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#386: Global warming's companion crisis: Reactive nitrogen and its threat to human and planetary health

VOICEOVER

This is Up Close, the research talk show from the University of Melbourne, Australia.

ANDI HORVATH

I'm Andi Horvath. Thanks for joining us. Today we bring you Up Close to the increasingly challenging impact on our world of reactive nitrogen. Nitrogen makes up 80 percent of the air you breathe in. In its inert form - that is non-reactive gas form - it's perfectly fine. But when it's in its reactive form, like ammonia, at critical levels it's a pollutant that affects the environment and human health, and it's become a problem on a global scale. All living things need nitrogen. The development of nitrogen fertilisers used in food and livestock feed crops has allowed for an increase in food production that meets the needs of 40 percent of the global population.

But intensive, massive scale agriculture has tipped reactive nitrogen out of balance. It's become an air and soil pollutant that has seriously degraded water quality, created higher levels of greenhouse gasses, fuelled climate change and is estimated to shorten human life spans.

According to our guest today on Up Close, our nitrogen footprint, like our carbon footprint, needs our attention right now. Environmental physicist, Professor Mark Sutton, from the Centre for Ecology and Hydrology in the UK, is a highly regarded researcher into the effect of ammonia emissions in the atmosphere. Mark is one of the world's leading advisors on nitrogen policy, speaking to governments and farming and food industries worldwide. He is also chair of the international nitrogen initiative of which we will hear more later.

Professor Mark Sutton is in Melbourne as a guest of the Faculty of Veterinary and Agricultural Sciences. Welcome to Up Close Mark.

MARK SUTTON

Thank you very much.

ANDI HORVATH

Mark, give us a sense of nitrogen as an essential element on our planet. Take us on a tour of a nitrogen molecule. How does it cycle through our living systems?

MARK SUTTON

Well the first thing to think about is that nitrogen in the atmosphere you mentioned, 78 percent of the atmosphere is unreactive nitrogen. That's two nitrogen molecules sitting tight together. Because they sit so tight they're completely unreactive. They give us the stability in every breath we take. So you breathe in - that was 78 percent nitrogen. This really is the stuff we breathe. Of course the atmosphere is only 16 percent oxygen. That's good news. If it was too much oxygen it would get explosive. So the nitrogen first off gives us stability. We need that unreactiveness. Half-life of that stuff in there, about 12 million years to turn over.

On the other hand there's incredibly tiny quantities of other nitrogen compounds. Slowly that stuff will get caught up in the biological system through biological nitrogen fixation where the bugs - the bugs in the soil - bacteria in the soil - actually put energy in to trap that to convert it to ammonia in the first instance. We need that as a key starting point for proteins. So what's the difference between a carbohydrate and a protein? Basically nitrogen. It's ammonia that comes in to make an amino group. So think about a loaf of bread being rich in carbohydrate. The thing that puts the protein in is nitrogen. A beefsteak of course is rich in protein. It's much fuller of nitrogen. So that's the big difference first off.

Now the challenge we face is we want to trap that nitrogen out of the atmosphere, get it into our food products. But actually biological systems are not that efficient with nitrogen. People are not that efficient. We've estimated in the international nitrogen initiative in a report we released for the United Nations Environment Program (UNEP) called Our Nutrient World we estimated that only 20 percent of the nitrogen we get into fertilisers and things actually finds its way to people in food. 80 percent is lost to the environment as all these different reactive nitrogen compounds which in excess are causing pollution and all those problems you mentioned.

ANDI HORVATH

Okay so let's explain how agriculture has led to reactive nitrogen being out of balance because it's fixed by some plants. It ends up in our system. It might become a part of manure or urine. We use it as fertiliser. So how has this become out of balance?

MARK SUTTON

The thing to think about is that in a natural situation with really very little amount of nitrogen the plants are trying to grab it as quick as they can. So the moment some ammonia or nitrate is released into the environment the plants are going to grab it back again, makes a very tight cycle. Now that's why in the old days at school we always talked about the nitrogen cycle. It's nicely, tightly coupled. When you start putting extra amounts into nitrogen either through fertilisers or through deliberate enhancement of biological nitrogen fixation in your crops, that's putting excess in. So let's say you put in some biological nitrogen fixation. You have some legumes. That might be great while the plant is growing a nice slow release production of ammonia. But then if you plough that crop in to get nitrogen ready for the next crop you've suddenly got this huge pulse of ammonia in the soil decomposing. Of course at that point you start getting the losses.

