Figure 1. Broad-shelled turtles are one of Australia's largest freshwater turtles and use snags to bask out of the water. Credit - UNE

Restarting dry rivers:
Risks to water quality

How best do we use water for the environment to restart disconnected rivers? Long dry spells means river channels dry out and can accumulate layers of leaf litter and the few remaining pools that provide refuge for native biota have ever deteriorating water quality.

Delivering flows to maintain water quality in remnant pools is vital to maintain habitat quality and provide refuge for iconic species such as Murray Cod and Golden Perch. However, there are a number of inherent risks with delivering water through a dry system – one is related to the development of blackwater or anoxic water in the pools, deficient in oxygen, which can kill fish and other animals in the river (Figure 1). Dry river beds can accumulate leaf litter and other organic matter that can be washed into the pools when flows recommence. This can trigger a bacterial feast that depletes the water of oxygen and transports poor quality water downstream into other pools along the channel.

There are several factors that can contribute to the development of blackwater and hypoxic (low dissolved oxygen) events in river channels and pools following the recommencement of flows. These relate to the condition of the receiving pools, whether they are thermally stratified (much hotter at the top than bottom), and the amount of organic matter and leaf litter that has built up in the dry river channels upstream.

Thermal Stratification

When flow stops and pools stagnate, temperature stratification can develop. Thermal stratification occurs when the sun heats surface waters to create distinct layers with differing temperatures. Due to the different density of warmer and colder water, layers of cold water often develop at the bottom of pools when there is little mixing by wind or river flow. This is a natural process, but has implications for water and habitat quality if the warm and cold layers don't mix for extended periods. Just like fish and people, many bacteria gain energy from using oxygen, so the cold water at the bottom of the pool can run low on dissolved oxygen as the bacteria feast on the organic material (bacterial decomposition; Figure 2). As oxygen levels decline, other processes kick in and

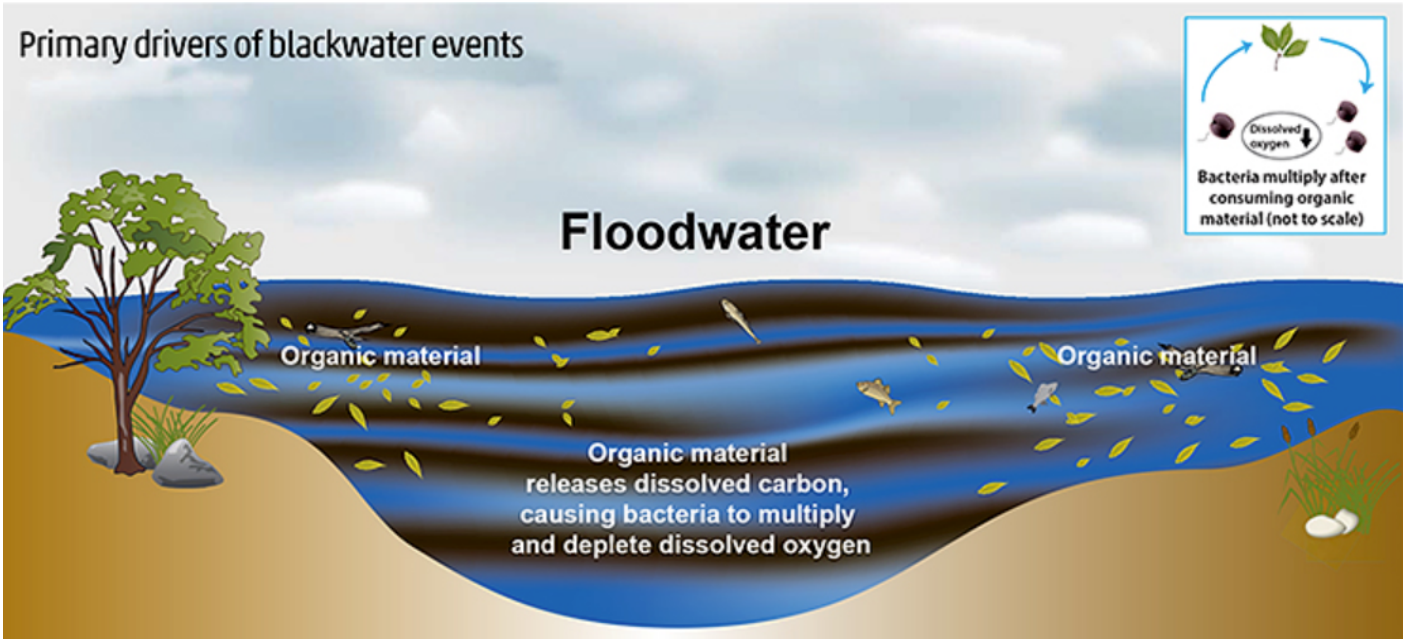

Figure 2. As floodwaters inundate large accumulations of leaf litter (organic matter) in channels and in the bottom of pools, a bacterial feast is triggered that depletes the water of oxygen. Floodwaters can then distribute this water of lower quality throughout the system. Read more on this phenomenon here. Credit - CEWO

