Environmental Quality: Monitoring and Analysis
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Lecture – 60
Soil – Air Transfer

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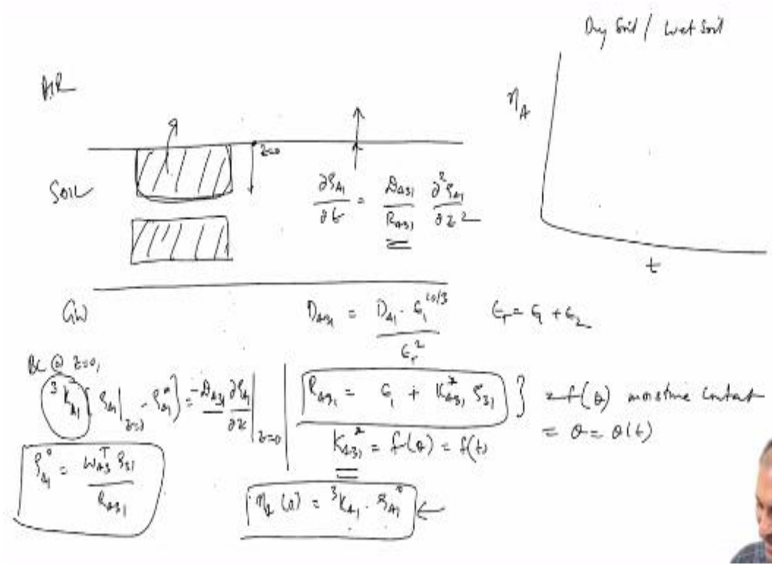

So, now moving on from sediment, similar kind of system with one significant difference is soil-air interface. Now, soil-air interface is much closer to us because we have interface with it directly, sediment-water interface is somewhere down there. So, a lot of times, sediment water problems are not even seen until a several decades after it is done. Soil-air you can see it very quickly for two reasons. One, there is groundwater sitting right next to it. So, it may reach the groundwater quickly.

So, let us say that there is a contamination here, why are we worried about soil-air exchange? If there is a contamination sitting here inside soil or there is a contaminations sitting right on top, so we did examples in the beginning of this mass transfer exercise that we said that there is impervious land surface. The chemical is dumped on the road or surface which is not porous. It sits there and it evaporates from the pure chemical from there, but if it is not impervious, it is soil, it percolates just the way chemicals into the sediment percolate over a period of time and then it reaches a state where pure chemical is either sitting there or it is all gone and then it is adsorbed, then it starts reversing, it starts going out. Everything we have done in the sediment case applies here, the model, we use the same model, this domain equation will still be it will just be ρ_{A1} instead of ρ_{A2},

$$\frac{\partial \rho_{A1}}{\partial t} = \frac{D_{A31}}{R_{A31}} \frac{\partial^2 \rho_{A1}}{\partial z^2}$$

Instead of sediment-water interface, we are using soil-air interface. The only difference here is

$$D_{A31} = D_{A1} \frac{\varepsilon^{10/3}}{\varepsilon_T^2}$$

We do this because unlike the sediment, the soil may contain moisture, and if it contains moisture,

$$\varepsilon_T = \varepsilon_1 + \varepsilon_2$$

if you think that epsilon 2 is negligible, you can assume $\varepsilon_T = \varepsilon_1$, therefore that equation will become

$$D_{A31} = D_{A1} \varepsilon_1^{4/3}$$

but until that point if you think that it is not valid, then you have to do this. Also R_{A31} is now

$$(\varepsilon_1 + \rho_{31}.K_{A31}^*)$$

ρ_{31} is the bulk density of the soil and K_{A31}^* one is the partition constant of chemical with the soil. Now, here you have to consider all the usual things that if the soil is wet the partition constant is based on $\frac{Koc \cdot foc}{H}$, if it is dry, then it is something else, it is higher okay. So, the same rules apply here. So, the retardation factor can change with time, this is something that happens in soil. So, R_{A31} is a function of the moisture and then moisture content is a function of time.

Moisture content can change. It can change during a day, it can change in months or weeks, years, everything okay. So what will happen now? If I solve this equation, diffusion is happening in the air and this is convection, there is a boundary condition at the surface can be

$$@\ z = 0,$$

$$K_{A31}^* [\rho_{A1}|_{z=0} - \rho_{A1}^{\infty}] = -D_{A31} \frac{\partial \rho_{A1}}{\partial z}\bigg|_{z=0}$$

same thing, all the same analysis for sediment applies, except this air.