It's the same with the fertiliser. A big pulse of fertiliser on at once or manure at once, the system can't use it all instantly. That's when you start getting the losses.

ANDI HORVATH

Right, so the problem is the system can't use it. Now you've said agriculture produces 70 percent of the nitrous oxide emissions in Europe. How does that work? How does it get into the air?

MARK SUTTON

The way that nitrous oxide is produced - and just to say nitrous oxide is two nitrogen atoms together with an oxygen. Again it's rather unreactive. It contributes to two problems, greenhouse gas warming and destruction of the ozone layer. That's produced when some of the nitrate in the soil and some of the ammonium in the soil starts decomposing. The bugs want to get energy from it. So as they process it trying to get a bit of energy some of that ammonium and nitrate is converted to what we call N_2O - nitrous oxide - on the way to becoming atmospheric nitrogen. But not all of it gets as far as atmospheric nitrogen. Some of it leaks out to make this gas at the same time. So that's happening in the soils all the way around the world. The net result is if you add up human sources from factory production and other things, the soil in agricultural systems is contributing 70 percent.

ANDI HORVATH

What are the factors that affect the level of nitrogen pollution? Does weather affect it?

MARK SUTTON

Weather is really important because the whole nitrogen cycle is weather and environment dependent. One of the examples is my own work on ammonium where we find that ammonia is coming out of systems based on its solubility. So if you think about your drink of Coke, if you warm up your Coke the bubbles come out. Cold drinks hold more gas. You warm up a surface, the gas comes out. It's just the same with ammonia. If it's cold a lot of it is going to stay in the soil dissolved. But warm up the ground and then it starts coming out in the gas phase. So this is a concern for ammonia emissions, in some parts of the world trying already to control those emissions by better practices. But if we've got climate warming, a warmer world is actually going to focus with more emissions rather than less.

ANDI HORVATH

Explain to us, is agriculture the sole source of nitrogen air pollution? Or are there other sources?

MARK SUTTON

Agriculture overall is the biggest source of these reactive nitrogen compounds in the world. But burning is also a major source. What I mean by burning is it can be burning of biomass, burning of fossil fuels, burning of gas. When you're driving your car the car is emitting what people often call NOX. NOX is nitrogen oxides. The reason they call it NOX is because that X at the end means there are several different forms of it. It's just a shorthand to explain there is nitrogen oxides - NO, NO2 - but don't worry about that. But that NOX, those nitrogen oxides coming out of the back of your car, that's actually huge amount of nitrogen. Now current technologies focus on breaking that down, converting it back to harmless N2. So if you're driving a petrol car and you've got a catalytic converter on it what that catalyst is doing is turning NOX back to N2.

Now that's good to reduce air pollution. But in fact I say that we need to go a step forward for the future. This is something we learned from agriculture in fact. In agriculture we're learning that we need to improve our nutrient use efficiency. It's all about coming to a circular economy, using all the resources. Now let's put that in terms of the NOX emissions. Those NOX emissions from combustion sources, power generation, driving of the cars, etcetera - now let's add that up and imagine it's a fertiliser value. Now fertiliser value - Australian dollar or $0.60 in US money - per kilo - multiply that by 40 million tonnes a year of NOX nitrogen. We get $40 billion a year worth of nutrient nitrogen going up as NOX.

Now I say all our thinking so far in fossil fuel burning has been to just destroy it as a pollution. That's so much resource and technological invention has gone into that but we're hitting the limits of how far we can go. If we can put more effort into developing technologies that say we are not going to destroy it. We've got NOX. We are going to scrub it out of that factory chimney, put it in a fertiliser bag and start selling that with a $40 billion a year market. That's great for the circular economy and of course the money generated would help us go further in pollution control than we currently are at.

ANDI HORVATH

Mark you helped evaluate the status of nitrogen pollution in a project that involved around 200 experts from 21 countries and 89 organisations. One group estimated it shortens the lifespan of the average European resident by six months. What is reactive nitrogen doing to our bodies?

