Cleaning Infrastructure Makes Dollars & Sense………………… Part 1

In this three-part series from Blue Earth Labs®, they will discuss filters, storage, and distribution systems and how regular infrastructure cleaning and maintenance extends the useful life of these systems, optimizes equipment function, increases overall performance of treatment, improves water quality, reduces need for pre-oxidants, and assists in managing primary and secondary disinfection. They will also discuss the impact that all components of this complicated combination of activities have on disinfection byproduct generation.

Just like your home, your car, and your equipment, maintenance of water treatment infrastructure extends equipment and facility life, provides savings on labor and repairs, and can significantly reduce energy and chemical costs. As an added bonus, routine maintenance improves the consumer's experience and reduces customer complaints.

Maintenance needs are driven by the impact of daily processes on infrastructure. All wetted surfaces, from source-to-tap, including filters, pumps, piping, tanks and miles of distribution network begin to degrade with use due to organic and inorganic matter contained in the millions of gallons of water these systems handle each day. Often, the surfaces of water treatment infrastructure have highly specialized coatings and surfaces to improve water quality; if these surfaces become degraded there will be a material decrease in water quality. Keeping these surfaces and coatings clean by regularly removing any accumulation of naturally occurring deposits significantly improves system operation and water quality. *In short, cleaning the infrastructure makes dollars and sense.*

The most noticeable part of this eco-system is the filtration system. They are normally a utility's first line of defense and the most apparent and noticeable component of these systems. These filters are the most complex part of the system particularly with advanced filtration, pre-oxidants and post-processing requirements for DBP control. Filters also play the biggest role in Long Term Surface rules and bear a huge burden in providing high quality water. They also can provide the largest savings in energy when regularly maintained. In normal operation, all types of filter media and underdrains will eventually become encapsulated and clogged, preventing proper operation that results in high head loss, short filter run times and more frequent backwashing. Eventually, overall water quality and system performance will be compromised. Keeping the media underdrains, troughs, and even sidewalls clean of organic and inorganic intrusion by removing biofilms and other contaminates improves operations and water quality

More specifically, for filter media to function properly, regular inspection of the media for density, particle size and uniformity coefficient is critical. If filter media is encapsulated, it reduces the adsorptive sites and the overall effectiveness and filterability of the media. (As seen in Figures 1-4) Encapsulation also causes the densities of the media to change, which causes a loss of the interface or mixing of the media. The results seen are often confused with rounding of the media and leads to the expensive mistake of thinking the media are worn out and require replacement. Upon microscopic analysis, the angular surface areas are often filled in, giving the media the appearance of being rounded. As the process of encapsulation continues, several problems can arise ranging from short filter run times and high head loss to lower filtration rates and inadequate bed expansion during backwash. Performance of the filter will continue to diminish until corrected.

There are several options to address cleaning filter media and these are described in detail below.

Doing Nothing

Because filters are omnipresent, operators tend to let filter systems operate until issues with turbidity breakthrough, high head loss, excessive backwash water, long ripening times or short filtration runs start causing operations problems. For both pressure and gravity filtration units, operators often resort to increasing the rate of flow through the remaining filter surface area or operating longer run times to make up for the production loss in emergency conditions. This approach could lead to exceeding approved filtration rates through the unit. Systems that take this position are reactive rather than proactive, often times just changing out the media at extraordinary expense rather than determining the root problem with the media and underdrain. The problems continue to increase until water production is limited to making backwash water and starving the distribution system at critical times of the day. Operating the filter systems in this manner ultimately is an extremely expensive approach. In the majority of cases, preventative maintenance and media optimization could have been utilized to avoid problems from occurring in the first place. Proper control and maintenance also allows the system to stagger the cost associated with proper media management over several years rather than incurring costs all at once at the point of replacement, and then starting the cycle again. Budget cuts and delaying maintenance “until next year” can lead to filter failure causing a full-fledged emergency. Thus, doing nothing about filters is the worst option.

Media Replacement

The majority of media replacements occur because inspection of the media shows its appearance to be “worn out or rounded” as discussed above. This interpretation is based on the observer seeing media encapsulated with organic and inorganic accumulation that inhibits flow or causes backwash issues in underdrain systems. This effect is further magnified by pre-treatment chemistry such as coagulants or pre-oxidants. This interpretation leads many operators to incorrectly assume the media is worn-out and requires replacement. Filter media replacement cost has escalated over the last few years for several reasons. The cost of media itself as well as handling and shipping, disposal of the old media, and the cost of confined space labor and equipment have all played a major part in the cost increases. The amount of downtime and the amount of backwash water alone are reasons enough for operators to look at alternatives to complete media replacement.

