Fine Particle Monitor trial at Leicester Leys Leisure Centre

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Why should we Monitor?

Cryptosporidium. Gardia. Just two of the names that strike a blow to the healthy abdomen, physically and metaphorically. These intestinal parasites can cause vomiting and diarrhoea; for the most vulnerable members of our society an extreme infection can be fatal. Worst of all, these creatures are incredibly difficult to eradicate. Tests have shown that crypto oocysts can survive in a 10% solution of chlorine; not very conducive to training the next budding Olympic champion.

Outbreaks of illness can lead to pool closures and raises the vexed question of liability. Today, those most at risk, the old and the very young, are major pool users. It is in everyone's interest to ensure that best practice is followed to avoid the instance of a reasonably foreseeable occurrence. The question facing the leisure industry is “what constitutes reasonable safety measures and how should any data be handled”?

The Need

The Drinking Water Industry have been facing the same problems for many years without completely solving the problem. Increasingly, over the last 10 years water quality has been monitored after filtration, by either turbidity meters, or in high risk areas, particle counters. Both instruments are scientifically proven, but it requires skill to set-up, operate, maintain and interpret the data. This is no problem for a major utility with extensive engineering resources but it does present a difficulty where staff are predominantly non-technical. There is a clear need to be able to emulate the functions of these instruments yet do so in a simple manner with equipment that is easy to install and use. Ideally, the data should be logged automatically with the facility to set alarm levels to warn the operator when problems occur.

Can FPM Help?

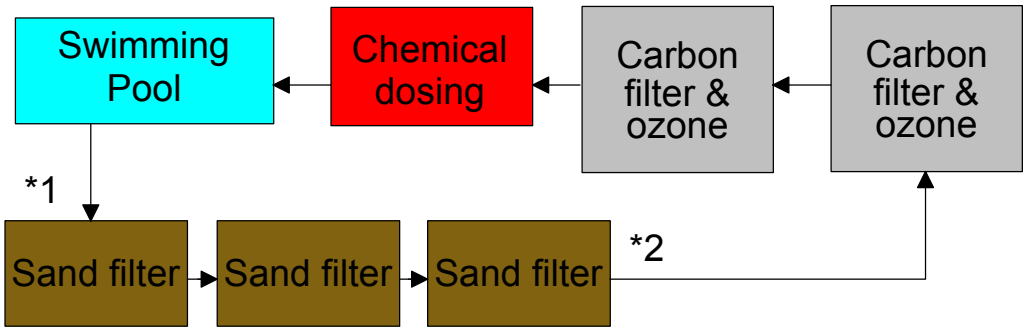
The Fine Particle Monitor (FPM) was developed, by Diverse in association with the Anglian Water Group, as a low cost alternative to turbidity meters and particle counters. It measures in units of Particle Index (PI) which is a combination of the number of particles and their size. In a normal water sample there are usually a large number of small particles (~2 μm) with an exponentially decreasing number of larger ones. PI is weighted so that it is more sensitive to these larger particles. As a filter begins to age, more larger particles can break through and these can be detected downstream. The importance of this skewed sensitivity becomes apparent when remembering that parasites, such as Cryptyosporidium, are typically 3-7 μm across, a region where turbidity meters are running out of sensitivity.

PI levels are not absolute but it has been our experience that drinking water is usually below 100 and that a PI of >1000 is certainly not drinkable. This report shows how this relates to pool water quality.

The FPM, pictured below, is easy to install and operate, requires mains power and a water feed point connected to a 3mm Tygon plastic tube. Water quality is monitored by clipping the tube into the sensor on the side of the FPM. Data is shown on the front panel display and it can be downloaded and stored on a computer via a serial connection. Alarms can easily be set and an internal calibration mode allows the operator to quickly verify that everything is working properly.