MARK SUTTON

Yeah, so we did that in the European Nitrogen Assessment. You can find it free online if anybody wants to read it. When that ammonia is emitted from agriculture, then you've got the car emissions, the NOX going up into the atmosphere now those are going to start reacting together. Ammonia together with NOX - NOX makes nitrates - you form ammonium nitrate. Funnily enough in another world ammonium nitrate is one of the fertilisers used in crops. But in this case it's just forming into super fine particles in the atmosphere. You can't see them. Less than a thousandth of a millimetre. They're so small that you can breathe them deep into your lungs together with all the other air pollutants, the carbonaceous materials and whatever.

At the moment the epidemiologists trying to look at this, they say we can't say whether one particle is better than the other so they're just assessing it on the basis of mass, ammonia and nitrate and then that particulate mass of those fine particles breathing deep in your lungs. That's what's giving threat for human health through cardiovascular diseases, through respiratory illnesses, etcetera.

ANDI HORVATH

You and your colleagues have linked nitrogen pollution to an increase in greenhouse gases. It also fuels climate change. Can you give us some insights into how that happens?

MARK SUTTON

There are several ways in which nitrogen interacts with climate. The first one of those is through nitrous oxide, laughing gas, very small quantities. It's coming out of the soil. It absorbs radiation from the sun. Because it is absorbing radiation from the sun then it's warming up, contributing to the greenhouse effect. The interesting thing is actually nitrogen as I said is everywhere. It's doing several things at once. If you get nitrogen into the atmosphere it goes up and then it's coming back down. It'll come back down on a forest. We already said that nitrogen is a fertiliser for crops. But if you have the nitrogen coming back down as ammonia and nitrate it's going to fertilise the forest. The forest is going to grow more. Because it grows more it's going to absorb more carbon dioxide out of the atmosphere. So it will have a cooling effect. So it's helping to remove carbon dioxide from the atmosphere.

So we've got a warming effect and a cooling effect. There are a couple of more of those as nitrogen interacts with ozone in the atmosphere. Nitrogen attracts with methane. The net result is that for the long-term effect nitrogen is really warming. There are some short-term cooling effects but we can't bank on those cooling effects. I'll give you another example. The particles in the atmosphere - we mentioned in relation to human health but those particles create light scattering. They also create more clouds. So that will mean that it's a cooling effect. Now some people will say well let's have more particles for the cooling benefit. But of course you can't do that because of the human health effect.

Now what's the juggle and how do we solve that in climate? My angle would be that we've got to reduce the warming effects. The cooling effects are all associated with other problems. If you deposit more nitrogen onto your forest, if it's a nature area you're going to have threats to biodiversity. So you can't count on that if it's a nature area. What we need to do is focus on more efficient management on nitrogen in agriculture so that nitrogen is going exactly where we want it. If we want to fertilise a forest specifically to grow it, let's add it in the right place but not just randomly. Equally we can then be more targeted to get to where we want the nitrogen to be.

ANDI HORVATH

Your report also estimated the annual cost of damage caused by nitrogen across Europe as being hundreds of billions of Euros. What do those figures actually mean?

MARK SUTTON

We were focusing on the human health impact of particles. We were focusing on the effects on biodiversity, the health effect of ozone. Then we've got the climate effects. Water pollution now is a very hard thing because what we're trying to do here is compare apples and pears. But we do our best. One of the ways to do that is called a willingness to pay. How much are people ready to pay to avoid pollution? What's the value of a human life? So if you've got six months life shortening due to particulate matter what would that be worth? Of course, human lives are worth a lot. You end up with the particulate matter having one of the biggest costs when you do that.

Interestingly we calculate it simply in terms of the fertiliser value. We'll ignore what economists call externalities, the things we should be including, but let's just put them to the side for the moment. We'll get a smaller number. We'll say how much nitrogen is being lost from European agriculture? Let's convert that to fertiliser equivalent, the price in a bag of fertiliser. We come up with a number of only €14 billion per year, still a pretty big number. €14 billion a year as lost nitrogen, up in smoke, down the drain. Compare that now to the European budget for agricultural support. In Europe we call it the common agricultural policy budget cap. That's about €57 billion a year. So what we're saying is that 25 percent of the entire agricultural budget of Europe, subsidies, is going up in smoke and down the drain as nitrogen. This is real cash value.

40 percent of the EU budget is agriculture. So this means that 10 percent of the entire EU budget is being lost as nitrogen. Now that is real cash money. That's the one that at the moment is getting more traction with the policymakers.

