time for the relevant particles to settle down, solids are recycled from the sedimentation.

Why is this it increases the particle size and increases the removal kinetics? Why is this in precipitation? We have different steps starting with nucleation and here the trigger has to be that it has to be super saturated saturation, has to be greater than 1000 or hundreds it is and then crystal growth agglomeration and so forth, here we have surface area, to be real in the second step we will have surface area limitation and also depend upon the level of saturation.

If you recycle some of the settled sludge back to the relevant process here, you will be increasing this surface area or the area available for the relevant crystal growth to take place. In that way, you will increase the removal kinetics that is something to keep in mind, that is with respect to precipitation.

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Upflow Solids Contact Basins

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Up flow solids contact basins seem to be common.

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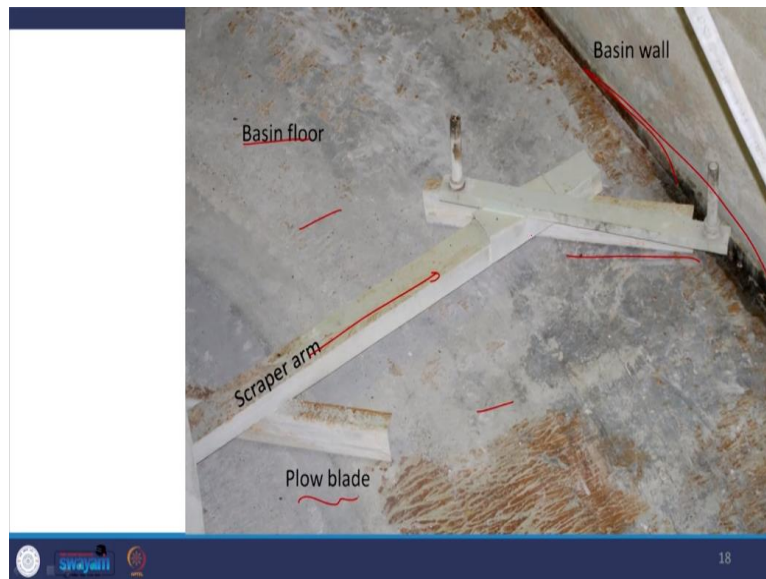


Upflow solids contact tank with radial weirs

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Up flow here with radial wheels, these are the radial weirs.

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And how are we going to scrape the sludge at the bottom? Here you have the scraper arm and this is the basin floor, this is one blade and another one which is flexible enough to handle this circular perimeter, that is why you have this kind of in setup.

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Second stage up flow solid contact unit and you see the radial launders. Some are along the periphery, some are radial launders of flow solid contact basins.

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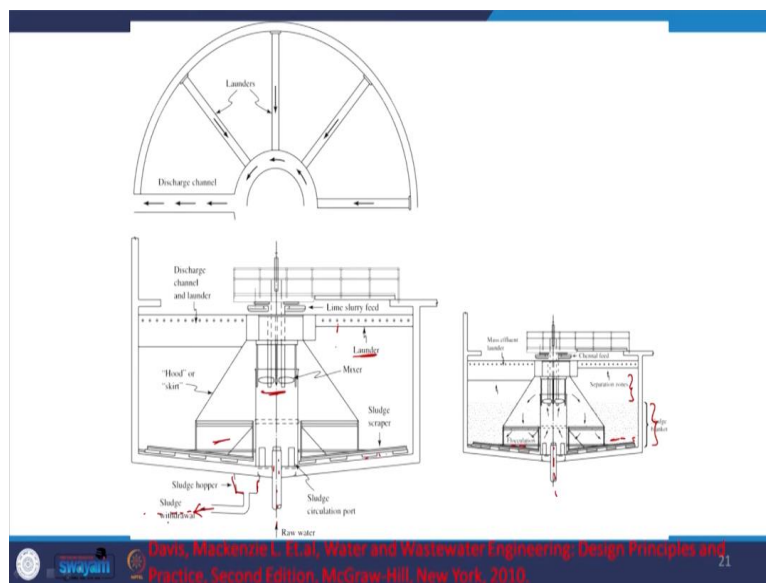
Upflow Solids Contact Basins

- Lesser size and number of basins result in a lesser capital cost than conventional basins
- Effective solids contact units draw the settled precipitate from near the floor at the center of the basin with a large diameter turbine or impeller and recirculate it with the incoming water ?



Lesser size and number of basins result in lesser capital cost, effective solid contact units draw these settle precipitate from near the floor and then re-circulated with the incoming water and in the previous slide we looked at why we are doing that.

