WEEG NEWSLETTER Nov-Dec 2021

The newsletter is published monthly by the University of Southampton's Water and Environmental Engineering Group WEEG, and reports things of interest in this field worldwide, as well as ongoing undergraduate student and research work in WEEG itself.

We believe that water and energy are the most important topics worldwide for the next decades. Our work covers river and coastal engineering, water and wastewater and energy related to water.

Editorial: We like to think that scientific development is linear, or perhaps like a tree – the mainstream moves along and progresses, other developments branch off and eventually disappear because they are superseded. However, it appears that this comparison is not quite right – changing boundary conditions for example may revitalise a seemingly dead branch. Or what seems to be scientific consensus suddenly appears doubtful. In this edition, we will look at two such examples.

Hydraulic Engineering International: *Can we learn from history? Part 1*

Waterwheels: Yes, waterwheels. They are mostly thought to be inefficient, outdated hydropower converters which really belong to the romantic age. …

The reality is very different. By the late 19th Century, waterwheels were highly developed hydraulic machines. Overshot wheels like the one shown in Fig 1 had efficiencies of up to 85% - almost as high as the most modern turbines. Here, it should be remembered that most waterwheels employ the potential energy of the water i.e. the head difference between upstream and downstream of a weir, rather than the kinetic power.

Fig. 1: Overshot waterwheel

Waterwheels were also developed for low and ultra-low head differences of 0.3 to 2 m. Again, the efficiencies reached an impressive 83%. A typical low-head wheel is shown in Fig. 2. This is a Zuppinger wheel, of which tens of thousands were built in Germany, Switzerland and Austria in the late 19th and early 20th Centuries. Virtually all of these disappeared in the second half of the 20th Century, but today – as Fig, 2 shows – they are being introduced again. Why is this so?

Fig. 2: Zuppinger low-head waterwheel

Well, the answer contains several aspects. Firstly, there is an increasing demand for power from renewable sources, and most of the old waterwheel sites are still available. Second, although turbines are highly developed, they are quite expensive for low power ratings and especially for low head differences. Third, waterwheels are the most fish-friendly hydropower technology, so their impact on fish populations is low - especially when compared with turbines. This means that they can be employed even under today's strict environmental legislation.

Beaver dams: Now, this is a rather different topic but still related to our overall heading. Beavers are of course aquatic mammals which build dams to protect their boroughs (where they live), and to store food. The dams can reach heights of 5 m, and lengths of several hundred metres in some cases. Typically, though, the dams are 1 to 1.5 m high and 10 to 20 m long. Beavers build their dams in streams and small rivers with average flow volumes up to say 8 m^3/s, and widths of up to 20 m. Beavers lived everywhere in Europe and Eurasia as well as in North America. In Europe of course, they were nearly all killed and only now do we see a rise in the beaver population.

So far, so good. But how is that related to our topic of 'learning from history'? Well, that's an interesting point. Research in hydraulic engineering and river re-naturalisation has been going on for several decades. The aim is to define what a natural river (or 'water body') is, and develop tools and strategies to make our rivers more natural and thereby improve their ecological value. One fundamental concept which arose from this work is the requirement for continuity, i.e. sediment should be able to move unhindered through the streams and rivers, and the aquatic life forms and in particular migrating fish should also be free to move. So, ideally all weirs and barriers need to be removed. Sounds good, and these requirements became part of the European Water Framework Directive which sets the conditions for the re-development and re-naturalisation of rivers.

Fig. 3: A typical beaver dam

But, we know from biology that beavers have been around for 15 million years, and that the ecosystems they created led to an adaptation of species to the conditions. Beaver dams probably existed in most small streams and rivers, at distances between several dozen to several hundreds of metres. The reports of travellers in North America, where beavers were still at large in the 19th Century, confirm this. Beaver dams have several environmental advantages: they store water, increase humidity and thereby reduce the danger of forest fires; they create new enriched ecosystems; they prevent sediment transport and thereby led to the formation of our valleys with streams and small rivers; and...

But stop: doesn't the WFD require free movement of sediment and fish to create more natural rivers, yet here we have the opposite?

Indeed*.* Current scientific consensus and its implementation in Directives somehow forgot about the beavers and their dams. It appears that, in order to create a more 'natural' river, small dams should be built rather than removed. In the case where there are no beavers, some sort of artificial beaver dam would need to be developed. However, very little work is going on in this field. Only in the US have some few researchers started to build 'Artificial Beaver Dams (ABDs)' or 'Beaver Dam Analogues (BDAs)'. So we are in the strange situation that previous developments (the beaver dams) which actually formed small river valleys and their ecosystems are forgotten, and the scientific consensus has developed in a direction separate from the historical facts.

Topic: *Biofilms in networking...*

At the start of December members of WEEG attended a networking event on 'Microbial Impacts - Harnessing Regional and interdisciplinary strengths', hosted by the National Biofilms Innovation Centre (NBIC). The aim was to promote collaborations across life and physical sciences, medicine and engineering in order to develop technologies based on microbes and microbial communities. The NBIC event was an all-day meeting with a packed schedule of rapid-fire pitches on concepts and capabilities. As well as NBIC, the University also hosts the Environmental Biotechnology Network which links researchers and practitioners using microbial communities for environmental protection, bioremediation and resource recovery: both are free to join, see www.biofilms.ac.uk and www.ebnet.ac.uk

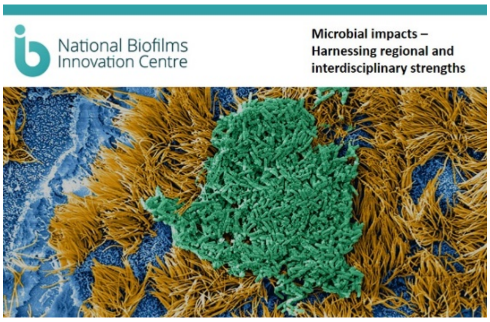

Fig. 4: NBIC networking event

...and in research

Meanwhile biofilms are a key topic in our labs, with PhD students and postdocs working on systems from wastewater treatment and nutrient recovery by self-forming granules (good) to Forward Osmosis (bad - biofouling?) See e.g. our Facebook pages for more info.

Contact: Dr Yonqiang Liu, Y.Liu@soton.ac.uk

Jobs in water engineering:

This section gives you ideas of the type of work you can do when working in industry.

Civil and Environmental Engineering at Southampton University:

WEEG: our modules offer the chance to deepen your knowledge in water-related areas, and give better preparation for environmental engineering projects.

Contact: Em Prof Sonia Heaven, s.heaven@soton.ac.uk, Bldg 178, Room 5021

Further information:

We have two Facebook pages, which provide a logbook of our laboratory activities:

www.facebook.com/Hydraulicslaboratory/

www.facebook.com/environmental.lab.university.of.southampton/

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