ANDI HORVATH

I'm Andi Horvath. You're listening to Up Close. In this episode we're talking with environmental physicist Mark Sutton about how agricultural practices are creating a global nitrogen pollution crisis and what we can do about it. Mark, is it true that you can detect nitrogen or rather reactive nitrogen, from satellites. Can we work out where the poultry farms are and where the piggeries are or the chicken farms because they would produce quite a bit of manure and urine?

MARK SUTTON

Well there's been a huge progress in the last years with the satellites both with measuring nitrogen oxides first. That's mainly from the combustion sources. But those NOX are coming from the soil as well. That's been the first step. Then the next step in the recent years has been to measure ammonia from space. But we're not yet at the level of individual chicken farms and poultry farms. This is bigger scale. Let's say you could get down to 10 or 20 kilometre resolution. That means that we can see the big patterns in the world from space. Now my own work is in ground-based measurements. So let's say we set up monitoring the United Kingdom, 80 places where we're measuring ammonia. We can see the areas where are high with pig or poultry or with cattle farming. We can see that nicely from the ground-based measurements. But we've got 80 points.

Now let's say a satellite and the satellite is going over the world scanning twice a day every 20 kilometres. This is making huge data sets. It's amazing. So when you look at India for example it's really high levels in the north of India you can see the diurnal change from the morning to the evening and through the seasons how it's high in the summer and low in the winter. But there are limitations. That method needs it to be clear, no clouds and a high-temperature contrast between the ground and the atmosphere. Funnily enough no clouds and high-temperature contrast is not something the UK is famous for. It means that so far those satellite methods are not really very useful in the United Kingdom and cloudy places. But in many parts of the world you really can get amazing levels of data from it, like in India which is really the ammonia capital for the world.

ANDI HORVATH

So can we tell how far these gases are travelling? Will they reach the penguins in Antarctica? Can the penguins sniff cow urine from other parts of the world?

MARK SUTTON

Actually it's the other way around I would say. The different chemicals in the atmosphere have got different residence time. So residence time is just a posh word for how long it will last up there. The nitrous oxide is up there for hundreds of years. So if we emit nitrous oxide here in Melbourne it'll be in the North Pole eventually. It will be very well mixed. So you'll see nitrous oxide in the North Pole from Australia. But to take another gas the ammonia, that's washed out because is very soluble. So whenever it rains, washed back to the ground. So Australian ammonia will not get to the North Pole.

But you just mention the penguins. There is an interesting story there, and also other seabirds. Our first work in this was in Scotland. We have a little island there are called the Bass Rock it's the place from where the gannet is named. We measured ammonia emissions from that. First off we came across an incredible number. To put that into context a farmer may typically put 100 kilograms of nitrogen per hectare per year on his field. I'm going to use the same units. So how much nitrogen from the seabird droppings goes onto the Bass Rock? For comparison - so a farmer is putting on 100 kilograms per hectare. On that Bass Rock the birds are putting on 52,000 kilograms per hectare.

ANDI HORVATH

That's huge.

MARK SUTTON

It is huge. The island itself is emitting from a seven hectare island 100 tonnes of ammonia into the atmosphere per year. So the island becomes this huge amazing ammonia hotspot. Now the good news for the world of course is that the bird?s population is relatively modest. So locally this is incredible. It becomes a natural laboratory for studying ammonia. We've done the same with the penguins. Our purpose actually was scientific in the first instance. What we want to do is understand how ammonia interacts with climate. If you study that in agricultural systems the challenge we face is that you go to another place in the world you've got different agricultural practices. So how can we compare?

So the natural systems with the seabirds means we're just looking at the effect basically of climate. What we find if we go to the tropics, somewhere like Ascension Island or Michaelmas we are seeing 50 percent, 60 percent of the nitrogen from the guano going straight up back into the atmosphere because it's so warm. You go to Britain we're up at about 20 percent. Then down to Antarctica we're looking at about two percent is evaporating. Most of it's staying in the system. So this really is a big global scale experiment with these amazing hotspots locally contributing to particulate and huge vegetation effects. But if we compare those natural emissions which are a wonderful natural laboratory with now what's happening due to human activities, the human activities are thousands of times bigger.