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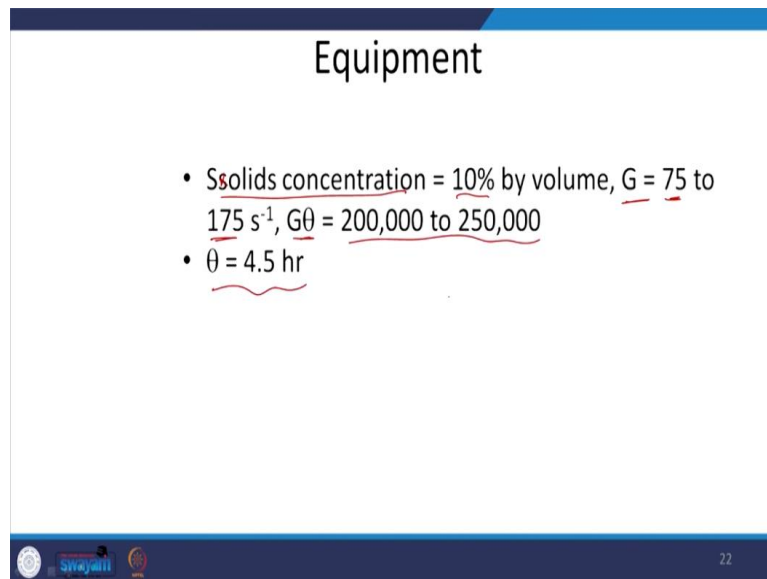


This is a typical system, raw water is coming up flow and then we have hood or skirt mixing out here, sludge scraper at the bottom, the relevant supernatant is going to be collected in the launders which we looked at earlier, that is what you see out here. It is coming up here and then flocculation is taking place out here and this is the separation zone.

This is relatively clear and this sludge blanket part of which will be scraped at this particular bottom you have the sludge hopper and it will either go to disposal or some of it will go for

recycling so that is what you have out here, you have the mixing out here and also the flocculation setup out here, let us move forth.

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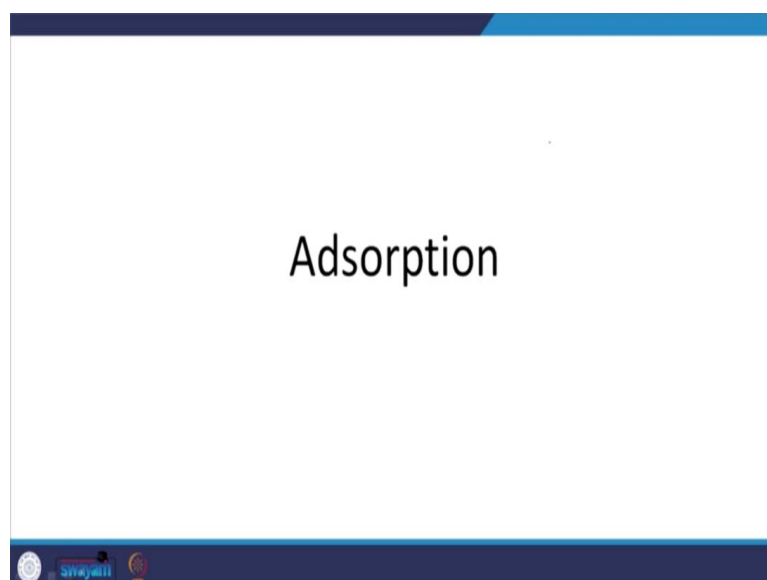
Equipment

- Ssolids concentration = 10% by volume, G = 75 to 175 s⁻¹, Gθ = 200,000 to 250,000
- θ = 4.5 hr

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Equipment, you have solids concentration to be 10%, different sources you have different piece of information but this is an acceptable range. And this is from Mackenzie Davis if I am not wrong, the mean velocity gradient gives you an idea about the level of mixing and $G\theta$, this is a relatively high value and this is for theta we are talking about, the sedimentation basins here.

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Adsorption

Until now, we looked at water treatment. What did we do we remove? Suspended solids, we looked at disinfection of the relevant pathogens and then we started looking at specific aspects if my water is hard especially if it is groundwater. What is it that I am to do? How

will I go about it? In that case, we looked at using the principle of precipitation. If I increase the concentration of the relevant ligand which is OH^- or CO_3^{2-} in the context of hardness removal.

I can use them or use that particular chemical or environmental chemistry background to be able to precipitate out Ca^{2+} as CaCO_3 and Mg^{2+} as magnesium hydroxide. That is the principle we used. There will be some compounds which I cannot remove by precipitation. For example, natural organic matter or there is other organic matter which is aromatic in nature.

You have any fatty compounds, they were not removed during your water treatment process in such, I want to be able to remove these relatively trace concentrations of organic contaminants organic compounds which might be toxic to me or which might create nuisance or which are not at acceptable levels, here we are going to use a different principle.