So, K_{A31}^{*} is the convective mass transfer coefficient at the air-soil interface, same. But the main equation, the retardation factor can change with time because K_{A31} is the function of time, K_{A31} is a function of θ which is a function of time. So, therefore, K_{A31} can change okay. What will happen if K_{A31} changes? What is the consequence if K_{A31} changes? The initial condition is just like what we did previously is row 31 divided by R_{A31}.

What will happen if the partition constant changes? So, if I have two scenarios, if I have dry soil and wet soil, wet soil means 10% moisture is there, still diffusion in pore air is happening, what do we expect the difference between dry soil and wet soil if I am doing flux calculation versus time. One of them will be higher when you have dry and wet, which one will be higher, may be dry, why? What is the highest flux? Time t0 is the highest flux, what will it be?

Highest flux will be ${}^{3}K_{A1}.\rho_{A1}^{0}$. So for which one of the two cases dry or wet? ${}^{3}K_{A1}$ does not change. It does not care whether the soil is dry or wet. It is going to be what it is because it depends on whatever is happening in the wind airside, assuming that airside does not change, what is changing in this equation?

In this equation does anything change if the soil is dry or wet? R_{A31} is changing, R_{A31} is higher or lower for dry? What is R_{A31}?

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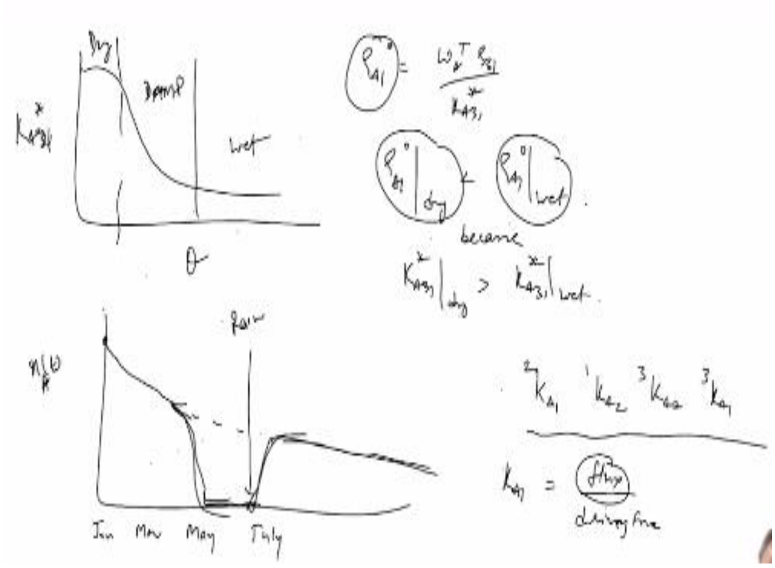

K^*_{A31} as a function of theta, this is dry, this is wet, this is damp, somewhere in between is called damp, yeah. So now, very dry sediment $K^*_{A31}$is high, what does this mean K^*_{A31} is high

$$\rho^0_{A1} = \frac{{w_A}^T \rho_{31}}{K^*_{A31}}$$

which means for dry sediment ρ^0_{A1} will be smaller, much smaller. So ρ^0_{A1} for dry is much smaller than ρ^0_{A1} wet because $K^*_{A31}|_{dry}$ is greater than $K^*_{A31}|_{wet}$. If you put this into the transport model, you can predict what will happen.

So the flux n_A versus t, so let us say we start with a wet season, it is wet, it is damp, so now let us say in December there is an agricultural field where this pesticide which is releasing, you will see a flux like this, flux is decreasing as a function of inverse square root of time. Then we go through, we started at January, this is March, we go to May, we go to July, October, what happens by May? The soil start drying very rapidly, okay. Then what you may see is this flux will drop down really low because now we are moving from a wet regime to a dry regime, it is going here.

So the flux is dropping down because there is more spaces available in this thing, all the pore components chemical in the pore now leaves the pores and goes on to solid, so there is nothing much in the pore, driving force is very small. Simply this is smaller. This is smaller, everything goes down. No driving force, they are all smaller, flux goes down, you will see very low flux, nothing coming up. Then July, there is rain and it jumps back up to almost its previous level as though it has not changed and it continues going down okay.

So this happens cyclically. This is one of the things that happens, in season in India it is very prominent, you can see it very clearly, you can feel it, you can smell, this is one of the reasons why you smell okay. This is application of the transport model in emissions in reference to soil. So, let us leave today's session with one small aspect of we are talking about all this, so we need, we have talked about ${}^2K_{A1}$, we have talked about ${}^1K_{A2}$we have talked about ${}^3K_{A2}$, we have talked about ${}^3K_{A1}$, which are all mass transfer coefficients.