ANDI HORVATH

Let's go back to India, so that's why it's happening so much in India. This nitrogen pollution is detectable there because it's hot and there's human activity.

MARK SUTTON

That's right. Now there are several things we need to understand about India. We face an interesting scientific challenge here because in China they've got huge amounts of livestock and crops, fertilisers. We don't see the same level of ammonia concentrations in the satellite in China. Much higher in India. So at the moment this is a land of exploration among the scientists as to why that is. Is it because in India there's a higher amount of livestock than fertilisers? That's a possibility. In China there are higher emissions of nitrogen oxides and sulphur pollution. Those create acids like sulphuric acid, nitric acid. They react with the ammonia. The ammonia is an alkaline. So that means that the particles are forming more quickly in China than they are in India. So the ammonia is lower but the particles should be higher in China. So those are a couple of possible explanations. There's also the meteorology is different. But it's at the moment quite an exciting question for us to explain as part of the global scientific community.

ANDI HORVATH

You've argued with the scientific community and beyond to make sure that our nitrogen measurements are related to meteorological data.

MARK SUTTON

Now this is a big challenge when it comes to upscaling our numbers. In the last years as people have first off developed where the emissions are, the focus has been on making an annual number of the total emission into the atmosphere for example. That's really useful for governments particularly as governments start discussing policies and they say well we are going to commit that our country will not emit so many more million tonnes of nitrous oxides or ammonia. So they want to know how much total for the year. That's largely based on best estimate averages, agricultural statistics, etcetera. The problem with that is, have a warm year your emissions will be bigger. Have a wet year they'll be smaller. If we want to project forward 50 years of what are our emissions going to be, we haven't included weather in those numbers.

So what we've really been saying as scientists is, we have to get that coupling between atmospheric processes [net]. That means that instead of just using simple rough and ready numbers together with statistics we must more develop process models of the interactions. There we are. We're back to our seabirds because our seabirds are enabling us to develop those process models, the mechanistic understanding that will ultimately help us to have a let's say climate dependent approach of how our emissions will be in the future.

ANDI HORVATH

With carbon, we're able to trap it inside wood. In fact there's a lot of tree planting going on for that purpose. Can we trap reactive nitrogen somehow?

MARK SUTTON

Well interestingly, wood of course is the biological product. Every biological product has got nitrogen and carbon in it. Nitrogen remember is the protein. So in wood the more we grow the wood the more we will also store nitrogen. Now there is a bit of a problem there nevertheless, sorry about that. Wood itself has got a very large amount of carbon and a very small amount of nitrogen. It can be up to 500 to one in wood. Soil on the other hand has a much smaller amount of carbon and a much larger amount of nitrogen, let's say 15 to one. So you can store more nitrogen in the soil. The more carbon you store in the soil the more nitrogen you'll store in the soil. So for some people who say from a climate perspective we really should aim to be storing more nitrogen and carbon in the soil together. That's I think in many cases a good plan particularly if a soil is degraded by taking more crops out than can be replenished by the nutrients going in.

So a term is often used called soil mining. So we've got problems in the world with too much nitrogen leading to pollution, problems in the world with too little nitrogen. If we keep taking crops out and we're not replenishing it with enough nutrients, the soil quality degrades. The carbon goes down, organic matter less, the nitrogen goes down. So in those areas yes quite right. Let's get more organic material, better soil structure, better water holding capacity, improving plant growth and nutrient recycling. But we have to be aware of a few pitfalls just to be ready. A soil with a higher level of organic material will be associated with higher greenhouse gas emissions from nitrous oxide.

So there we are. We are in a juggling game. It's a very exciting juggling game. But this is why we need the science to weigh off not just in terms of qualitative statements but get the numbers right and find the optimisation of how much and when in different situations.

ANDI HORVATH

I'm Andi Horvath. Our guest today is leading nitrogen policy advisor and environmental physicist Professor Mark Sutton. We're talking about the growing problem of nitrogen pollution and what it would take to come to grips with it here on Up Close. Mark let's explore the quandary of needing to feed a planet now and into the future and that includes increased livestock production with the resulting nitrogen pollution problem. I mean the elephant in the room is we eat meat. The problem would be minimised if the world ate less meat. Can we really ask people in both developed and developing nations to eat plants instead of animals? How do we do this?