The Trial

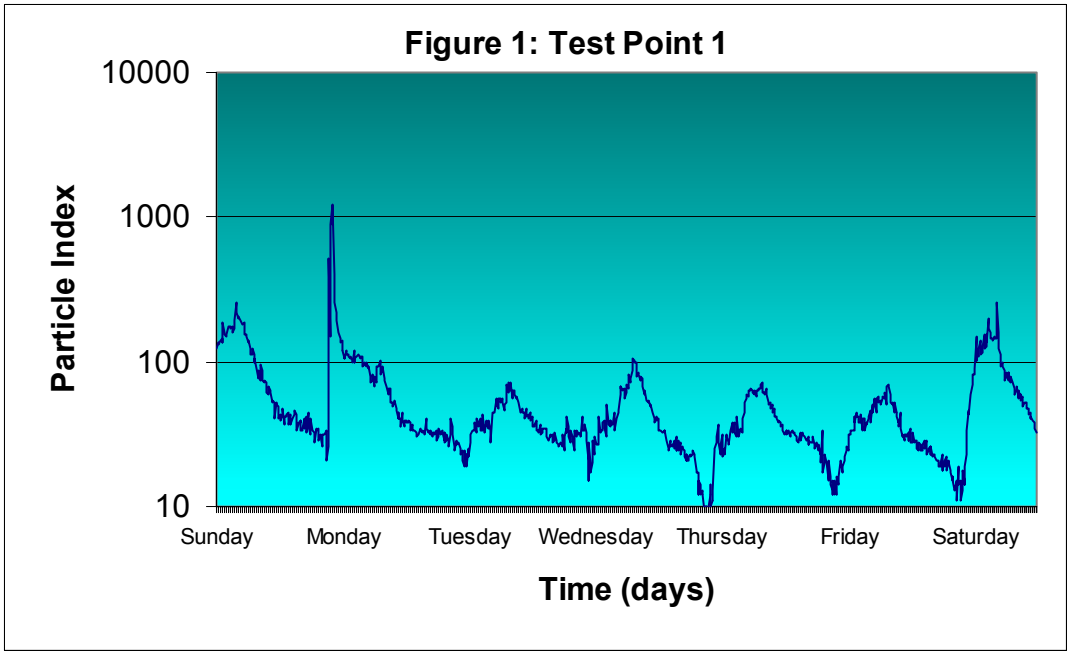
The purpose of the trial was to investigate the effectiveness of FPM monitoring water quality in public swimming pools. An FPM was fitted at the Leicester Leys Leisure Centre (LLLC) in October 2001 and the PI data recorded over a period of nearly 12 months. The schematic below shows, in block format, the layout of LLLC treatment plant and the two FPM test points that were used.



Schematic of Leicester Leys Leisure Centre
(Arrows show direction of flow, *1 and *2 are FPM test points)

Test Point 1

In the first trial FPM was positioned before the filter beds, effectively monitoring the base level of the water purity. This position produced some very interesting data, a sample week is shown in Figure 1.