It is also important to note that the cost of media replacement is higher than the job cost alone. Replacement takes filters off line, at times for days or weeks. There is also additional risk. During the replacement process, the risk to the infrastructure specifically the underdrains, is high due to the process undertaken for replacement. Coatings in bays can be damaged and other parts of the systems may have to be repaired, further delaying a return to service. The costs of replacement alone are compared with cleaning costs in Table 1.

Table 1: Replacement versus Cleaning Costs for Various Media Types

(cost per ft^3)	Replacement Cost*	Cleaning cost**
Filter Sand	$40	$23
Anthracite	$55	$23
Greensand	$70	$30

Zeolite	$110	$30

*Includes average labor and average shipping

** Includes catalyst, neutralization process and average shipping

Simple Media Cleaning

Varying simple chemical approaches have been used in an attempt to clean filter media with less than stellar results. The lack of proper testing, followed by misapplication and use of experimental processes developed "on the fly", yield inferior results to fully planned cleaning executed by trained personnel.

One such approach is to attempt cleaning the media through oxidization by increasing pre-chlorine feed rates or simply adding chlorine directly on top of the filters.
While this approach may improve filterability, it also can cause formation of DPBs in the finished water. Sodium hydroxide and simple acids like citric, phosphoric, hydrochloric acid, and sodium hypochlorite have all been utilized. However, these chemicals are mostly ineffective because they struggle to remove years of organic and inorganic constituents in the raw water. Another challenge is the effect of chemistries utilized in the water treatment processes, such as coagulants and pH adjusters, which limit the efficiency of these cleaners by encapsulating the media preventing the penetration of the cleaners. Further, these acids are hazardous and require special handing. In addition, these acids can cause issues with the filter infrastructure. For example, if hydrochloric acid comes in contact with stainless steel it will cause it to become brittle and prone to failure. It is also critical to not perform neutralization of the acids in the filter bay after cleaning. Neutralization can lead to media damage from extreme heat production causing breakage or changing the hardness specification of the media. A more common issue is the recoating of media surfaces with matter that was just removed. .

Simple cleaning is chosen because it is appears to be inexpensive as it uses commodity chemicals and local personnel. That said, in the end the savings don't materialize because it rarely is effective and can create the appearance of proactive maintenance while temporarily masking the real issues.

Advanced Chemical Cleaning

Advancements in cleaning processes and chemistries have generated more specialized NSF 60 certified formulations designed specifically to clean most types of filter media in place and to also clean the underdrain systems by penetration of the cleaners through the stratified layers of the media, support gravel and underdrains.

This approach should always start with a specifically customized laboratory filter media analysis that defines the best application rates for the specific filter and analyses the amount and type of contaminates that will be removed so that the waste can be well understood. Based on this analysis, the cleaning is performed in a two-step process with appropriate concentrations of a powdered formula having a slow dissolution rate and an activation catalyst. In step one of the cleaning process, the powder formulation is mixed with water and pumped as slurry on top of the filter media bed. This step allows for coverage of the cleaner over the entire surface area of the filter and allows for penetration throughout the media depth. In step two, an activation catalyst is added to the mixture and allowed to mix utilizing air scourer or surface sweeps. The catalyst starts the reaction of the cleaning process and allows for organic breakdown to speed up the removal process. The entire process usually takes less than 24 hours per filter unless the media is particularly fouled.

The amount of residence time that the cleaning chemistry stays in contact with the media is critical, as the slurry must sit long enough to penetrate the depth of the media down through the underdrains. This process can be accomplished in a 24-48 hour period on most projects, but is dependent on the severity of the fouling. As previously mentioned, the use of a catalyst increases the efficiency of the cleaning process and aids in the removal of organic and inorganic contaminants from the encapsulated media. Adding the catalyst at varying times can improve the cleaning process and is proven to be more effective with air agitation or mixing.

This approach has proven to be much more effective than simple acids discussed above because it is more able to penetrate the entire filter bed and address underdrains and walls. The result is optimal contaminate removal, reduced cost and overall improved performance of the entire filter including the underdrains.