MARK SUTTON

I think we really have to be sensitive to everybody's needs and remember that we can't tell anybody to do anything. That's not going to be helpful at all. What we first need is the evidence of the relationships so as scientists we can be really clear in our information. For me one of the first points in this, in our assessment work, was the discovery that in the world as a whole, 80 percent of the plant harvest in agriculture - 80 percent of that nitrogen is not going to feed people. Eighty percent goes to feed livestock. Only 20 percent goes to feed people. So when people say we need the nitrogen to feed the world, actually what we're really saying is we need the nitrogen to feed the livestock.

So the second piece of evidence to put together is well how much livestock do you need to eat for a healthy diet? Now in Europe we found out that we're eating about twice the total amount of protein that we need for a healthy diet, particularly in relation to red meat and the World Cancer Research programme guidelines on red meat intake. We were at 207 percent. Now we did some scenario analysis in a report called Nitrogen on the Table. That can be found freely on the web. Just Google that. That report showed that what would happen if Europe decided to eat differently, if we went to 25 percent less of beef or 25 percent less of pig and poultry. I'll give you the 50 percent scenario. I call it demitarian. Demitarian is a new word maybe for you -

but if you've got normal and vegetarian, demi means half.

ANDI HORVATH

So halfway between.

MARK SUTTON

Halfway between. The interesting thing with halfway between is that you wouldn't do it if you weren't eating meat from let's say an animal welfare perspective about no meat. But from an environmental perspective it's not meat or no meat, it's about how much. So what if we were to eat less? First off in Europe we would come down from 207 percent to 107 percent of the recommended intake of red meat according to the World Cancer Research programme. So actually we're coming down to the guidelines. Then what else would happen? We would reduce our ammonia emissions, our NOX emissions, from soils, our methane emissions. They're different according to the different categories but broadly speaking a 50 percent reduction in meat intake leads to a 40 percent reduction in the level of pollution. That is without taking any action even on improving agricultural practices. Of course improving agricultural practices can do a whole lot more as well. Actually we were also eating too many calories but we wanted to keep that the same. If you were to bring your total calorific intake down you could go more than 40 percent.

The next thing it did was to say, well hang on a moment, if most of our agricultural activity is going to grow the livestock we've now got a huge amount of agricultural land free to do something else. So we've got a huge land use opportunity. That meant we had to do two sub-scenarios. One where we would grow more and more grain to sell that to contribute to food security in other parts of the world. The other we called a greening scenario that said well we'll turn much of that arable land over to biofuel generation and use the opportunity to grow energy. So the big question here is how much livestock should we eat? Now, for myself I think it's clear, nobody in another part of the world is going to welcome Europeans saying you should eat less meat. That's really not helpful.

In India there's an increasing amount of meat, and in China in dairy products. So I think a different approach is needed, if Europeans think this is a good thing to do is to do it themselves. So as part of that as scientists we've taken up the do it ourselves approach. Already in 2009 we made a declaration. We called it the Barsac Declaration - B-A-R-S-A-C - again the Barsac Declaration is on the web. What we said is that as scientists we will make a commitment to ourselves that when we organise a conference we will make available not just normal and meat, and not just vegetarian, but demitarian.

ANDI HORVATH

In order to deal with nitrogen pollution Mark we obviously need a multi-pronged approach. What role can farmers play in controlling nitrogen fertilisers? Are there things that can be used that plants prefer that are not the nitrogen fertilisers?

MARK SUTTON

I think there are several possible strategies here. One some people are advocating is more use of biological nitrogen fixation. To my own view, if that's in a crop legume where you're growing a seed, then fair enough. The nitrogen fixation is happening slowly in the soil. As far as I'm aware that will be quite tight coupling and you'll get a lower level of pollution. What we have to be concerned about with those legumes is if you're growing it as green manure because your aim there is to get nutrients into the system but then plow that crop into the soil so that it's ready for the next crop. That's the challenging bit there because that's when you'll get the big losses. So actually in that instance, biological nitrogen fixation will be creating pollution just like any other.

