THE IMPACT OF 1080 ON AQUATIC ECOLOGY

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Alastair Suren is a freshwater ecologist working for the Bay of Plenty Regional Council in Whakatāne. Prior to this, he worked at NIWA Christchurch where he was involved with a wide range of research and commercial work looking at flow-biota interactions, the impacts of urbanisation on streams, and wetland ecology. While at NIWA he also led research examining the effects of 1080 on freshwater ecosystems, and on the fate of 1080 in catchments.

TRANSCRIPT

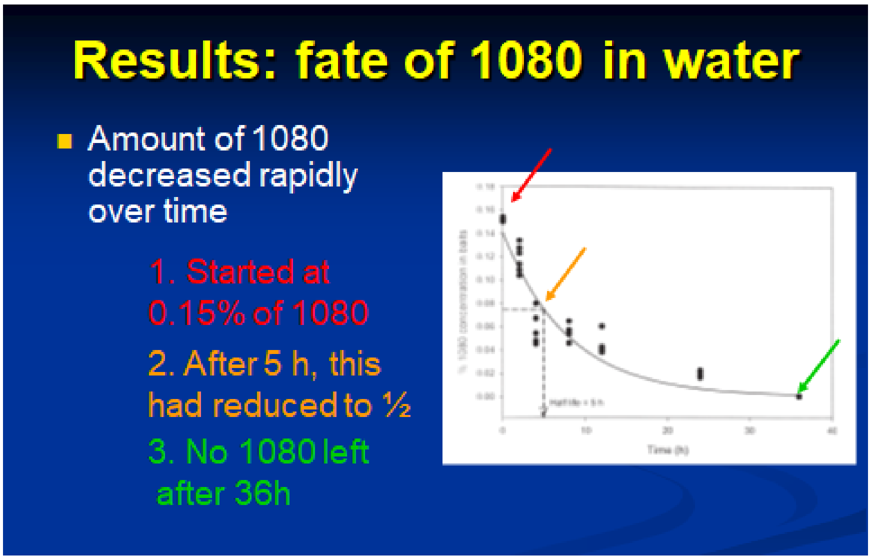
Kia ora everyone. I was at NIWA in Christchurch before coming north to the Bay of Plenty Regional Council. I became involved with the following studies as a result of what could best be described as a low-key assessment of a 1080 drop on the West Coast with the West Coast Regional Council. Following this low key assessment, I approached the Animal Health Board to conduct some more robust studies to answer the very important question, 'What effect does 1080 have on aquatic ecosystems?' I eventually did five studies while at NIWA, which were all funded by the Animal Health Board, and it is these studies that I will now discuss.

These studies essentially build on previous work, and answered questions such as:

- What happens when 1080 baits land in streams?
- What effect does 1080 have on stream life (fish and stream insects)?
- What effect does 1080 have on kōura?
- What is the fate of 1080 under rainfall – do streams become contaminated?
- Does 1080 enter soil and groundwater?

Within New Zealand, 1080 is the only pesticide allowed to be applied aerially. However helicopters simply cannot avoid flying over streams during these aerial operations. Although some regional councils implement buffers around their bigger rivers, most of the smaller ones have no such buffers, and it is these small streams that baits can, and do, land in. For example, the slide here shows a small stream in the Lewis Pass area with a 1080 bait in it.

The question is, then what happens to these baits? I wanted to see how quickly 1080 leaches from baits once they have landed in a stream. At NIWA, we do a lot of work with flow and ecology. We had a flow tank which could circulate water at 20 cm per second around the tank. This velocity is typical of an average mountain stream. I placed baits in the flow tank and measured the 1080 levels over time at 1 hour, 2 hours, 4 hours, 8 hours and 12 hours to find out how much 1080 was in the baits. From this I could easily calculate the time it takes for 1080 to leach out of the baits.



The graph shows that overall the amount of 1080 in the baits decreased very rapidly over time. You can see time is shown on the X axis - 10 hours, 20 hours, 30 hours and on the Y-axis is the 1080 concentration. We express the amount of 1080 in a bait as percentage weight of 10u0 per weight of bait. We start off at 0.15% weight of 1080 per weight of bait. As you can see after 5 hours that decreased to half the concentration, and after 30 hours there was no 1080 left. You can see the rapid exponential decay and then it tapers out over time.