To get a correlation for mass transfer coefficients, you need to, how do you get a correlation for mass transfer coefficient, you need some estimate of the driving force and then you need flux. So, any K$_A$ equals $\frac{flux}{driving\ force}$. How do you measure flux? Say flux across sediment water interface or flux across air soil these things, how do you measure flux? What is the simple, any simple technique?

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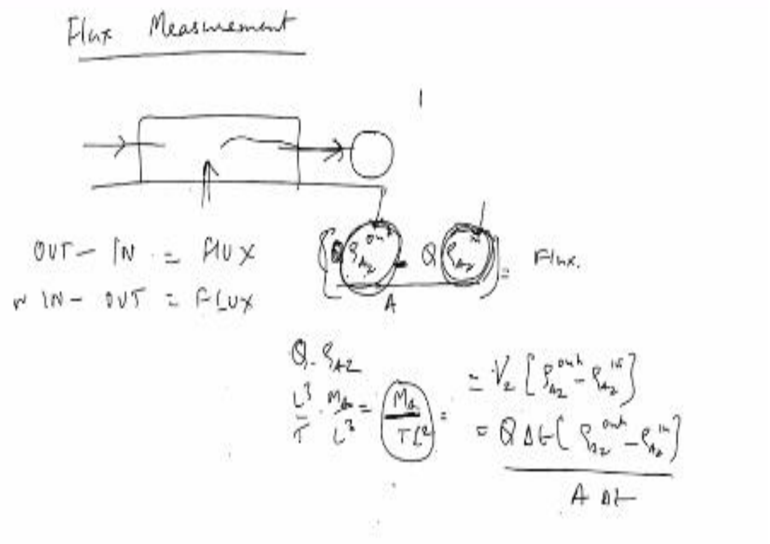

Concentration, driving force, how do you measure concentration and driving force? You just measure the concentration in whatever distance that you want from water, air, you take a sample of water, you take a sample of air, analyze it by whatever techniques you already learned. You take sample of sediment, take sample of soil, take sample of air and this is how you do, there is nothing else, no other way of doing it.

So, all the driving force measurements are done by actual core, in soil and sediment you take a core and you find out where what is the contamination and then you find out what is the concentration. You take an air sample, you take a water sample, you get concentrations in the bulk water, okay. So that is done. How do you measure flux? Okay, so one way to do it is simply by mass balance, using the box model. So, simply conservation of the mass balances out minus in is flux or in minus out is flux depending on which direction it is.

Out minus in flux means it is coming into the system, in minus out is it is going out of the system, so either way it is by mass balance is what you can do. So in a river for example, you can say

$$\frac{(Q\ \rho_{A2}^{out} - Q\ \rho_{A2}^{out})}{A} = flux$$

It is continuously you are doing. In the chemical analysis series that you have seen, how many measurements can you do like this, in a module on chemical analysis that we have done in all the organic chemicals that you have seen.

What does this imply, $(Q\ \rho_{A2}^{out} - Q\ \rho_{A2}^{out})$, as I have written this equation what does it imply? What is assumption in terms of measurement? I have written $(Q\ \rho_{A2}^{out} - Q\ \rho_{A2}^{out})$, what is the assumption here?

So, this is a steady state system we are looking at, there is nothing else happening, no reaction, no accumulation is happening. A lot of times you would like to do this when you write it like this in terms of Q, you have to collect the entire mass of what is coming out and that will give you this. So, the rate of material that is coming out and divided by the area that gives you flux, lot of times if you can do it continuously, you can measure this as a function of time quickly and it is giving you instantaneous flux okay.

But many other chemicals you see you do not have probes, we are not able to do that, just like the way we collect air sample through a tube, you cannot, you have to collect a lot of these samples, you have to collect a large volume of the water and then whatever is the concentration rho A2 out - rho A2 in. In other words, we have to collect a large amount of water delta t into rho A2 out - rho A2 in divided by A will give you the flux value because you are unable to measure instantaneously, you have to collect for a period of time for 5 hours, large volume.

Then you extract the large volume, you will get a mass of chemical that is in the volume and that divided by the area and the delta t, yeah, delta t will come here and the time interval. So, this will give you a volume, it is essentially this numerator divided by the area and time interval, yeah. So this will give you the flux, this is a time average flux. The flux is not an instantaneous value. In this case it is a time average flux, you cannot get one value at one particular time, that is not possible in this case okay. So there are other complications to flux measurement, I show you some images on Tuesday. We will stop here.