The next thing we need to bear in mind is that when you feed those crops to an animal whether it came from biological nitrogen fixation or whether it came from fertiliser, when it comes out of the back of the animal it's going to be poo and urine in the same way. That poo and urine is really a challenge to manage well. The reason is, it's less consistent than a fertiliser product. The farmer can't always be sure of what he's getting. Now fertiliser if it's a well-designed fertiliser, you can get high nitrogen use efficiency from it particularly if you've got some added enhancements to the fertiliser. Some of those might be that if it was urea fertiliser which is used across much of the world, it's got really high ammonia emissions. So let's not put it on the surface, but put it in the soil. Get it away from the surface. Reduce your emissions and save another 30 percent of nitrogen for the crop rather than for the air.

ANDI HORVATH

Could we move towards a marketing campaign together with governments and food industries that actually perhaps label it nitrogen safe, like dolphin safe?

MARK SUTTON

Perhaps on that phrasing though I'd be a bit cautious myself. I think let's tune our words - call it low nitrogen or something - less polluting nitrogen. But I think labelling in relation to nitrogen would be brilliant. One of the challenges as we know with nitrogen is that so few people know about the nitrogen story. Everybody has heard of carbon footprints. You get carbon footprints with your breakfast cereal nowadays. But you mention nitrogen footprints and very few people so far will know about it.

ANDI HORVATH

Sounds like an education program coming on that makes us low nitrogen savvy.

MARK SUTTON

There really are so many opportunities. The big thing for farmers, of course farming is central to this discussion, is the search for methods which will be good for the environment and profitable for the farmer.

ANDI HORVATH

Clearly there's a case for looking after one's nitrogen footprint. Do any countries do a good job of actually regulating nitrogen pollution? Are some countries leading the way with this?

MARK SUTTON

There really are leaders in this field. There are trailers as well. I'm coming from Europe where we've got in the EU, whatever 28 countries, and the leaders I would say have been particularly the Netherlands and Denmark. Of course we've got lots of different nitrogen forms. We've got the nitrates. We've got the nitrous oxide. I think it's fair to say that many countries in Europe are buying into the climate discussion and doing more on that. But my own area is ammonia. On the ammonia the interesting thing is that the requirement for low emission manure spreading - they didn't just go to put [into rows] but they required injection in the Netherlands. They required that in 1993. So all farmers in the Netherlands since 1993 with a few special exceptions with a particular soil type, have been required to inject their manure in the soil, have a lid on the manure tank, etcetera.

Now Denmark came in. All farmers since around 2003 were doing it. Now the rest of us have just been watching from a distance and saying oh we couldn't possibly do that. It'll put the farmer out of business. It's too much tough life for the farmer. They don't want a regulatory approach. They'll say we need a voluntary approach. But of course the question is how much change do you really get with a voluntary approach?

ANDI HORVATH

Mark, what could we do on a global scale with international cooperation?

MARK SUTTON

I'm leading the international nitrogen initiative. We've recently agreed with the United

Nations Environment program for a big new approach on nitrogen. If you think about the Intergovernmental Panel on Climate Change, the IPCC, there's never been anything like that for nitrogen. That's now what we've established, with a core grant of USD$6 million from the UN together with adding up to a total of USD$60 million from all the partners together. This is a major new effort to bring all the science together - air, land, water, agriculture, food, combustion - to synthesise the science. Then of course to identify where we will be in the future if nothing is done. What are the options? Where are the win wins? Bringing that to the United Nations. What we'll be looking for in the next year or so is presenting that to the United Nations Environment Assembly and starting to ask the question.

You've got policies on water and air and climate. They're all fragmented. How can we start to be more joined up? How can - and inform your policy thinking - and getting the connection between nitrogen science and policy, and of course, real change.

ANDI HORVATH

Mark you've created amazing momentum with the nitrogen footprint. We wish you well with that. The management of nitrogen is critical. It's critical to more efficient future food production as well as also planetary and human well-being. Mark, thanks for being our guest on Up Close.

MARK SUTTON

Thank you.

ANDI HORVATH

We've been speaking about the critical management of reactive nitrogen pollution with Mark Sutton, Professor of Environmental Physics from the Centre for Ecology and Hydrology in the UK, and a highly regarded researcher into the effect of ammonia emissions in the atmosphere. You'll find a full transcript and more info on this and all our episodes on the Up Close website.

Up Close is a production of the University of Melbourne, Australia. This episode was recorded on 6 December, 2016. Producer was Eric van Bemmel, audio engineering by Gavin Nebauer. I'm Dr Andi Horvath. Cheers.