Once it leaves the baits, with all this water flowing past, the 1080 chemical is diluted to extremely small quantities, often below detection, and is simply washed away. It is probably the only time I would be happy to say, ‘dilution is the solution to pollution’. We also know that because 1080 is a natural product, it is broken down by bacteria, although this rate of decomposition is slower in colder waters such as in the South Island.

Most Regional Councils and the Health Department require operators to monitor water quality after a drop for signs of 1080 contamination. The Ministry of Health has set guidelines to ensure that no 1080 contamination of drinking water supplies exceeds 2 parts per billion for safe drinking.

Landcare Research lab tests have shown no significant or prolonged contamination of surface waters with 1080 after drops, and they analysed over 2,400 samples. This is an impressive result, especially when considering that we can detect 1080 to a degree of 0.1 parts per billion.

To give you an idea as to how sensitive the test is to detect 1080, let me explain what 1 part per billion is. Imagine 1 gram of something put into a single 10-tonne dump truck. Then imagine that you have another 99 more 10-tonne dump trucks driving past. Thus 1 gram amongst those 100 10-tonne trucks is 1 part per billion. But we can detect 1080 down to 0.1 parts per billion: that is 1/10th this amount. So, if we cannot detect 1080 in water at concentrations of 0.1 parts per billion, it raises the philosophical question that if we cannot detect it, is it still there? Obviously I do not have the answer to that question because everyone’s philosophies are different, but the point I am trying to make is that the tests for 1080 are incredibly sensitive, and yet the vast majority of results have returned an absence of detectable 1080 from water sampling.

Once I had shown that 1080 leaches from baits relatively quickly, and that it is often diluted to below our ability to detect it, I then had to answer my second question, 'What was the effect of 1080 on stream life?' I examined the effect of 1080 on fish and invertebrates in five streams near Greymouth that flowed into the Grey River near Red Jack's Creek. These streams had very small discharge as I wanted to minimise dilution. They were generally no more than 1-2 metres wide, and mostly quite shallow. Their average discharge was less than 100 litres per second, which represents very small streams where dilution would be minimal.

I wanted to simulate a worst case scenario of a lot of baits landing in a small area. As part of earlier work characterising the degree to which streams become contaminated with 1080 baits, I walked up a number of streams in operational zones where 1080 was being applied aerially. The most number of baits I counted up a 100m section of stream was 8, so I put in ten times that in one location in the small streams I used for this experiment. This was to ensure that I was creating a big loading to see if that worst case scenario could affect fish and invertebrates.

I monitored fish and invertebrates survival above and below the baits. The fish species targeted were longfin tuna, upland bullies and koaro. I put these fish in separate cages, at 2 sites above the baits, and 2 sites at increasing distances below the baits. I then looked at survival 1 and 4 days after the introduction of the 1080 baits. I did not run the experiment for more than 4 days because there would be no 1080 left in either the bait or the water by then. I was thus only interested in short term acute effects. I also collected water samples to measure how much 1080 was in each stream after I added the baits, and to confirm that all the 1080 had disappeared by day 4.

I only assessed the effect of 1080 leaching from baits, and not of animals consuming baits. Some people might think that is a big weakness to the study, but I did this because all our native fish are predators, and would not eat cereal bait. Fish are visual feeders and feed on things floating in the water column or at the surface of the water, or moving along the streambed. They will swim by a bait and simply ignore it. This behaviour is why Landcare Research had to force feed tuna 1080 bait in a study they did to assess whether tuna were affected by 1080.

Most invertebrates would also not consume baits. They are so small that they could not consume a whole pallet. Although an individual animal might crawl onto a bait, only those invertebrates such as caddisflies or stoneflies that have mouthparts to allow them to actively 'shred' and bite into decaying leaf litter would ingest parts of a 1080 bait. Furthermore, any consumption would only be by those animals that directly encounter a bait, and I was looking at the effect of 1080 leaching from baits on the entire community that would be potentially exposed to the 1080.