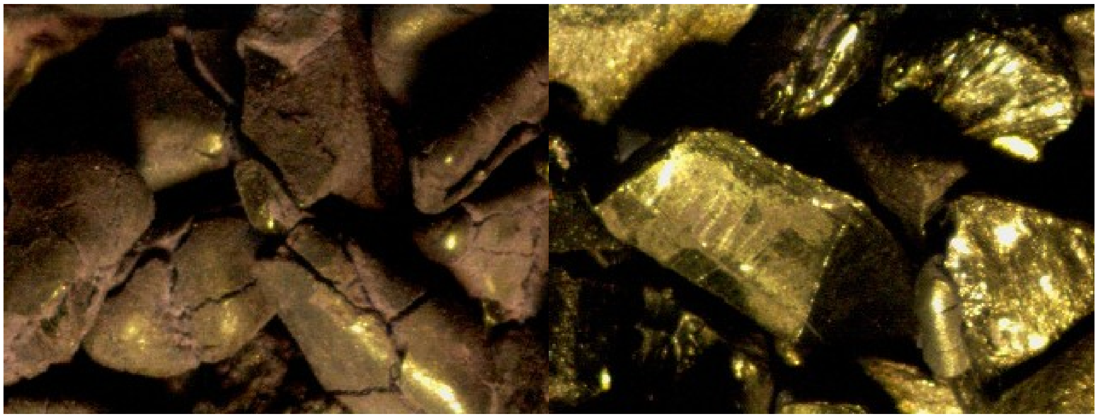


Figure 1: The sharp angles of apparently rounded media (l.) are restored after cleaning (r.)

The entire cleaning process is much less labor intensive and time consuming compared to complete replacement. The case for in-situ chemical cleaning was recently demonstrated in New Braunfels, Texas. The City of New Braunfels owns and operates an 8 MGD surface water treatment facility commissioned in 1991. The treatment facility treats water from the Guadalupe River with ten 128 square foot convention dual media, support bed with Enviroquip underdrain (Ovivo) gravity filtration units. Due to the age of the media and the loss of water flow through the units, the treatment facility was experiencing higher than normal head loss and short run times. They suspected that the media and underdrains had become encapsulated and clogged with organic and inorganic constituents from the water source and the normal chemical additions that are utilized in the coagulation and sedimentation process, as well as for pH adjustment. Visual inspection of the media showed significant mudballs and heavy buildup of organic and inorganics on the walls and troughs of the units.

Two mitigation options were considered by the New Braunfels Utilities engineering staff. The first option was to remove and replace all the media, support gravel and clean the undrain systems. Option two was to clean the media in place seeking to completely dissolve, dislodge and clean the mudballs formation as well as cleaning the deposits that were encapsulating the media and the underdrain.

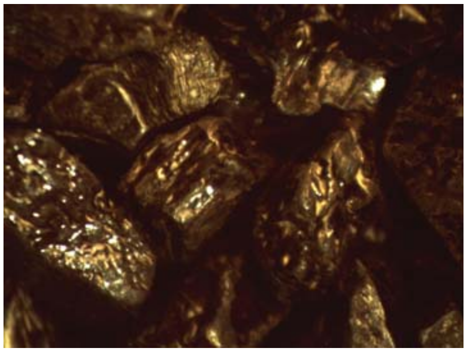
A laboratory analysis of the constituents was performed to determine the composition of the contaminant buildup in order to determine which chemical formula and what quantity would be most effective. The weight loss difference as shown in Table 2 is a direct correlation of the total constituents removed from the media. Further, the analysis provided information of the makeup of the constituents and volumes being removed using inductively coupled plasma (ICP) testing, an important step in disposal of the waste. Preliminary testing concluded that the media could be effectively cleaned in place instead of replaced.

It is important to note that regardless of which option is chosen, replace or clean in place, the analysis is valuable and should be performed on a regular basis. Doing so will not only provided a baseline that will assist in determining the optimal intervals between media replacement or cleaning and inspection, it will also provide insight into treatment requirements for example by indicating changes in coagulant feed rates to improve either filter performance or treatment efficiencies of the sedimentation process and loading on the filtration system. The results can be analyzed from year to year to see the overall operational control of the filtration system (See Table 2).

Filter ID Heavy Cleaning		5
Mixed Media		
	Dry Weight Loss	2.9%
	Total lbs removed	61
	Mg removed (ppm)	658
	Ca removed (ppm)	2,075
Sand		
	Dry Weight Loss	1.4%
	Total lbs removed	184
	Mg removed (ppm)	623
	Ca removed (ppm)	1,009
Combined		
	Total lbs removed	245

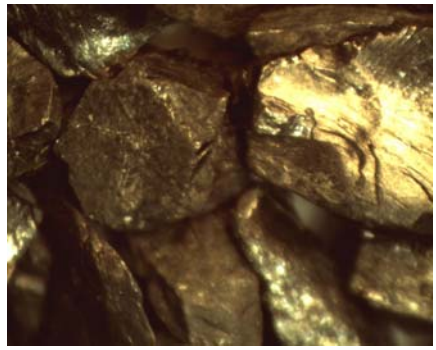
Table 2: Amount and composition of the constituents removed from Filter 5 during standard laboratory cleaning.

