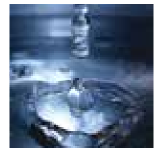
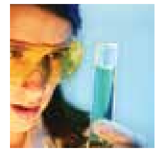
CARUS
WATER


Bio-Penetrants, a New Weapon in Controlling Biological Growth and Regrowth

BIOPURGE®
CASE STUDY

INTRODUCTION

Water quality, wheather it in a well or a distribution system, is affected by many factours. Biofilms are often the result of interactions between existing piping systems which have some deposits or growth, and which experience some form of contamination through disinfection breakdown, or through the entrance of organisms into the system. It is not always necessary for the pipe to have been in use for a period of time, however. Installation and maintenance practices can also impact water quality, even in new pipe. This paper will explore some of the common influences, which are not always considered, and provide some insight into a new technology, bio-penetrants, that has been demonstrated to be effective.

The presence of biofilms in public drinking water systems is a topic which has been widely discussed and studied in the last decade. While the biofilms themselves may not constitute a serious health risk, they set the stage for opportunistic bacteria to develop into a true health hazard when combined with inadequate or absent disinfectant residuals.

BIOFILM PROPERTIES

Three primary factors are necessary for the growth and reproduction of bacteria:

- Carbon and energy source
- Nutrient source
- Nitrogen source

Many water supplies derive the carbon and energy source from a carbonate species, which is naturally occurring or added as part of a treatment process. The nutrient levels in most waters can vary significantly, and are essential to biofilm growth. Nitrogen is the most problematic factor in many supplies. Many water supplies, in an effort to control trihalomethane (TTM) formation have switched to chloramination as the primary disinfection process. The use of chloramines may cause additional biofilm problems, as the process can result in an abundant source of nitrogen from ammonia component of the disinfectant.

The secondary factors needed for biofilm growth and regrowth are:

- Ambient water temperature
- Flow rate
- Concentration of inorganic material
- pH
- Type of surface/substrate

These secondary factors will not contribute to biofilm growth unless a nutrient source as described by the three primary factors is present. When the nutrient source is present, these secondary factors are very important. Water temperature can significantly affect bacterial growth. During summer months when temperatures are highest, bacterial growth is stimulated. The flow rate of water in the pipe, type of surface/substrate (type of pipe and deposits or tuberculation present), and concentration of inorganic materials work together to increase the amount of available nutrients for cell growth. The pH that provides for optimal cell growth is neutral. However, the biofilm pH is usually not the same as that of the water in the distribution system.

SOURCES OF CONTAMINATION

Bacterial contamination necessary for the formation of biofilm generally comes from one of three sources:

1. Breakthrough that occurs when the concentration of available disinfectant is not able to adequately eliminate or inactivate the bacteria which are present
2. Cross-connection contamination which allows bacteria to enter the distribution system due to back pressure or backsiphonage; or through infiltration, which allows bacteria to enter the distribution system due to aspiration

SOURCES OF CONTAMINATION (Cont.)

3. Contamination during installation or repair of the distribution system itself or of a plumbing system connected to the public water supply distribution system. Contamination is often caused by the entrance of only a few free "floating cells" (planktonic cells) into the distribution system. Minimum or inadequate disinfectant residuals or other disinfectant demands can allow these cells to attach to the wall of the pipe or other matter in the pipe. Once attached, these bacteria begin to grow rapidly, secreting a mucopolysaccharide (slimy) substance, which envelops or surrounds the cell. This secreted slime substance serves as a physical barrier to disinfection and allows the bacteria to continue to reproduce rapidly. This slimy substance is known as a glycocalyx, and is often resistant to normal operating or extremely high chlorine residuals.