Figure 3. Upper Gwydir River near Bundurra showing leaf litter in the water and on the banks soon after flows reconnected in January 2020. Credit - UNE

nutrients such as phosphorus and nitrogen are released from the sediment into the water where they can fuel the growth of algae.

Algal blooms

Rivers can replenish their oxygen from wind and flow, but this is a relatively slow process, especially in stagnant river pools. In the heat of summer, warmer water in the upper layers of disconnected pools provides ideal conditions for algae to grow. The reconnection of surface flow can break the stratification causing the colder nutrient rich water at the bottom of the pool to mix with the overlying warmer water, often resulting in a rapid bloom in algae (Figure 4). This in itself isn't always a problem (unless the algae is toxic). As algal blooms establish they can reach up to 100,000 cells/mL and often form dense layers in surface waters where they capture the light and heat needed for growth. A sudden drop in ambient temperatures can cause a collapse of this floating algal mass, sending it to the bottom to further fuel the microbial feast, rapidly stripping the water of dissolved oxygen. Similarly, if the cold, low dissolved oxygen bottom layer dominates the pool, then mixing without the dilution from incoming flows can also cause the whole pool to become deficient in oxygen, putting stress of fish and other animals if dissolved oxygen levels fall below 2 mg/L (around 20% saturation).

Restarting dry rivers and the risks of low oxygen and blackwater

When flows commence large accumulations of leaf litter in channels and in the bottom of pools mean oxygen concentrations can suddenly drop as bacteria use the incoming organic matter (Figure 3). This bottom layer can increase in depth over time and is usually high in nutrients as a result of the breakdown of organic matter. Although challenging, this situation isn't generally a problem for fish and other animals in stratified pools because the quality of the upper layers of the pool remains sufficient for them to survive. This situation was found in many of the deeper weir pools (Mungindi, Collarenebri, Brewarrina) along the Barwon River before the

Figure 4. Walgett weir on the Barwon River during an algal bloom. In the heat of summer, warmer water in the upper layers of disconnected pools provides ideal conditions for algae to grow. The reconnection of surface flow can break the stratification causing the colder nutrient rich water at the bottom of the pool to mix with the overlying warmer water, often resulting in a rapid bloom in algae. Credit - UNE

delivery of the Northern Fish Flow back in April-July 2019.

Bacterial decomposition of this organic material occurs quickly and can significantly lower dissolved oxygen concentrations as flows travel along the river and reconnect refuge pools. If the volume of leaf litter is low compared to the size of the flow, then this isn't a problem. However, if large amounts of leaf litter have accumulated, then low oxygen 'hypoxic' water quality can occur. Mixing this incoming water with the potentially poor water quality in disconnected pools can magnify the response. These processes were likely a contributor to the fish kills in the Mehi River at Moree in 2020, and are similar to processes throughout the river channels and floodplains of the Murray Darling Basin.

What we do

Understanding these interactions has become a focus for environmental water delivery in the northern Murray-Darling Basin given the drought conditions experienced over the past few years.

Monitoring under the LTIM and MER programs, along with other state-based programs aim to improve our knowledge of how the condition of refuge pools changes as they dry, and how rivers of the northern Murray-Darling Basin respond to reconnection following long periods of drying. These programs continue to improve our knowledge of how best to manage and deliver water for the environment (timing, duration, volume, magnitude) to replenish pools during dry times.

Figure 5. Broad-shelled turtles eat crustaceans and carrion, helping to maintain a healthy food web in the Barwon River. Credit - UNE

Click here for more on Flow-MER

Managing water for the environment is a collective and collaborative effort, working in partnership with communities, private landholders, scientists and government agencies - these contributions are gratefully acknowledged.

We acknowledge the Traditional Owners of the land on which we live, work and play. We also pay our respects to Elders past, present and emerging.

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