Based on the laboratory testing, cleaning the media in New Braunfels removed approximately 245 pounds of deposits from Filter No. 5. This included 3,084 ppm of (Ca) and 1,281 ppm of (Mg). These results were repeated with each of the ten filters over a period of two weeks until all the filter units had been cleaned and topped off with filter media.



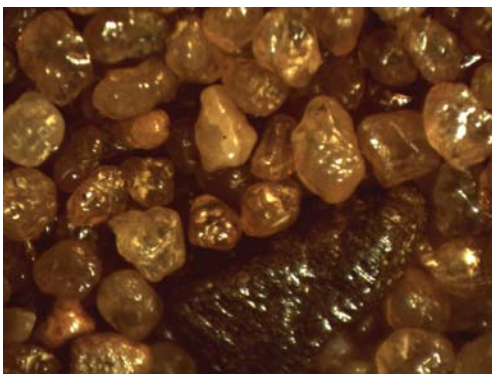
Anthracite Before Media Cleaning

Figure 1



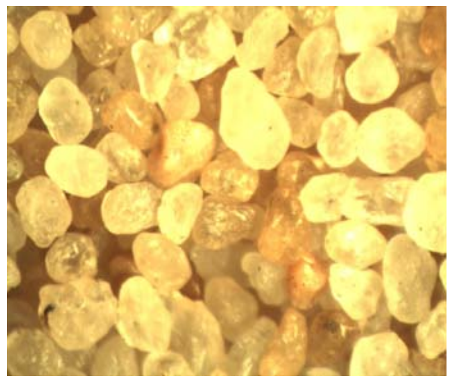
Anthracite After Media Cleaning

Figure 2



Sand Before Media Cleaning

Figure 3



Sand After Media Cleaning

Figure 4

It should be noted that prior to cleaning, an interface could not be located in the filters due to mixing of the sand and anthracite and their closeness in specific gravities. After cleaning, there was a clear separation of the interface as seen in Figure 5

Figure 5- Interface Sample Site

After cleaning, New Braunfels experienced significant operational improvements including increased flow production by over 1 MGD, reduced head loss, reduced effluent turbidity averages from 0.2NTU down to 0.03NTU, and improved media stratification to provide interface. Filter run times were extended from 50 hours to an average of 95 hours, which improved backwash flow and reduced backwash water by 50%. Finally, the cleaning reduced the energy cost of recycle pumps, the chemistry cost to retreat the recycle water returning to the head of the facility, the chlorine demand through the filter bed, and it provided for removal of mudballs and other particulates while extending media life. Based on the media analysis and report, it was recommended to clean the filter media every three years in order to keep the filter running at an optimal level of performance.

While the media was being cleaned, the entire filter walls and associated structures were also cleaned to remove contaminates that had accumulated on the sidewalls, troughs and wetted surfaces. This additional step provided enhanced inspection of the concrete surface area and improved the appearance of all wetted surfaces. As a result, performance and operation control improved due to reducing disinfectant demand and prevent sloughing off of material into the filter bed.

Based on this experience, The City of New Braunfels has added the media cleaning and surface cleaning applications as part of their SOP's and has implemented a budget to continue with the proper cleaning and maintenance on their filtration units. In return, they are seeing the benefits of improved operations and saving dollars on reduced backwash water, lower head loss and reduced chlorine demand. They have achieved lower filter turbidity and have extended the life of their existing media while saving a significant amount of capital project funds by cleaning instead of changing out their media that can be deployed to other needs.

Figure 6

Figure 7

Figure 6 & 7 depicts a filter basin before and after applying the cleaning solution to the walls and troughs.

Conclusion

While some filters have degraded to a point that replacement is the only choice, most can and should be cleaned on a regular basis. While a utility may elect to perform this operation on their own with basic acids, the specifically developed and field proved formulations are well worth the higher upfront expense as has been experienced in New Braunfels among others. Utilities can also chose to use external resources to assist in these processes. In most cases, the cost of in-situ chemical cleaning on a turnkey basis will be less than half the cost of replacement and will be considerably faster and less complex. This lower total cost will free up resources to support the myriad other projects facing utilities. But whether utilities chose these more advanced proven methods, or the likely higher costs basic acid approach, there is no doubt that the most expensive option is to do nothing.

- Bob Cashion, National Training & Field Services Director, Jason Peters, Vice President of Product Development Blue Earth Labs, LLC
- John Krause, NBU Water Treatment Facility, David Kenley, NBU Engineering
- Paul Cashion, Project Manager S4 Water Sales & Service