Week commencing 14th November 2001 FPM pre-filter

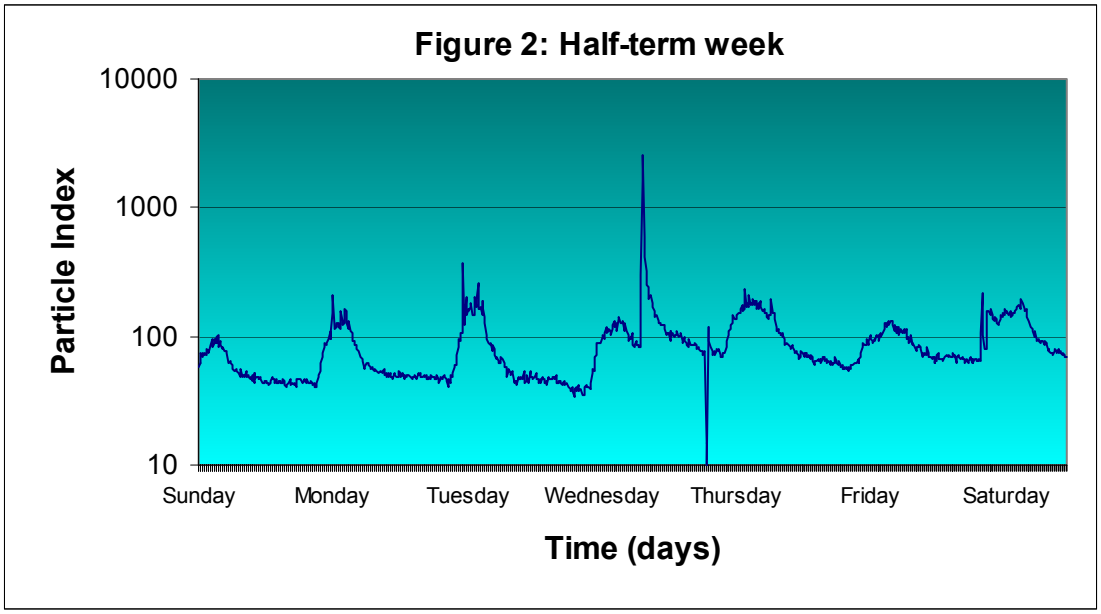
In order to understand the cyclic variations we should note that the pool opening times are:

12-8 pm Monday to Friday
10-5 pm Saturday
10-6 pm Sunday

The x-axis begins at midday on Sunday and repeats in 24 hour cycles.

Normally PI builds up consistently throughout the day reflecting a relatively constant pattern of use. When the pool is closed the filters have time to purify the water and the PI drops gradually back to a base level of around 20-30 units. Weekend use starts early and generally is busier, again we see this reflected in the PI data which peaks before midday with a higher than normal reading. The exception to this schedule occurs on a Monday when the "over 50's" swim from 9:30am. This session is heavily used, a fact that correlates strongly with the very high peak that occurs early in the morning.

Figure 2 shows a school half-term week coinciding with the Queen's Jubilee celebrations on the Tuesday.



Week commencing Sunday 2nd June 2002 FPM pre-filter.

Once again the PI faithfully records what is happening in the pool. The "over 50's" session was cancelled so the Monday peak is missing. Tuesday was a special holiday and saw the heaviest usage during that week, PI rose on this day above the norm. With half-term in full swing week days were as busy as weekends, so the normal pattern disappeared. The anomaly in all these correlations occurs on Wednesday

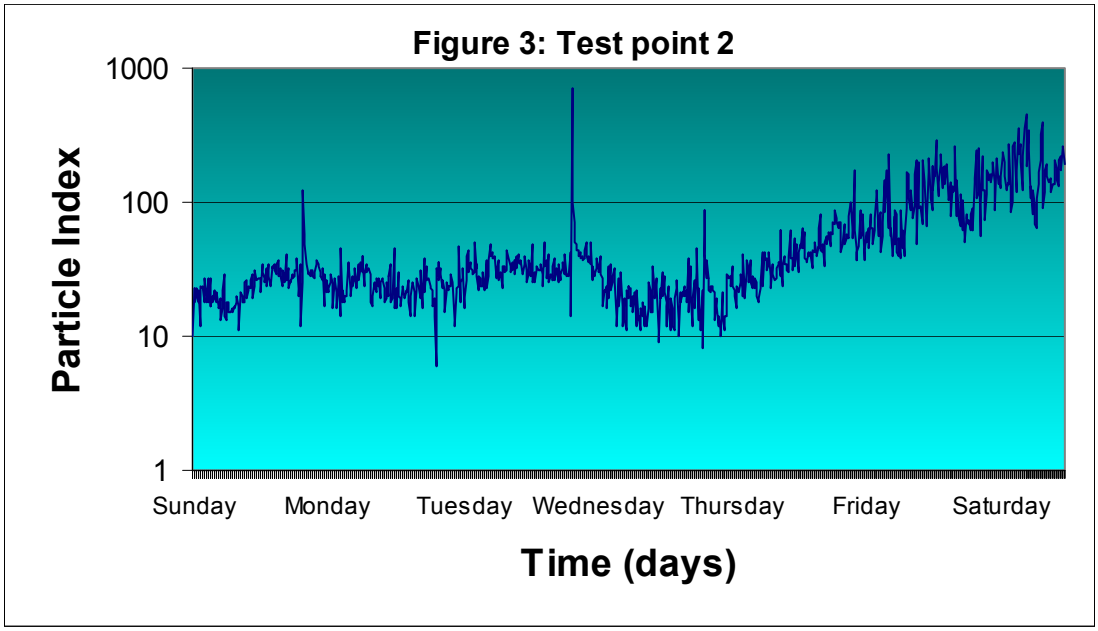
when a very high PI peak occurred, washed down to normal levels in about 3 hours. This event did not correspond to a particularly heavy usage - but it could be a particular soiling event. That is this may simply be due to the very condition that we are seeking to identify. Although in general higher usage will result in higher PI, we would not expect this to be an exclusive condition.