INDICATORS OF BIOFILM GROWTH

Any one of the following symptoms indicate that a biofilm may be present:

1. Typical or atypical growth during bacterial analysis (presence of colonies or confluent growth – Too Numerous To Count [TNTC])
2. Lack of disinfectant residual, or difficulty in maintaining a consistent disinfectant residual
3. Presence of a slimy growth in water drawn from the tap or on pipe walls
4. Musty or yeasty odor to the water
5. A decrease in flow velocity

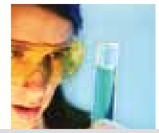
When any of these symptoms are present, samples should be collected and analyzed for bacterial culture and speciation to determine if a biofilm or biological regrowth is present. The specific organisms usually associated with biofilm include:

- Pseudomonas
- Bacillus
- Aeromonas
- Aerobacter
- Acinetobacter
- Enterobacter
- Escherschia
- Gallionella
- Leptothrix

These bacteria all produce a slimy sheath. The first five are not typically enumerated or identified in the coliform testing procedures required by current federal regulations. The next two bacteria (Enterobacter and Escherschia) are coliform bacteria, and would require investigation by the water supply. The last two organisms are iron-reducing bacteria and are found in both wells and distribution systems where a source of iron is abundant. Because the slime protects the bacteria by coating it with a slimy sheath, conventional disinfection using chlorine is generally not able to both penetrate the slime and eliminate or inactivate the bacteria.

Often times, the chlorine removes only the outer slime sheath, resulting in a higher bacterial count when the bacteria itself is exposed, without inactivating or eliminating the bacteria. One species of Pseudomanas, P. aeruginosa, is a very common organism found in biofilms. The organism is the causal agent for "swimmer's ear", and can also cause skin irritations and lesions. It is the most common culprit of swimming pool or spa closings. Recent research has linked P. aeruginosa to respiratory infections and related illnesses in both the very young and elderly populations, and persons with compromised immune systems, which includes persons undergoing dialysis, chemotherapy or treatment for other chronic illnesses. Contact is usually made when the water is in an aerosol form, through showers or vaporizers. A pink or rusty colored slimy substane usually accompanies the presence of this organism.

The focus of this paper is to study the results of treatment at three locations where bio-penetrants were used successfully to aid in dispersing the biofilm and exposing the causal organisms to disinfectant. The treatment was used after analysis of the water was performed to document that a biofilm was present, and after conventional superchlorination and flusing procedures had failed to restore water quality.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BIOPURGE®
CASE STUDY

CASE STUDY #1 WELL REHABILITATION-BACTERIAL NON COMPLIANCE

This utility experiences loss of production on an annual basis due to excess iron in the column pipe. While the performance of the well in Specific Capacity in gallons per minute per foot of draw down (SC) remains steady, there is a loss in output. Treatment of these wells with acid and chlorination is successful in returning the output to acceptable levels. However, following treatment, bacterial sampling required by the regulatory agency showing no growth was not achievable. The well(s) required numerous additional treatments of 500-1000 mg/l of chlorine in order to achieve compliance. This was difficult for both the contractor and the utility, as the well was not available for use until two days of negative growth were accomplished. The use of the biopenetrant in the last two years has allowed the utility to place the well back on line immediately after treatment, as the chlorine is able to perform its job more efficiently.

CASE STUDY #2 WELL REHABILITATION-PRODUCTION LOSS DUE TO IRON REDUCING BACTERIA

This well experienced rapid loss in Specific Capacity and production due to iron reducing bacteria within the formation. These bacteria were causing large amounts of iron and consequently iron oxides to reduce the output of the well. The use of acid for remediation was not satisfac- tory. After using both the bio-penetrant and a similar penetrant for iron oxides, the production of the well was brought back to standards similar to when the well was installed.

CASE STUDY #3 NEW CONSTRUCTION- BIOFILM REMEDIATION

This utility had completed the installation of 5000 feet of 12” water main. The regulatory requirements for placing the main in service were as follows:

1. Passing a pressure test to insure no leaks were apparent
2. No bacterial growth on two consecutive samples

The pressure test posed no problem for the utility. However, bacterial sampling indicated too numerous to count (TNTC) growth. After chlorinating to levels of 500 to 1000 mg/l and allowing 24 hour contact time, the results were still TNTC. Speciation was performed and the organisms were identified as Pseudomonas aeruginosa and Bacillus subtillus, both slime forming bacteria. The water main was treated again with 500 mg/l of chlorine with the addition of the bio-penetrant. The results indicated no growth and the treatments were repeated, again indicating no growth.

CONCLUSION

Biofilm growth in wells, distribution systems and new construction is an issue that has plagued utilities for many years. The occurrence of these problems in some ways appears to be rising. The information presented above is designed to give utility personnel the tools to recognize, identify and treat these types of problems. The use of non-phosphate bio-penetrants is indicating results, which will allow utilities to greatly reduce these problems and their side effects.

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