Sustainable Water Treatment

Sustainable water filtration that also provides cost and performance benefits
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Dryden Aqua in Edinburgh have been conducting R&D and product development for the last 10 years on AFM, an Active Filter Media that replaces sand in all types of sand filters for the treatment of drinking water and wastewater. The research was supported by the European Commission under the Life Environment initiative.

Dryden aqua have invested over £1 million pounds in the development of a manufacturing process to produce AFM which has now been certified for use in Drinking water in the UK. The product is manufactured from recycled glass so it is 100% environmentally sustainable. However the development of a sustainable water filtration media was not the driving force behind the product, but rather the need to solve biological and operational problems that affect all pressure and rapid gravity sand filters.

When water is passed through a substrate such as sand the media will become colonised by bacteria. In slow rate sand filters this is actually desired, however in rapid gravity and pressure filters, the muco-saccharide alginates excreted by bacteria acts as a bonding agent, which eventually cause coagulation of the sand. The alginates bind the sand grains together increasing the pressure drop and promoting channelling. The performance of the filters continues to deteriorate and as channelling develops, a conduit is formed which allows the passage of solids as well as bacteria and oocysts directly through the filter bed.

In systems where disinfectants such as ozone or chlorine are used before filtration, the concentration of combined chlorine and THM`s will increase in the product water. The bacteria also respond by producing more alginates as a defence mechanism against oxidation by the disinfectants. The use of chlorine prior to filtration such as in the case of swimming pool filters, can actually promote the coagulation process, therefore chlorination should always be used after filtration, unless very high levels of disinfectant are applied.

In order to reduce or eliminate the problems, Dryden Aqua started a research program in 1997 to develop a water filtration media that would actively resist bacterial fouling. The principal researcher, Dr.Howard T Dryden conducted a PhD project in to the use of zeolites as a water filtration media. Zeolites act as a molecular sieve to remove ammonium from water. However the ammonium also acts as a food source for bacteria which results in rapid coagulation of the filter bed. Similar problems occur with activated carbon, which is an excellent substrate for bacteria and hence a poor media for mechanical filtration. Research was instigated to use zeolites loaded with catalysts, the intention being that the catalysts would cause the dissociation of dissolved oxygen to form free radicals on the surface of the zeolite which would then prevent bacteria from adhering to the media surface. The research was successful, however problems were encountered, so other aluminosilicate material was tested. Glass is an aluminosilicate, it was discovered that by altering the surface structure of the glass, the substrate developed a high zeta potential as well as catalytic activity. The process is called zeolitification, and the product developed by the process is AFM.

AFM is not a zeolite, nor does it exhibit molecular sieve properties so it does not need to be regenerated. However the shaped surface has a very high zeta potential measured at around –70mv. The high potential allows AFM to adsorb solids, organic matter and some heavy metals directly from solution. These components are held on the surface of the AFM by the weak attractive forces, which are sufficient to hold on to the material during the operation run phase of the filter. However when the filter is in back-washed, the weak bonds are broken and all of the solids are eluted from the bed.

The high zeta potential generates a slip zone on the surface of AFM, which makes it difficult for bacteria to achieve a strong bond with the substrate. The catalytic activity of the media also generates a high surface oxidation potential, which cracks carbon double bonds. This property prevents the bacteria from forming a strong bond with AFM, and indeed AFM exhibits a degree of self-disinfection.

The zeta potential and catalytic activity of the media virtually eliminates biofouling, however it is important that there is some dissolved oxygen present in the water for the process to be effective. In addition to these properties AFM also acts in exactly the same manner as sand, and will physically remove solids from the water. Conventionally, sand without pre-flocculation will remove solids down to about 10 to 15 microns. AFM has the same mechanical performance however the high zeta potential and surface adsorption properties permits solids removal down to micron and sub micron level.

The key issue with any media filter is the efficiency of the back-wash. It is absolutely essential that all the solids and waste removed by the filter during the operational phase are eluted during the back-wash phase. If any solids are retained the in filter, the solids act as a food source for bacteria, which would promote coagulation of the bed. In sand filters the solids are glued to the media by the alginates excreted by the bacteria. However with AFM, because the bacteria concentrations are at a low level, the solids are not stuck to the filter media. Back-wash performance is therefore very effective with AFM, on average 50% less water is required to back-wash the media in comparison to silica sand, and 30% more solids are removed by the process.

AFM has been used for the treatment of clean water and for the tertiary treatment of sewage effluent. After 7 years of use in sewage effluent the performance of the AFM has not deteriorated and there are no signs of biological fouling.

AFM provides a means of efficiently treating biological wastewater such as sewage effluent to produce a very high quality effluent. Typically when the influent solids load is above 50mg/l you can expect a 90% reduction in the filtered water. If coagulants are used prior to AFM, sub micron filtration can be achieved with discharge solids levels consistently below 1 mg/l. In clean water systems such as reservoirs, and river water, the performance of AFM is stunning. Indeed in some cases there is no need to use flocculation prior to filtration. Dryden Aqua has however developed a new flocculent called NoPhos, which is based on a Lanthanum rare earth. The flocculent works synergistically with AFM and improves the performance of the filter as well as removing phosphate at the same time. Traditional flocullents such as ferric and aluminium based products are toxic to aquatic life, NoPhos has a much higher threshold and is now used for phosphate control in public aquarium to control phosphate levels. Considering that the value of the fish can be many millions of pounds in an aquarium, AFM with NoPhos offers a much safer alternative to the problem of phosphate control. The same simple technology can be applied to sewage effluent as well as other types of industrial wastewater.

AFM is a direct replacement for sand in any sand filter, there is no need to change the equipment or the filter operating parameters. It is also unlikely that AFM media will ever need to be changed, especially in clean water systems. The cost of AFM is considerably more than the price of sand, however when the performance benefits and Life Cycle operating costs savings are taken into account, the return in capital can be measured in months.

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