LLLC report that it takes ~2 hours for the entire volume of water in the main pool to be circulated through the filter and dosing system. A sudden increase in usage affects the PI much more than the same number of people spread out over a longer period. This is an important factor to take account of when positioning any monitoring device.

The filters are also backwashed periodically, thereby causing a temporary increase in particle numbers in the pipes for a short time. However, back wash events do not affect the FPM readings at this position because the additional particles would have to travel through the filters, treatment zone and pool before reaching the FPM.

Test Point 2

Finally the FPM was placed after the sand filters at location "2" on our block diagram. The results, shown in Figure 3, do not exhibit the daily cycle that was visible pre-filtration.



Week commencing Sunday 20th January 2002 FPM post ozone

However the PI is consistently lower than before and there is evidence of a gradual increase in PI from Thursday to Saturday. A possible explanation for this lies in the way the filters work. If the filter is working properly we might expect a reduction of

between log 2 to log 3 from input to output. In PI terms this would reduce the daily peaks to little more than statistical noise at the output of the filter. With the passage of time, the filter begins to foul up, the reduction efficiency falls and additional particles are shed into the output. Thus we would expect to see some gradual increase in PI as the filter starts to clog. Backwashing - typically carried out Monday and Wednesday return the PI to a low value. These results shows some justification for this explanation.

Not unreasonably the pool were unwilling to disrupt the filters so that we could simulate a “failure” situation but this does not devalue the results that we have recorded - particularly the water quality data obtained with the FPM at position 1.

Conclusions

This trial has amassed data over 12 months and allowed us to demonstrate a broad correlation between usage and PI. A strong daily cycle can be monitored if we site the FPM before the filter bed and this could be used to set alarm levels irrespective of whether or not the filter has failed. If the filter does fail then a significant increase in PI will be registered and the unit will go into alarm. However, there is probably less likelihood of this occurring than a large body of swimmers raising the PI to potentially dangerous levels before the filter can react.

The underlying question is now, not whether the filter has failed but whether it can cope quickly enough with this scenario. By monitoring the base levels for several weeks, staff will be able to set there own alarm levels and tune the instrument to suit unique conditions.

In terms of deployment FPM is easy to install and needed no maintenance during the period of the trial. The data logging facility can be used to provide a permanent record of pool cleanliness.

Realistically nobody can yet detect oocysts in the tiny concentrations that can cause infection in a real-time environment, this is especially relevant in a volume of 100,000 litres such as at LLLC. However, oocysts are not the only problem, so being able to monitor water quality is still of considerable value. FPM can provide a single number that can be related to water cleanliness. Pool staff will rapidly become familiar with the simple format and be able to make value judgements about pool safety without the need for statistical analysis or specialist training. For example, when the PI exceeds a certain threshold staff would limit the number of new swimmers entering the pool so that the filter had time to react before the particle concentration reached hazardous levels. More work is required to establish exactly what these limits should be but FPM is ready now to take up the challenge.

A full specification for the FPM can be found at:
http://www.diverse-technologies/layer3/fpm1.htm

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