Did 1080 affect the invertebrate community below where I introduced it? From my water sampling, 1080 concentrations were found at only very low concentrations, about 0.2 parts per billion, which lasted for only a short period of time, After 24 hours, no more 1080 was detected. This result again emphasised that dilution is really important in reducing the effects of 1080.

The invertebrate community was dominated by caddisflies, midges, mayflies and stoneflies. We found absolutely no effects to biotic metrics that we calculated that described aspects of the invertebrate community. Although we found a slight significant difference with one metric above and below the 1080, I regarded this small difference as not ecologically significant. It must be emphasised that there is a large difference between statistical significance and ecological difference. For example, if we record the temperature on one day at 23 degrees, and on another day at 21 degrees, that is statistically different. However, would we really feel that difference, and would it affect us?

There is a big difference between statistical differences and ecological differences. The subtle statistical difference in only one of the many metrics that was used to describe the invertebrate community was not regarded as ecologically meaningful. All the other metrics displayed no consistent differences above and below the 1080 baits, as would be expected if the 1080 leaching from the baits was killing invertebrates. Because of this, I could confidently say that we did not observe any adverse effect of 1080 on the invertebrate community – even at the very high doses that we exposed these animals to.

We also recorded no fish mortality, suggesting that fish are tolerant to dissolved 1080. The USEPA have done some work on toxicity of 1080 to fish, and regard it as 'practically non-toxic' to the fish they used, one of which was fingerling rainbow trout. This lack of toxicity simply reflects the different metabolism animals have. Thus, dogs are very sensitive to 1080, whereas fish and other cold blooded animals are very, very tolerant, simply because their physiology is different.

From these results, I concluded that 1080 leaching from submerged baits had no detectable biological effects on fish or invertebrates. This reflected mainly the huge effect of dilution and also the fact that these animals are naturally tolerant to 1080.

What about kōura? Kōura are big enough to consume 1080 baits, and if they do, what are the implications? Will they die? So I did a study to look at that.

This study was run in a stream simulator at NIWA Christchurch, with water flowing through a pool and riffle area. I added kōura, invertebrates and leaf litter for food and left them alone in the simulator for about a week to acclimatise. I placed 10 kōura in the riffles and 10 kōura in the pool, each in separate cages. After 1 week, I placed a single pellet in each cage at dusk, because kōura come out to feed at night. Again, I wanted to simulate a worst case scenario of a pellet landing in an area where a koura would encounter it in a very short time – to minimise the time that 1080 could leach from the bait.

I also did not give any bait to another 8 kōura placed in the flow tank. These animals acted as control to see if they could absorb 1080 through their gills or their exco-skeleton. I then monitored the behaviour of all koura over time and measured their tissue for signs of 1080 after 1, 2, 4 and 8 days. After those times I randomly selected replicate kōura, euthanized them, analysed the viscera (or guts), the stomach and the muscles for signs of 1080. I always collected water samples as well.

What did I find? The highest 1080 concentration was only 1.1 part per billion, despite putting 20 baits in the simulator with a discharge of only 5 litres a second. Again this low concentration highlights the importance of dilution. I also found that kōura consumed the baits. Indeed, one individual ate almost half the bait, which I thought was quite interesting, but no mortality was observed, and their behaviour seemed unchanged. I did not interview them because I can't, but they looked and behaved perfectly okay!

What is important to note is that over 1, 2, 4 and 8 days the 1080 concentration in the koura viscera and muscles decreased, suggesting that kōura metabolised and excreted the ingested 1080. This is a well-documented physiological response of many animals which consume sub-lethal doses of 1080: they metabolise and excrete it. I was happy with these results as they confirmed the results of other studies of 1080 on other animals, in terms of the ability of animals to consume sub-lethal doses of 1080 and metabolise it.

I also found no 1080 in the control animals. That strongly suggests that 1080 contamination of koura flesh can only arise by direct consumption, and not by animals sitting in water where baits may have landed. This result also suggests that 1080 cannot enter via the gills or the exco-skeleton.

