A field study assessing the impact of on-site wastewater treatment systems on surface water quality in a Co. Monaghan catchment

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So today I want to just give an overview of a study that is ongoing in the Milltown Lake catchment which is in Co. Monaghan.

The Milltown Lake is located in Co. Monaghan just north of Castleblayney. It's actually the source or abstraction point for a local group water scheme, the Churchill and Oram group water scheme. And for those of you who are not familiar with the group water schemes, they are actually co-operatives, where the local community comes together to source and distribute their water. This particular group water scheme services approximately 1,900 people with 735 metre cubed of water being abstracted daily. And you can just see the lake and most of our sites are located within the catchment area of this lake, which is 34km^2. Owing to a general concern from the group water scheme about the quality of their raw water they instigated a monitoring programme within the catchment, in collaboration with Dundalk Institute of Technology, which aimed to investigate point and diffuse sources of pollution within the catchment. And at all stages in this process the community have been very actively involved, which has been to the benefit of the researchers. A number of pressures on the catchment were identified as a consequence of this work, relating to poor farmyard practices, run-off from slurry and fertiliser application and then a particular problem was direct access of cattle to water courses.

But in this area the sub-soil permeability in this area is generally of low permeability. And as a consequence it was felt that on-site wastewater treatment systems warranted further investigation. On-site wastewater treatment systems have the potential, as we have heard, to contaminate water, for varying reasons when they are malfunctioning. Their actual ability to attenuate contaminants is dependent on things such as soil, the sub-soil type, depth to bedrock, proximity to surface water, the depth of the unsaturated sub-soil layer, and then other factors relating to the maintenance and overall operation of the system.

So in order to characterise the on-site wastewater treatment systems within the catchment, we did three things. We carried out a household questionnaire. We followed this up with visual inspections of the sites. And then we started an intrusive monitoring programme of a sub-set of the on-site systems within the catchment.

So 154 households were questioned in total. And of course as expected the majority of these households had traditional septic tanks, with an average number of occupants of 3.1 individuals. And over half of the systems were greater than 16 years old at the time of the survey, which meant that they had

been installed prior to any current guidelines. And a good percentage, 21%, were actually older than 30 years. A sub-set of these were then visually inspected. So we went out and looked at the site trying to gain information regarding construction, overall condition of the site. And what we found was, 38% of those systems were dependent on soak aways which are really pits filled with stone and don't correspond to current regulations. We also found many other problems. Some tanks were actually above ground. Their settlement chamber wasn't even positioned below ground. And here you can actually see a set of pipes flowing over ground towards a soakaway. But 17% of the systems investigated in this visual inspection were actually found to have direct discharges, two of which had no settlement tanks at all. There was simply a pipe that went straight to the drain. And this shows an example of one of these pipes. This one was easy to spot. They weren't always as easy to spot.

So this work, this initial survey warranted further investigation of these sites. So we set about establishing a monitoring programme for a set of five sites. At each of these five sites we installed a set of monitoring wells between the tank on the site and the nearby watercourse. The number of these monitoring wells depended on the distance of the tank from the nearby watercourse. We then also located monitoring wells outside of the area of the predicted effluent plume. And then samples were collected once every two weeks for a period of a year, and analysed for range of indicators of effluent pollution, both biological and chemical. And this work focused on the systems that were in operation within the catchment at the time, regardless of the age, their type or their maintenance level. And this was done in order to try to gain an understanding of the fate of the contaminants that could potentially be arising from these on-site systems. And also to get quantifiable data on their potential contribution to loading within the catchment. And we also wanted to take into account issues surrounding location, poor installation or poor maintenance.

So just to give you a summary of the five sites that are included in this study, they were each given arbitrary letters to identify them. Most of them were the traditional septic tanks. We only had one secondary system. The site selection for these, we had lots of criteria to select these sites, but it actually came down to home owner consent really, at the end of the day. Our secondary system was approximately five years old. It was the youngest system there at the time that the study began. The rest were 30 years old or older still. And the number of occupants, they were all adults occupying these households. And it ranged from one to four adults. On questioning the home owners, some said that they had desludged intermittently and then some every year or between a year to every two years. Most were reliant on soakaways. There was only two had a percolation area. In November 2008 we then set about characterising these sites. We did a site characterisation based on the guidelines that were current, the EPA guidelines that were current at the time of this study. And this incorporated a percolation test in exactly the same way as if we were going about installing a new system at these sites.

The percolation test is based on the t-value system. Basically if you have less than three it indicates high permeability and wouldn't be suitable for a septic tank, greater than 50 low permeability, and again not suitable. And none of our sites, following the site assessment, were deemed suitable for a septic tank. Two were considered suitable for the installation of a secondary system. Both with recommendations for a soil polishing filter.

This table gives a summary of the depth to water table at these sites. It is a range of the depth to water table across all of our monitoring wells. A lot of our monitoring wells actually had a very low depth to water table. So about 0.15 to 0.18. And across the whole of the monitoring period that water table tended not to vary much throughout the year. There was no relationship with cumulative rainfall. And the combined effect of the shallow water table that was generally found at most of the piezometers of this site, and the thick capillary fringe that's often common in this type of soil, indicates a reduced unsaturated zone. So our expectation would be that there would be reduced capacity at these sites for aerobic attenuation processes to occur. As well it's worth pointing out that during our site assessment a number of issues relating to the installation of these sites was actually raised. And I am going to come back to those at a later stage.

