David Glanz: There was a time when Australians kicked up a stink over sewage. It was such an issue in the new suburbs of our big cities, that prime minister, Gough Whitlam established the national sewerage program in the early 1970's. Today we don't give the issue that much thought. Out of sight, mostly out of mind, that the waste management system represents billions in sunk costs, so repairing it and maintaining it is a multi-million dollar business. My guest today has made a huge contribution to cutting those maintenance costs, as well as complaints about noxious odors. I'm David Glanz and I'm talking in Brisbane with Professor Zhiguo Yuan.

David Glanz: Professor Yuan is an ARC laureate fellow and the director of the Advanced Water Management Centre at the University of Queensland. He's a fellow the Australian Academy of Technology and Engineering and in 2015, he won one of the academy's prestigious Clunies Ross awards. Welcome Zhiguo.

Zhiguo Yuan: Thank you, good to meet you David.

David Glanz: Our sewage system in many places is a century or more old. Should we be worried about the state that it's in?

Zhiguo Yuan: Yes we should and most of the infrastructure were built 1500 years ago. The aging and one of the issues we have is corrosion of the old infrastructure, and with that corrosion we could lose our infrastructure quite rapidly, and so we need to worry about this, and we need to do something today to avoid big issues in the future.

David Glanz: And, how far away is that future? We talking a timescale or a few years or decades.

Zhiguo Yuan: I think we're talking about decades, but we have to action quite early on to avoid really big, big issues. If you have to replace a sewer pipes underneath a city that's a lot of effort, a lot of money, and that's quite costly.

David Glanz: Just out of interest, do you happen to know, where here in Brisbane today, how many kilometers of sewage pipes that are under just this city?

Zhiguo Yuan: Under this city, I have to really look at a number, I know in the nation, the country, we have about a 110,000 kilometers of sewer pipes. That would go around the earth if you would link all, or connect all the pipes, it would go around the earth for multiple times.

David Glanz: So its an amazing system but obviously a system where a lot can go wrong, where there can be corrosion, leaks, and other problems.

Zhiguo Yuan: Exactly, and so corrosion, you lose infrastructure, and also that, of course issues, performance of the sewer networks, for example the rain water can come in through inflow infiltration, and then that water, when that flows to the Waste

Water Treatment Plant will add considerable high global load to the treatment plant and some of the treatment plants are not able to cope with that such intensively increased load in wet weather conditions.

David Glanz: All right, so actually too much water is a problem?

Zhiguo Yuan: Too much water for Waste Water Treatment Plant, definitely an issue. Of course when you have to much water you could also have flooding and then you have overflow of waste water into the rivers, and oceans, et cetera, et cetera. So, big issue.

David Glanz: I live in what was known as in the 19th century as Marvelous Smell-bourne because apparently it stank. Melbourne stank. It doesn't stink today. You came up with a solution to sewer smells. Can you tell me about it?

Zhiguo Yuan: So sewer networks are often run anaerobic conditions, and that means that no oxygen or very low level of oxygen, and such conditions. Some microorganisms in sewage will convert sulfate in sewage to hydrogen sulfide.

David Glanz: Is that the bad-egg smell?

Zhiguo Yuan: Yeah, when that water does not cause any smell issue, and does not cause corrosion either, but hydrogen sulfide is volatile, It can leave water, get into the gas phase. When you get to the gas phase, two things will happen. One, if that gas manages to leave the sewer network and go to the atmosphere close to somebody's house, now you have an odor issue, or that hydrogen sulfide can be oxidized by oda, another type of microorganism on the sewer pipes surface exposed to air. So there you have oxygen, you have hydrogen sulfite, and that type of a microorganism can oxidize and sulfite to Sulfuric Acid, and that acid corrodes our concrete pipes.

David Glanz: And what your solution to deal with the microorganisms, or to do with the hydrogen sulfite?

Zhiguo Yuan: And so we have developed quite a number of solutions. So one is we developed a model, I call it a Suez Model which is able to predict what's going to happen when you're try this certain type of wastewater, sewage sewer networks, and depending on retention time, depending on the composition of the sewage, and then we can predict hydrogen sulfite production. Most of the spatial variation and temporal variation, and in that case that tool can be used to guide what utilities to deal with the problem and more, with more focus. So you can focus on the areas with bigger issues in other areas. So this really improved the management of odor and the corrosion, so that's a tool for predicting and optimizing. In terms of technologist to address sewer corrosion and odor utilities are using a lot of chemicals already, including oxygen nitrate, aerosoles, magnesium hydroxide, and at the time when we started working on this issue

there were no clear guidelines in how to use those technologies because of the lack of knowledge to support it.

