Topic 2c - Part 2 (Applications case study): Street level sensing - instruments & particle measurement

You're measuring in various ways. These are sucking air down. But you've also got a slightly more visible way of measuring pollution.

We're not interested in all the particles in the air. We're only interested in stuff that either gets into your airways or deeper down into your lung. So we talk about two specific size fractions, either PM10-- [COUGHS] excuse me-- which is thoracic convention, which is everything gets below about here, and then PM2.5, which is the fine fraction-- [COUGHS] excuse me-- so obviously getting into my lungs.

That's all the pollen floating around in the air.

And so yeah, it's all the bits of trees that are coming down. That gets deeper into the lung and can therefore cause more systemic effects deeper into the body.

So the idea is that the smaller the particle, the further in it gets.

Indeed. So we've got lots of protection mechanisms. Our nose is lined with hairs, and it's wet, and the same with our throat. And when particles hit that, they stick to it.

So as the particles in the air goes deeper down into your lungs, more things either contact the edge of the airways or they settle out. So it's only the smallest ones that behave more like gases that get deepest down into the lung.

But then your air intakes here are taking those in. You're also directly looking at the particles. You're collecting the particles as well.

Yep. So there's two ways. We can either collect them onto a filter, and then we can take them back to a laboratory. And that's in-depth analysis, where you extract the particles from the filter, put them through some big, expensive machines. Or we can look at them in real-time, either weighing them, or counting them, or seeing how big they are, or seeing what the chemical composition is.

It's very noticeable on the surfaces here. They're covered in stuff. Now, you're collecting this as well, aren't you? How are you doing that?

Yeah, we are. Well, we're collecting the particles. We're interested in polyaromatic hydrocarbons, like what you get from vehicles or what you might get from wood burning.

Let's have a look at these filters, then. Where are they?

OK. So we've got some behind you here. Now, this is what we call a high-volume sampler. And it's sucking air in onto the filters at about a hundred liters a minute. So you can see this measures-- this detects the flow in here.

So the air is coming in here.

Air comes in here through this size-selective inlet. So only particles bigger than 10 microns in diameter are then deposited onto a filter. So we come along every two weeks, and we put a stack of filters in here, which are labelled up so we know when we get them back to laboratory that they've come in in the right order. So we have unexposed filters at the top.

And then at midnight, the machine shuffles the filter across into the flow line. And then midnight, it shuffles one out again. So we have a stack of large filters that have been exposed. And you can see--

Oh, and there's a difference-- the top and the bottom. [LAUGHS]

They're quite dramatically different, yeah.

So this is beautiful, clean, white. And that's--

It's dirty black.

Is horrible, yes.

Yes.

So that's one day.

That's one day, yeah.

Wow. And then this is like one of those old record stack things--

Yeah, kind of like that.

--that shoots one in, collects the down--

Shuffles one along and--

--shuffles one down.

Yeah.

And then you can take this back to the lab and directly compare it with the other measurements.

Yes. Yeah.

And how much does that worry you, what we're looking at on those? We're standing here. We're breathing that.

Yeah. So I mean, we've got other ones that are designed really to mimic the flow rates that we have. And so yeah, you can see how black the inside of your mouth and your lungs will get just from breathing this stuff in. It's really not very pleasant. The medics can take what's called a bronchial lavage. They can flush out your lungs. And you can see the particles within your lung lining fluid that they flush back out.

It sounds fascinating and worrying all at the same time.

Yeah, and still horrendous, yeah.

And it was very noticeable even to me cycling here this morning. I wouldn't normally cycle on the big street like this. And when I got here, my nose was streaming. And that's my body trying to get rid of these particles.

Yeah. I tend to sneeze and cough as soon as I come here. I'm not here all the time, by the way. It's a once every two week visit for people to come here and do things to the instruments.

So the instruments are collecting the pollution, but you're not.

Yeah, the instruments are pretty much completely autonomous.

Let's talk a little bit about all the various intakes we've got around us. So tell me where this air is going.

What we have up here-- some instruments, as you've seen, are collecting particles onto filters for laboratory analysis. And we collect them onto different types of filters because different types of filters are used in different types of analysis. So some filters you heat up to drive off the particles. Some you put into water to extract the particles from. So that's why there are lots of different samplers up here. And that's why we have boxes like this or this just sucking in air onto filters, which are then analyzed later.

So where are they all going?

OK. So if I compare-- there are other instruments that are downstairs, and we just have the

inlets up here. So this one's PM10, as you can see. It has PM10 written on the inlet here. And then that goes straight down.

This one's PM 10. And then it's got another part here, which is a cyclone. And that removes everything above PM2.5. And this works like a vacuum cleaner. It swirls air around. And only the smallest particles get through. So we're just eliminating the big stuff and only collecting the small stuff.

And then what else have we got down here?

Well, I can move around. So here we've got-- this is just a general inlet. But again, down there, we have something that measures mass in the same way that those two measured mass.

This one works as an optical particle counter. Inside here, we have another filter collection system. And we have another filter collection system which is exactly the same over there.

When you're trying to understand how well an instrument works, it's good to have two samples of exactly the same thing so you can understand variability in the sample. So this is exactly the same as the one over there. And that one behind you there is exactly the same as that one over there.

So you've got pairs so you can check--

So we've got pairs so we can understand whether one instrument's working very well and the other one isn't.

So all these different intakes are going down to different instruments. And then you've got chemical analysis down below, and counting, and sizing.

Yeah, chemical or physical analysis.

So a complete picture of what's going on.

Yeah, that's right.

So should we go and have a look downstairs?

Yeah, let's do that.

[MUSIC PLAYING]

Over on the side?

[MACHINERY WHIRRING]

All right. So what have we got in here, then?

OK. Well, as you saw on the roof, we've got lots of size-selective inlets that are pulling air down. So inside here, we've got lots of big pumps that are pulling air in into our different bits of equipment.

And what are these bits of equipment? What have we got here?

OK. So we can start off over here. This instrument breaks apart the chemical composition of the particles, so the secondary inorganic aerosols. We've got things to look at the black carbon in our aerosols. It samples directly onto a filter tape. And we look at the blackness of the tape. One of those optical particle counters here, and we've got the other one, as I've said, which is the pair, over there.

Right.

There are these two, which are measuring PM10 mass and PM2.5 mass.

And then we've got some gas analyzers as well?

We've got some gas analyzers here. Now, as you can see, these don't draw air directly down. We pull gases in through Teflon tubing. So Teflon is really not very sticky. So we make sure we capture all of those gases.

And here, we're monitoring for nitrogen oxides, ozone, sulfur dioxide, and carbon monoxide. Here, we've got a particle counter. So here we size segregate particles and count them.

We've got some gases over there. It's really important that the data that we disseminate is of a high quality. So we have to have separate gases with known concentrations we put through the analyzers so we can compare what we see here to what we see at a background site or what we see in a different city.

So that's the calibration to make sure the numbers are right.

That's the calibration side of things. Then we've got a gas chromatograph that measures a whole range of chemical components of organic gases, so from methane and ethane up to ring compounds like benzene.

So this is where everything that's in this invisible air becomes visible to you.

Yeah. So this is where we get the data.