The second in our series of **BlueTech Forum** interviews is with Glen Daigger, Professor of Engineering Practice at the University of Michigan. Recently securing first place in Water & Wastewater International's Top 25 Water Industry leaders, Daigger's previous roles include president of the International Water Association and chief technology officer of CH2M Hill.

Professor Daigger is a member of the O_2 Technology Assessment Group (TAG) and will be hosting a roundtable briefing on nutrient removal and recovery.

In your 35-year career you must have seen several waves of change or disruption caused by innovation in technology development, what are the key ones?

People tend to think that we have been dealing with water for so long that, surely, we have everything figured out. One of the things which keeps me coming back is that there's always something new coming along.

First, on the wastewater side is the emergence of nutrient removal and recovery, especially phosphorus - but also nitrogen - and how wastewater treatment has been transformed from simply removing carbon, BOD (biological oxygen demand) and COD (chemical oxygen demand**)** to also removing nutrients.

On the sludge side we've seen the transition from sludge to biosolids, but we are now looking more broadly at the materials and organic matter that we can extract from the wastewater stream and use productively. Agricultural land application of biosolids is a historical practice, which has been improved so much from both processing and safety perspectives, but now we see the emergence of other technologies to extract energy and other materials.
On the drinking-water side we've seen the emergence of advanced water treatment technologies - the much more widespread application of membrane technologies, advanced oxidation, absorption technologies - and then finally the marriage of water and wastewater in reuse.

We need to better recognise that, where we have water supplies that need advanced water treatment, and when we practice wastewater reclamation – it is the same set of technologies. Our ability to take water of any quality and produce potable water, that's really transformational.

You were talking earlier about the shift from a disposal culture to a resource reclamation culture, when it comes to wastewater processing, what do you think the next stages of development are?

We are at the beginning of a journey. As we continue it we will find that some of the best opportunities are not the obvious ones, we just have not turned over those rocks yet.

For instance, we are hearing about electro-chemical technologies like microbial fuel cells, which are starting to move from the laboratory into pilot projects. Researchers working in those areas say 'You know energy is not the highest value product, maybe it is some of the organics or some other things that are in these streams.'

Being in a commodity business is often not the best business to be in, so that to me is an example of the next round of thinking. Some researchers are thinking of converting organic into bio-methane, which is interesting, but how can we extract organic matter that is foundational in terms of the chemical process industries so we have something which is of higher value? There has got to be more here, let's go find it.

In terms of the whole water cycle, including water use for growing urban populations, what do utilities, cities and governments need to do? What actions do they need to take to leverage solutions?

The first is to help educate people in terms of the broader benefits of water so that we have the financial resources to do what we need to do. People say, 'Well how can we afford good water management?' and then they go pay their water bill and their cellphone bill, and we all know what the difference is. When the economists look at it they look at the broader economic value that's created by an effective water management system versus its cost. What they

find is a ratio of benefit to cost that is something on the order of 5:1. We as the water profession have done a horrible job of just telling the facts about the value of water to society, and then we complain we do not have enough money. But we are not willing to go out and talk to the public in terms of the bargain that we offer.

Next, in terms of water scarcity, the model is the portfolio of water supplies. The priority for implementation is efficiency, then reuse, then rainwater capture and then desalination, as necessary, to close the water balance.

Water is not scarce all the time. You have periods of plentiful water and then periods of drought, so it's about putting together a combination of water supply sources that can respond to these different conditions.

Finally, what do we do when it rains too much? With climate change, the period of time when there is the right amount of water is going to be smaller and smaller. Water management is evolving in terms of green infrastructure and make-room-for-the-river approaches - looking at a portfolio of solutions to decide where you absolutely defend and where, for certain hydrologic events, we cannot build dykes high enough.

Which technologies are likely to cause the biggest disruption in the next 10 years? And what are the barriers to their implementation?

The adoption of technologies is driven by either emerging needs or new science.

The explosion of knowledge in the biological sciences and the emergence of molecular tools that allow us to characterise mixed biological populations comes from the 'new science' side.

The recent example of this is the discovery of Anammox in the late 1980s. It became known to science in 1990 and then the technologies coming out of that discovery were commercialised quite quickly and are now being implemented in the mainstream. Anammox is a great example of how an advance in science provides knowledge of what can be done, and then the engineering hardwires it.

There has been so much advance on the wastewater side with biological processes that now some water utilities are thinking about using biological processes for drinking water treatment. This, of course used to be anathema in water treatment. The perspective was that “the only good micro-organism was a dead micro-organism”.

Now some are thinking about the water that we distribute – does it contain not only an absence of pathogens, but also the presence of desirable organisms. Some are asking ‘Can we manage our systems so we are producing a micro-biome in drinking water that enhances health?’

So what is evolving in terms of nano technology?

Water treatment was one of the first applications of nano technology, in that activated carbon was used by the Ancient Egyptians. The pores in activated carbon are actually of nano size, so in water treatment we have been using nano technology not for decades, or centuries, but for millennia.
What is evolving in terms of nano technology and manufacturing processes is the ability to create physical devices that were not possible before. I think we will see some really interesting water treatment technologies coming out of that - resins and membranes that are designed and constructed from a molecular level upwards, targeted for specific constituents.
If you look at membrane processes right now, we use brute force. The constituent that we are trying to remove can be in the parts per billion of the water that we are treating, yet we push the bulk material through.
Our own bodies are replete with membranes, and those membranes are smart; they target the constituent and that is what gets transported. Some are working on engineering and manufacturing membranes that selectively transport specific constituents out of water and we know this can happen.

Congratulations on coming first in Water & Wastewater International’s top 25 water leaders. How can coming generations of water scientists and engineers make successful leaders in the global water industry?

That was a real surprise. I was not anticipating that in anyway, so it was just a wonderful surprise. First is do not give up on your dreams. One of the great things about water is that, if you have a dream to make a difference, you

absolutely can, and the key is to stick with it. Second, one of the really enriching things about water is that it's a wonderful community of people. None of what I've been able to accomplish has been by myself. So, develop a network of colleagues to multiply your efforts.

You're hosting the roundtable on nutrient removal and recovery at BlueTech Forum. What are the benefits of attending an event like this and what advice would you give delegates?

I have learned so much by interacting with the world of innovators, and entrepreneurs, and people that are looking to take ideas and put them into practice. If you want to make a difference in terms of getting new ideas into routine use, there is a whole body of knowledge that you need, and getting engaged with a group like this is one of the best ways to learn.
There are great opportunities for people to extend their networks, so pick a topic that is of interest to you and sit at a table that has people that you do not know. If the table is one where you know everybody, go to a different table so you extend your network.

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