WEEG NEWSLETTER March 2023

The newsletter is published 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 all know that electricity and water do not mix. We need to keep them separate for safety reasons, and – in case of underwater cables – to minimise energy losses. There are, however, some instances in the natural world where both co-exist... let's have a look.

Hydraulic Engineering International: *Water and electricity*

Water: Water is a good conductor of electricity, because of the ion content that occurs in all natural water (even rainwater), and in particular in sea water. This means that we do not really observe many phenomena in water which are caused by electricity, or electromagnetic waves for that matter.

Lightning: a flash of lightning is a spectacular event, which can release from 1 to 5 GJ of energy with a millisecond duration. Lightning strikes occur mostly on land, but sometimes a flash of lightning may hit a water body, Fig. 1.

Fig. 1: Lightning strikes over the Atlantic Ocean off the coast of Florida (Jeffrey Greenberg / Education Images)

More than 90% of lightning bolts strike over the continents: but lightning that strikes the ocean can be far more intense. For example, rare 'superbolts' with flashes 100 or 1,000 times brighter and more powerful than a regular bolt, are far more likely to hit the ocean.

Before the lightning strikes, an ionised layer of air forms above the water surface, caused by the build-up of charge before the lightning bolt. This means that when the discharge occurs, the charge spreads over the surface of the water rather than into the water itself. In consequence, only fish near the strike are at risk. On the other hand, swimmers or even people just standing in the water on a beach can be in real danger.

Electric fish: These are very intereting species of fish, which can generate electric fields and are usually also electro-receptive, i.e. they can sense electric fields and changes in them.

There are two main types of electric fish: the 'weakly electric' ones which use electric fields e.g. to locate prey or to communicate; and the (even more interesting) 'strongly electric' fish which are able to electrocute their prey. Electric fish have from one to four internal organs where an electric charge is produced using electrolytes, a bit like an electrolytic capacitor. The charge is produced by separating ions.

The weakly electric fish emit signals either as pulses or waves, and with their receptors they can sense changes in the surrounding field and thereby e.g. locate prey. The frequencies emitted by these fish are in the 200 to 1500 Hz or impulses per second range. Fig. 2 shows the type of electric field that is generated. In the literature, these frequencies are termed 'high', but in the world of electromagnetic waves overall these frequencies are of course extremely low. More about that later.

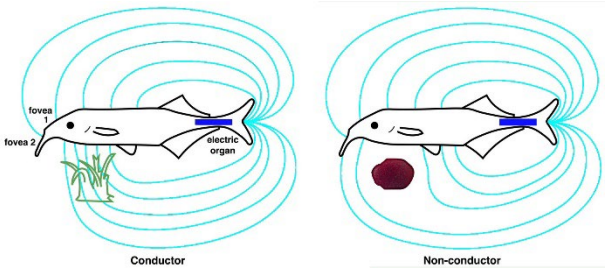

Fig. 2: Electric field (Chiswick Chap/Wikimedia CC)

The strongly electric fish can build up quite high charges of up to 850 Joules, with the freshwater species using high voltage / low current charges, and the sea water species low voltage / high current. These charges are used to stun prey, and in self defence. The well-named *Electrophorus electricus* (sounds like a cartoon animal?) can generate up to 600 V, the *Electrophorus voltai* up to 800 V at 1 Amp! This is enough to dissuade alligators from eating them, as some videos show.

Here I would also like to thank those heroic researchers who undertook self-trials to assess the effect of these electrical discharges on human beings….

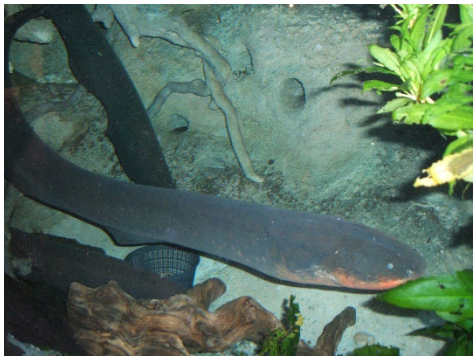

Fig. 2: The electric eel (S Johnson/Wikimedia)

Underwater communication: it is generally assumed that electromagnetic or radio waves cannot penetrate water. This is however not quite true. Radio waves in the frequency range between 300 and 3000 Hz can actually propagate into sea water to a depth of around 100 m. Such waves are used e.g. for communication with submarines. In fresh water, which has a conductivity around 400 times lower than that of sea water, the propagation loss reduces dramatically for this frequency range, so the necessary signal strength reduces as well. This may well be the reason for the 'low' frequencies the weakly electric fish employ. Here it would be interesting to compare the frequency range for fresh and seawater species...

New hydraulic engineering facilities: *small tilting flume and wave tank*

Our Water and Environmental Engineering Group WEEG will be moving into a new building in Chilworth, in the very near future. Part of this move is the construction of a new large wave-current interaction flume (as reported in the last Edition), and two new small facilities.

Tilting flume: a 12m long, 0.40 m wide and 0.4 m deep tilting flume will be installed for small scale experiments, student projects and teaching. The flume will have a maximum flow volume of 25 l/s.

Wave tank: the new wave tank is also 12 m long, with a width of 0.50 m and a depth of 1.0 m. The wave tank has an absorbing wave paddle, which compensates the wave reflected from the models in the tank. Wave periods range from 0.5 to 2.5 seconds, and wave heights of up to 200 mm will be possible.

Both facilities are financed by the University of Southampton. For more information please contact Dr Gerald Muller, g.muller@soton.ac.uk

EBNet webinars: *BES and LCA*

See https://ebnet.ac.uk/events for details of events on Bioelectrochemical Systems and on Life Cycle Assessment for Environmental Biotechnology applications, on **16 March**.

3rd year project: *Overshot waterwheel for Bosham Mill*

Bosham Mill is an old mill which originally had two overshot waterwheels with a head difference of around 3m. The head difference is variable since the downstream side is tidal. We were asked by Bosham Sailing Club, which has its headquarters in the mill building, to design a replacement wheel so that the hydropower could be used again. The task was undertaken by a Civil Engineering 3rd year student, Tom McFarlane.

Fig. 3: Bosham Mill

The wheel design gave a power output of 5 kW. This is reduced during high tide, when the wheel dips into the water at the downstream side. Luckily, we found a PhD thesis from 1935 where this exact problem was analysed, so that we could quantify this reduction.

Jobs in water engineering:

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

Advert: A senior post in a wonderful location with some fascinating professional challenges:

Senior/Principal Water Resources Engineer

https://www.icerecruit.com/job/213452/senior-or-principal-water-resources-engineer

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: Dr 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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