This shows a diagram just giving you an indication of the layout of piezometers at our sites. So we have …and this is another site as well…so you basically have the septic tank and then a series of piezometers down gradient of that nearby water stream. I am going to focus on two sites, site D and site F, and just to give you a background of some of our observations at these sites. I don't have time to go in in too much detail about all of the data that was generated. But it will just give you an overview, a picture of what was the general trend that we saw at these sites. We used chloride as a natural tracer of effluent pollution. Chloride doesn't get involved in any of the background attenuation processes. So it's a good indicator of the effluent plume and any decrease in chloride would probably be accounted for through dilution and dispersion.

I haven't shown any of the background control data, but the chloride at this site was elevated, very much so in comparison to background data. And was sufficient to allow us to actually draw effluent plume maps of all of our sites. Just to give you a background of the actual diagram, what it actually shows is, it shows the distribution of the data, of each of the monitoring wells. And the graph goes from the nearest monitoring well to the septic tank, and then as you move away, the furthest piezometer from the septic tank. And the furthest piezometer from the septic tank was actually located in the alluvial deposits adjacent to the stream. And the general trend we found at these sites was high, elevated concentrations in the monitoring well adjacent to the tank and then declining progressively with distance from the tank. And this is the same as what we found for all of our indicator parameters. But the degree of reduction varied, depending on the parameter in question.

This is again a diagram from the same site. And it just gives you a little picture of what was happening with regard to one of our indicator parameters,

nitrogen. On the left we have ammonia concentrations. And on the right, nitrate concentrations measured as milligrams per litre. And you can see that we have high concentrations of ammonia adjacent to the tank, and then declined thereafter. But as ammonia declined we got increases in nitrate, peaking 16 metres from the tank and then declining thereafter. And this indicates nitrification occurring. And as the nitrate then moved further from the tank it declined with distance.

But as I was saying the degree of reduction varied depending on what indicator parameter we were talking about. This table shows the difference between the site I have just been talking about, site F, in the piezometers adjacent to the tank or closest to the tank, and a piezometer further away. In this case our monitoring well further way, in this case 48 metres from the tank. Nitrate, well I have actually shown the results for all of the dissolved inorganic nitrogen, so ammonia plus nitrite plus nitrate. And there was high concentrations adjacent to the tank and then declining. But nevertheless…this would all have been nitrate at this point...nevertheless high…9.57mg/l. At our other sites, one of our other sites, site D, and this was the new build site, this was a secondary system, 128mg/l 22 metres from the tank and then declining to 8.1m at distance. And this piezometer, 102 metres from the tank was actually less than a metre from the nearby watercourse. But some of our other parameters, like phosphorus, actually declined to background levels at this site. The same with dissolved organic carbon. Our faecal bacteria also experienced high reduction rates. But nevertheless there were still relatively high concentrations in the monitoring wells furthest from the tank.

And this brings us then back to some of our other sites. I focused here on two sites. In particular, site F and site D where I have just spoken about. But what about some of our other sites? Well actually it turned out that at two of our other sites we had direct discharge pipes, which means that the sub-surface pathway was unlikely to be the main pathway of the source of contamination to surface water. And these direct discharges are something that is of major concern for us within the catchment, and something that we are investigating further. And what we have done is, we have actually carried out investigations using caffeine as a tracer which we can directly link back to human source of the contamination, and then linking concentrations of our indicating parameters to caffeine. And what we have found is a high relationship between caffeine and e-coli numbers at these sites. And we are continuing that investigation.

So just in summary, from what we have found at these sites, parameters such as phosphorus, some of our parameters such as phosphorus were largely removed during the soil treatment process. Some others were also reduced, had large reduction levels, but were nevertheless present, at high levels in the piezometers closest to the adjacent streams. And that includes our faecal bacteria. Nitrate experienced low reduction levels at all of our sites and were still present at relatively high concentrations adjacent to our stream. In fact

maximum levels of 12.3mg/l were found within one metre of the adjacent stream at one of our sites.

And there was a general problem of direct discharges within this catchment, which is of major concern and warrants further investigation, where we were able to apply tracers of human effluent to the other indicator parameters and linking one to the other, allowing us to distinguish between what is background agricultural pollution and what is arising from on-site systems.

And just a final note. I had alluded to this earlier. But following our site investigations, site characterisations of these sites, what we found was that of the five sites that we actually intrusively investigated and monitored over the yearly period, two of the sites, the only two with percolations had inappropriately designed percolation systems. Another site, site F, which I have been talking about, actually had a broken in-flow pipe. And there was also a suspicion that some of their grey water is actually being piped separately down a drain to the west of the site. Two other sites, sites J and K, had pipes discharging directly to a nearby watercourse. And the system at site D, which was the only secondary system in this study, had never actually been turned on. So despite the fact that it was a new system the owners had not turned this on. And this really flags the issues relating to installation and maintenance of these systems. Because there were issues relating to their installation and maintenance even before you take the sub-soil characteristics or permeability into account. And it highlights the need of effective education for the homeowners in order to allow them to be able to meet their obligations under the Water Services Amendment Act which was already spoken about earlier this morning. This is crucial. And remember the people who were involved in this study were people who were actually concerned about water quality, because they allowed us to go in onto their sites. And that's something to remember. These are people who are concerned. What about the rest of us?

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