Zhiguo Yuan: So one big thing we did was to develop, or start a full understanding of the mechanisms of those chemicals, and which supported optimizations of those technologies, and we had a slogan, we called it Putting Science in Sewers, really to understand how sulfite formed and how those technologies work to remove sulfite. They all have different principles, different mechanisms involved, so we had, revealed all those mechanisms to develop application guidelines, and even uncontrolled methods. So that's sort of one category of research outcomes we have produced.

Zhiguo Yuan: On the other hand, we have developed another type of a chemical which works with a different principle. So with the chemicals I just outlined, you need to add the chemical to sewage 24/7 because they work to principle of either removing sulfite after it's formed, because sulfite formed all the time. You need to add that chemical to remove it, so you need it 24/7 dosing to remove sulfite or they try to lock sulfite into liquid phase, so as I said sulfite in liquid is not an issue, only when it goes to air, you have the issue, so if we add chemical to keep in the liquid, then you don't have that corrosion and that odor issue anymore, but once again that method also requires 24/7 dosing.

Zhiguo Yuan: What we have done with about the new method, we target the microorganisms which are responsible for the production of hydrogen sulfite, and typically when the sewage flows through the sewer pipe there is ylem layer we call the Bar Film growing on the inner surface of the pipe. They play a key role in producing hydrogen sulfite So they're sitting there, and sewage is going through, they just convert sulfate in sewage into sulfite. So, what we try to do, we try to kill them.

Zhiguo Yuan: So, we add, we develop a new chemical and we add that chemical to the sewage and the sewage will take that chemicals through the pipe. When, and the sewage is traveling through the pipe the bar film gets in contact with that chemical, so they get killed. They get killed, they can't produce sulfite anymore, not in the next two weeks, three weeks, and then after that we can dose, we can give another dose, so then they get killed again, so what we have done was to convert the 24/7 dosing technologies into intermitten technologies as you can understand if you dose only once every two to three weeks in comparison to dose 24/7, now you'll see the costs. We achieve a better results so this technology is now in a market place and being used for sewer corrosion and odor control.

Zhiguo Yuan: We also develop another type of technology we called Electric Chemical Methods, really when you add chemicals to sewage you need transport liquid chemicals bulky to the side, then you have to put on side of storage tanks with Occupational Health Issues et cetera. So a lot of complication there, and then utilities will have to do a lot of work to make it safe.

Zhiguo Yuan: So what we have developed was a technology to produce the chemical on sight. So, the technology actually will dissolves iron plates, so we have iron plates and they give current, and then iron will dissolve, and then it dissolves in water to form fueric or fueric salt, and in that case you'll have the same effect, but without this large transportation cost, and what we consume is electric of course. We need to consume some electricity, but overall the economic benefit is massive when we use such a technology.

David Glanz: All right, it sounds like millions of people that never heard of you have a lot to thank you for, and a number of companies, I'm sure are very aware of your work also have a lot to thank you for. I was wondering now if we can talk about a different gas, and that's Methane. I understand you have an interest there as well. Methane is a much more powerful global warming gas than carbine dioxide so the release of methane is proportionately a bigger problem than the release of carbon dioxide. I believe you been looking at the release of methane as fugative emissions from waste water plants. Can you tell me a bit about that work?

Zhiguo Yuan: Indeed, I have been working on that for more then 10 years, so my team is actually the 1st to report myth of information in the public scientific literature of myth of information sewers. In the past, according to the IPCC guidelines and IPCC stands for Intergovernmental Panel on Climate Change. The guidelines assume no myth of information in sewers, but what we measured sewer pipes and we found a substantial myth of information in the sewers. The is actually not surprising is as expected because as I said sewer networks can be anaerobic, and anaerobic conditions, they are organisms which can convert organic carbon in sewage to methane, and methane is not very soluble at all when that is formed. That can be omitted to atmosphere, and it's quite annured actually, once it forms it quite it's very difficult to remove it, and this is going to manage to get out of the network to the atmosphere, and causing greenhouse gas emission.

Zhiguo Yuan: Methane is very potent greenhouse gas. 25 times stronger of CO2 so that means methane, once emitted, you can add to the greenhouse gas emissions. So, we published a paper in 2018 what we searched, reporting myth of information sewers, then we did some other work afterwards to model myth of information, and with that we produced our simple qualification guidelines which is being discussed with industry to see if that can be used to replace the methane, current methane accounting guidelines from sewer networks. So it's still ongoing, but our research has already attracted attention by IPCC, so they are considering our report and taking that seriously in the future so the accounting guidelines may be more accurate based on the scientific research outcomes.