The conclusion from the koura study showed that they are unlikely to become contaminated due to their small home range, the presence of other food which they might prefer to eat and the rapid leaching rate of 1080.

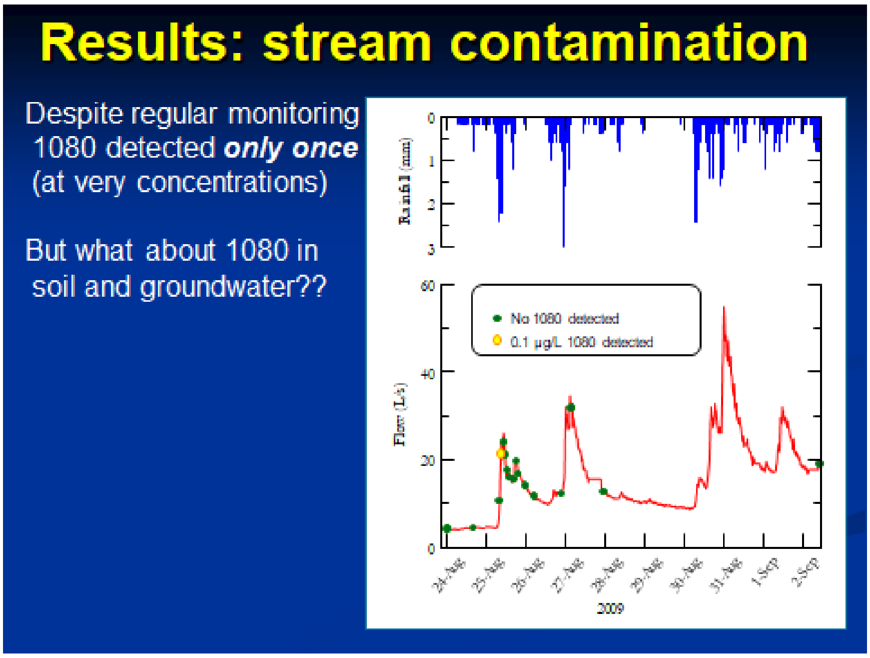
Some people are also concerned about what happens after a drop of 1080 and it rains. Does the 1080 leach out and contaminate streams? This lead me to my fourth study, which was done in a small sub-catchment that was excluded from a larger aerial drop done by the Animal Health Board a few weeks prior. It was not until heavy rain was forecast that 1080 was aerially applied to this small sub-catchment.

I did this work with a hydrologist at NIWA Christchurch, and we were examining the chances of 1080 contaminating surface water if 1080 was applied immediately before rain. Because the majority of the area had been subject to an aerial 1080 application a few weeks prior to our experiment, we assumed that few (if any) baits in the sub-catchment would be consumed. 1080 was aerially dropped 1 day prior to forecast rain, and we monitored a small stream, every hour for 12 hours after the start of the rain to see if we could detect 1080 in the stream. We continued the monitoring at increasing lengths of time for up to 9 days after the rainfall event. We had lots of coffee during this time as well!

These photos show the very steep country, well forested with black and mountain beech. You can also see the size of the very small stream, which was only about 5 litres a second

at base flow. Again this was done as we wanted to minimise dilution, and give us the best chance of picking up a 1080 signal.

What did we find? This graph shows the date the 1080 was dropped, at that second dot. We also collected a water sample prior to the drop to show an absence of 1080 prior to the drop. The rainfall is shown on the Y axis, and when it rained the stream flow increased. The one yellow dot on the graph is the only time where 1080 was detected, at 0.1 parts per billion. Every other sample we collected was below this detection level. I am not saying that there was no 1080 in the water, but I am saying that we simply could not detect it, even at 0.1 parts per billion. That is the limit of detection.



So, despite this very intensive monitoring during a rainfall event we detected 1080 in stream water only once, and at a very low concentration.