The principle is that I am going to have a media and this will be able to adsorb, the key aspect is “ad”, adsorbed. We will come back to look at what this is adsorbed, it will be able to adsorb that organic matter which is hydrophobic. We are looking at a couple of terms here, one is adsorption. And the kind of compounds we are trying to remove are typically hydrophobic,” Phobic”, phobia.

Fear, they did not like it, hydrophobic, so hydro, water phobic. Those compounds which are hydrophobic and we are trying to achieve them by adsorption, in the next 2 sessions, we are going to look at adsorption. Let us move forth.

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Definition

- Adsorption vs. Absorption
 - Adsorption is accumulation of molecules on a surface (a surface layer of molecules) in contact with an air or water phase
 - Absorption is dissolution of molecules within a phase, e.g., within an organic phase in contact with an air or water phase
 - Sorption : Includes both

Activated Carbon.

Definition, first aspect is to be aware of find difference, of considerable importance. One is adsorption the other is absorption. What is the difference? I think I have a picture later. That should be clearer. But let us look at the definition, no need to mug up anything but you need to understand the relevant aspect. Adsorption, ad, is accumulation of molecules.

Keep in mind it is accumulation of molecules, but were on the surface, which is in contact with the water phase, at least for our case we are talking about water phase. We are going to have a surface media and the media can be activated carbon, and that is your surface. And here we are talking about removing contaminants from the water. I will not look at here.

That part of the activated carbon that is in contact with the water is the surface and my particular molecules of interest are going to accumulate on the surface, why? We will look at that later. But the principle is that they are accumulating on the surface. The other one is absorption, absorption meaning it is more or less dissolution of molecules within a phase.

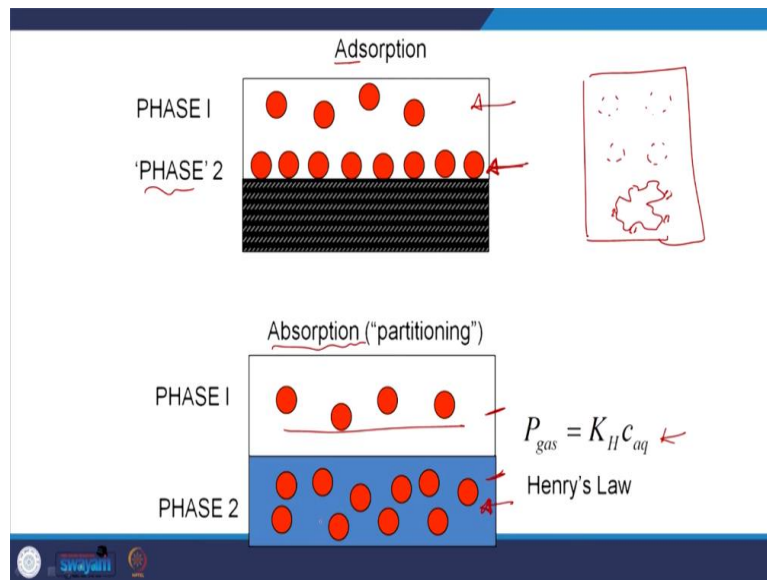
For example, if water is there and I add sugar, the sugar is not going to stay on the surface, it is going to be absorbed in a way, that is not a great example, and then it is going to be dissolved, dissolution. That is dissolution. It is not on the surface; it is dissolution of molecules within a phase. For example, an organic phase in contact with an air or water phase.

Then you can have relevant compounds that will stay both in the air and also your relevant solvent phase. For example, if I have a scent bottle and I opened it up, the compound is pretty volatile, it is going to now change phase, some of it and it will be in two phases, one will be

in the gaseous phase one in the solvent or a aqueous phase, depending on the kind of solvent or scent bottle that you have.

General term sorption that is the relative term that is going to encompass both adsorption and absorption, adsorption is on the surface, absorption is into the interior, this is within a face. Let us look at the picture.

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Adsorption, I have a compound here. Initially everything is present in the relevant water. And then I add my media, this is my media. And some of it is now adsorbed on to my surface, it is adsorption, as you see it is adsorption. One is in the bulk phase, bulk liquid and the other one is the other phase where it is absorbed.

It is called phase but it is a bit tricky to call it phase because we are talking about accumulation on surface, the other one is absorption. Absorption one will be in the water. The other way one can be in the solvent or one can be in the air, one can be in the solvent, here it is not on the surface but within the phase, that is why it is absorption.

One example that is mentioned is Henry's law which gives us the relationship between concentration in the gaseous to the concentration in the aqueous phase, there we are not talking about adsorption but dissolution into 2 different phases, that is something to keep in mind.

With that, I will end today's session. And in the next session, we will look at adsorption, what drives absorption, what kind of media do we typically use to achieve adsorption and what are

the compounds you can typically remove? That we will get it done in the next session. Thank you.