David Glanz: Now, just to go off of a bit of a different direction, your background is a scientist. you're actually Aeronautical Engineer, how did you make the transition from Aeronautical Engineer to someone who specializes in sewage and sludge.

Zhiguo Yuan: Yes, that's an interesting question, and I think every time when I receive an interview I get that question. I was indeed trained as an Aeronautical Engineer, actually did 11 years Aeronautical Engineering as a bachelor student and graduate student, and master student, and then PHD, in my PHD was from aeronautical engineering. I actually quite liked that profession and the issue back then was aeronautics is not something you can do by yourself. It requires big team, it requires a lot of money to design and fly controllers and so on. When I finished my PHD, that was 1992. I was in Beijing, China.

Zhiguo Yuan: There was no, not a lot of funding available to help us do the aeronautical research, and I did not want to waste my time. I wanted to do something useful for the main cantt, and so I was a, there was a trigger for me to think to get out of the aeronautical engineering field and then another as I said I wanted to do something very useful for the main cantt and environmental engineering became my choice after my PHD, and then initially, I joined cantt university in Beijing as a Postdoc working on the modeling and the control of wastewater treatment plant.

Zhiguo Yuan: So, the modeling and the control background was really from my education. Wastewater was new to me so there was, that was sort of by stepping stone like modeling control method, and I just applied that to wastewater treatment plant. So, it's not as easy as it sounds, there was a lot of new learnings I had to make and to know what happens in wastewater. Then, after that gradually I realized more and more this is a very inter scientifically interesting world. We look at microorganisms, how they work for us rather than against us, and also I felt value over my research work, So I can see my research outcomes were being taking up and by what utilities, and by the industry and I really see all right, my research has led to positive outcomes to the community, so that really encouraged me to continue in this field.

Zhiguo Yuan: So, I was, I moved into this field in 1994 and I have remained in this field ever since. Now it's 2019, I'm still here.

David Glanz: Oh, well this helps explain why so many young people have no idea what they are going to do in life because you went all the way through to a PHD and then changed directions, so we all have multiple careers in us. One of your interests I understand is Biological Nutrient Removal and Recovery. Now, does that mean what I think it means, are we now talking about harvesting goodness from human wastes?

Zhiguo Yuan: Yes, as a, it's called Resource Recovery from wastewater. Wastewater is actually 19.9 if not more percent water, plus some pollutant. So this stays the para dime for wastewater management is changing, is changing from pollutant removal, removal pollutant from wastewater, and then we discharge the water to the river et cetera. So, now the focus is actually not only to just remove, to remove the pollutants, I also convert pollutants into products that we can use in this Society. [crosstalk 00:17:34]

David Glanz: What, as fertilizers?

Zhiguo Yuan: We have multiple resources in wastewater, the number one, I would have to say, or try to say is water. So you have actual the majority of that is water. So we need to develop technology to recover that water for feedable purpose applications, and then we have energy organic carbine can be converted to bioenergy to methane. So now we talk about methane again.

David Glanz: Uh-huh

Zhiguo Yuan: So we can produce methane from organics in a more controlled way. You know, contained way, so you can control the space. So you can actually harvest that methane as a energy source. So, that's an energy recovery part. Energy recovery from wastewater, and then we, wastewater also has nutrients, phosphorus, nitrogen, potassium. It's all valuable fertilizing compound, to be produced struvite, for example from the nitrogen, and phosphorus, and the magnesium in wastewater to form struvite, and that is a slowly releasing fertilizer, then you can apply to agricultural land, or to the fields to support a grass to grow et cetera. So, it's fertilizer recovery, so there's multiple ways to convert wastewater pollutants into valuable products.

David Glanz: I understand you're involved with something called integrated urban water. Can you tell me a little bit about that?

Zhiguo Yuan: Urban water typically has four subsystems, if you like. So, we have water production, then we have water distribution network, then we have wastewater collection, then we have a wastewater treatment. Those are four subsystems.