Finally, what about soil and groundwater, do they become contaminated? This question led us to the last study that looked at the fate of 1080 when it leaches from a bait in the catchment. Where does it go? Does it move into the soil and groundwater and eventually end up in the stream? To help answer this question we had 4 goals:

- to quantify the 1080 transport in overland flow
- to understand 1080 movement into the soil
- to examine whether 1080 enters groundwater
- to monitor 1080 concentrations in stream water

We wanted to quantify the importance of all these different pathways of 1080 and look at how long 1080 stays in the environment. We designed a somewhat ridiculous study whereby we placed 2 kgs of 1080 bait into a small area ($0.4m^2$) of hill slope. This huge amount was applied to such a small area simply to allow us to detect the 1080, and thus determine where it goes. Remember, we were interested in assessing the movement of 1080 from baits, into the soil water, the groundwater, and the stream water; not how realistic that movement was. For some context, aerial applications normally apply 1080 at about 2.5 kilograms per hectare, so the application rate we used was 50,000 times more than operators are allowed to apply. We then did lots of monitoring of water flowing across the soil or entering the soil, groundwater or stream. We applied the baits just prior to forecasted heavy rainfall, and collected samples throughout the rainfall period.

We ringfenced an experimental area by driving metal sheets into a slope up a steep sided valley about 25-27 metres away from a small stream which was about 3-4 metres wide. We caught any runoff from this area by collecting all the surface runoff at the base of the experimental area. We also deployed lysimeters, these big suction tubes, into the soil to sample soil water. We used a vacuum to pull the water from the soil into the tubes, and we took samples. We also installed a groundwater bore at the base of the experimental area near where we collected the stream water samples. The photos show the locations where we monitored the runoff, soil water, groundwater, and stream water. You can see that the forest floor was a mixture of fir, grasses and a few ferns. It was about 50% vegetated, 50% bare. The picture also shows the lysimeter as we take a water sample out.

Again we were lucky with the rain, and drank lots of coffee. A total of 75 mls of rain fell over a few days, equivalent to a 1 in 5 year rainfall event. Stream discharge increased and groundwater levels rose, because of the rain falling into the catchment and soaking into the soil water to enter the groundwater. We collected 95 samples during our coffee drinking experiment, but we only analysed 56 because the analysis of 1080 is very expensive. We deliberately chose those 56 samples to have the highest probability of containing 1080. These samples were all collected in the first 8 - 12 hours. Our thinking was that if we found 1080 in these samples, then we would return and process the other samples to see how long the contamination lasted for.

We found little, if any, overland flow, despite the hill slope being quite steep. More than 99% of the rainfall infiltrated into the soil water, which we were quite surprised at. We found no 1080 in the groundwater, or in the overland flow and stream samples, despite using that huge amount of 1080. The only 1080 we did find was in 7 soil water samples, of which 4 were right at our limit of detection of 0.1 part per billion.

The highest concentration we detected was 1.4 part per billion, and this was found in a shallow soil water sample 10 hours after the rainfall started. To put this concentration into context, the Ministry of Health safe limit for drinking water is 2 parts of 1080 per billion, so we could have drunk that soil water and have been fine. After 4 days, the concentrations in the soil water had decreased even more, down to 0.3 ppb and 0.1 ppb in the shallow and deep lysimeters respectively. This simply reflected the fact that it had now stopped raining, and that water was slowly seeping through the soil, and becoming more diluted as it worked its way downhill.

To summarise these results, only minute amounts of 1080 were detected in the soil water, none in the groundwater, overland flow or stream water. This was despite the huge amount that we applied to a small area at the head of our experimental area. This result again demonstrates the huge role of dilution during rain. However 1080 was detected in soil water following leaching from baits, but only at very, low concentrations.

From these results, we concluded that surface water and shallow groundwater can become contaminated, but under a realistic scenario it is negligible.

To summarise:

- 1080 rapidly leaches from bait and is diluted to extremely low concentrations
- Leached 1080 has no demonstrable effect on fish and aquatic invertebrates
- Koura can consume 1080 and metabolise it without harm
- Aerial applications will result in only minute quantities of 1080 leaching into surface water
- Any 1080 entering soil and groundwater becomes extremely diluted – often below detection

The relevance for lake restoration efforts is quite simple, in my mind anyway. Land based applications to remove pest species are unlikely to have any adverse effects on lake ecology or water quality and finally it is highly unlikely there would be any adverse effects at all on kōura.