Zhiguo Yuan: Integrated urban water managing means we consider one goal and operate in multiple subsystems together to achieve that goal. Some, it was five years ago. We published a paper in science reporting what we observed. Something we do in water treatment had a major impact on sewer corrosion, and so we, in drinking water treatment, we add a coagulant which can be alum, or ferric chloride. When we add alum, alum is used very commonly in the world including Australia. About 2/3 of the utilities use alum, alum in sulfate as a coagulant. When you add that to water treatment you actually form, you remove from natural organic matter suspend your solids, but you leave behind sulfate in your drinking water and that sulfate will get to your house. You consume that water, then that water will, sulfate containing water will flow through your sewer networks, aswenulk sulfate is source of a hyphen sulfide. So, what do we do upstream at a drinking water treatment has contributed to the sulfate level in wastewater, which contributed to sulfite production, in which contribute to, leads to corrosion and odor issue.

Zhiguo Yuan: So we were calling for consideration of different coagulant for example, you can use ferric chloride to replace element sulfate as a coagulant, and then you reduce the sulfate level in wastewater, you reduce sewer corrosion and odor,

but that's not an end of the story. When we add ferric chloride as a coagulant, that ferric will remove solids, and [inaudible 00:21:11] matter, will form a drinking water sludge. [inaudible 00:21:15] Then, our research has shown if you add drinking water sludge to sewer network then that ferric in the drinking water sludge will become available for sulfite removal in sewer networks, and that sulfite ferric just become available again, the second use of that ferric.

Zhiguo Yuan: First it's removed from solid, now it's removing sulfite, again that's not the end. When that feed flows to ferric, flows to your wastewater treatment plant, and that one will become available to remove phosphate. To lock phosphate into your sludge. So, then you remove sulfate and phosphate from your wastewater and typically you need to do a lot of things to remove that phosphate. Now, that ferric we add initially can be used to remove phosphate.

Zhiguo Yuan: Then, in the bowel gas production, methane production. We were talking about methane production, and through converting organics in sludge of wastewater to bioenergy hydrogen sulfite formed there. What we have found is the ferric, we added to the drinking water treatment, when that flows through, always through to your anerug digestor recover bioenergy, that ferric becomes again available to remove hydrogen sulfite in your bowel gas, so then you clean out your bowel gas. You save a lot of costs in the bowel gas clean up. So, this I think is a very good example to show the importance integrated urban water management.

Zhiguo Yuan: So, when you do one thing upstream always to think about potential effects which can be positive, can be negative, and then that will help us to make better decisions, in managing the whole urban water.

David Glanz: It's actually Like you say, it's one system, just with different stations to stop along the way.

Zhiguo Yuan: Exactly, so there's one system, different components of one system. You have connections there, and that connections can give you our positive results or can give us negative results, so we need to take that into consideration.

David Glanz: I mentioned right at the begin that the vast majority of people completely ignore the sewage system. It's taken for granted, but one thing that has caught the public imagination in the last couple of years is talk about fatberg in the major cities of the world. I think London is been one of the ones that has been the most talk. From my understanding is a fatberg is a huge conglomeration of so called flushable wipes and fat presumably from the cooking process, and these block up the pipes. Is that a problem we currently face in Australia is our system old enough and fatty enough to have this problem?

Zhiguo Yuan: I haven't come across big reports about the fatberg in Australia but that's definitely an issue when you're, we're not doing something different from the British, so their cooking, their cooking oils going through the sewer network,

and we also have a so called flushable wipes. They're not really flushable. We should not flush any wipes to the network but there are products in the market encouraging people to flush it through the toilet, and that's not right.

Zhiguo Yuan: When you have the oils, and when you have the wipes, and we have other stuff in the wastewater one day they will form, it will form somewhere, and maybe before the sewer get blocked you probably will not know, and when you know that's going to be bigger effort to actually remove it. From video, video produced by the British of saying massive, massive size of a fatberg. To remove it, and that's not very nice job really, and very stinky. [crosstalk 00:25:20]

David Glanz: I could imagine

Zhiguo Yuan: You have to go underground to remove it.

David Glanz: So the take home message from this for those who don't necessary follow all the signs but the take home for this at least is don't flush wipes.

Zhiguo Yuan: Don't flush wipes, we're actually working with Queensland Urban Utilities. We have done some experiments in our part of the sewer located at the Lakepoint Wastewater Treatment Plant. We got a 1.2 kilometers of sewer pipes for research purpose. We did experiments there, and we showed the white pipes, the wet wipes do not get broken down, and they there, and they will get stuck to something in sewer network, and then once that starts accumulating we will have issues.

David Glanz: Well, I think we will leave it there. Thank you so much for your time today. That's been really fascinating.

Zhiguo Yuan: Thank you, David.