THE FACTS ON BIOFILM

“Did you know that…. a biofilm begins to form… the instant a clean pipe is filled with water”.

1) WHAT IS A BIOFILM?

A Biofilm is a community of micro-organisms attached to a solid surface.

A Biofilm community can include bacteria, fungi, yeasts, protozoa, virus and other micro-organisms.

A Biofilm is a collection of micro-organisms surrounded by the slime they secrete, attached to either an inert or living surface.

Common examples of Biofilm:
- the plaque on your teeth,
- the slippery slime on river stones,
- the gel-like film on the inside of a vase which held flowers for a week.

Biofilm exists wherever surfaces contact water.

2) SOME FACTS ABOUT BIOFILM

✔ More than 99 percent of all bacteria live in Biofilm communities.

✔ Biofilm can cause problems by corroding pipes, clogging water filters, causing rejection of medical implants, and harbouring bacteria that contaminate drinking water.

✔ Biofilm is not removed or affected by chlorine, bromine or hot water. Although treatment of the water system will kill free swimming bacteria, it will not affect those in the Biofilm. Consequently a rapid re-infection of the water will occur.

✔ Biofilm happily colonize many household surfaces, including toilets, sinks, countertops, and cutting boards in the kitchen and bath. Poor disinfection practices and ineffective cleaning products may increase the incidence of illnesses associated with pathogenic organisms associated with normal household activity.

✔ Biofilm are responsible for diseases such as otitis media, the most common acute ear infection in children in the U.S. Other diseases in which biofilms play a role include bacterial endocarditis (infection of the inner surface of the heart and its valves), cystic fibrosis (a chronic disorder resulting in increased susceptibility to serious lung infections), and Legionnaire's disease (an acute respiratory infection resulting from the aspiration of Legionella which live in the Biofilm).
Biofilm may be responsible for a wide variety of "nosocomial" (hospital-acquired) infections. Sources of Biofilm-related infections can include the surfaces of catheters, medical implants, wound dressings, or other types of medical devices.

Biofilm are highly resistant to antibiotics. Consequently, very high and/or long-term doses are often required to eradicate Biofilm-related infections.

Some Biofilm are beneficial. Sewage treatment plants, for instance, rely on Biofilm to remove contaminants from water.

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3) THE COST OF BIOFILM

Microbial Biofilms cost billions of Euros’ yearly in:
1. Equipment damage
2. Product contamination
3. Energy losses
4. Medical infections

4) SOME QUESTIONS ABOUT BIOFILM

Q: Why worry about Biofilm if it's stuck to a surface? I mean we don’t consume it so what are the dangers?

A: We can consume it if it detaches from the surface. The majority of free-floating (planktonic) bacteria have detached from a Biofilm. Biofilm can detach one of the following ways: A big chunk releases because it is unstable, or bacteria decide they want to move and begin to make their way downstream. This is when Biofilm becomes especially dangerous.

Biofilm poses a variety of health risks. Pseudomonas aeruginosa is one opportunistic pathogen known to cause disease. People with compromised immune systems, simply can't handle the bacteria. Same with Legionella - older people, those with a compromised immune systems, smokers are very susceptible to infection.

Q: How is Biofilm different from suspended (planktonic) bacteria?

A: Being attached rather than suspended makes a world of difference. Biofilm organisms have an enhanced survival mechanism. Bacteria change as soon as they are attached to a surface. The most obvious change is that they excrete a slimy material. Biofilm bacteria turn on a whole different set of genes, which makes it a significantly different organism to deal with. Biofilm behaviour is much more complex because they live in organized communities. They are resistant to traditional biocides (such as chlorine and bromine) and antimicrobial agents. Traditional disinfectants are effective for killing single cells, but not clumps therefore it only kills micro-organisms on the outside of the Biofilm.

Q: Why are suspended bacteria counts unreliable?

A: The monitoring of bacteria is tricky. Most of the bacteria that cause problems are sessile, or attached to a surface. Suspended bacteria counts provide false security because although you may have no suspended cells, you could still have Biofilm that is attached to the surface and may release clumps at any time. For the most accurate results, water should be sampled at the source (i.e. drinking valve), not further up the line.
Micro Biology made simple: BIOFILM FORMATION

STEP 1 - SURFACE CONDITIONING

Almost immediately after the clean pipe surface comes into contact with water, an organic layer deposits on the surface (Mittleman 1985). Therefore the first substances that come into contact with a surface are not bacteria but trace organics. These organics form a conditioning layer which neutralises excessive surface charge and surface free energy which may prevent micro-organisms from colonising a surface. The other advantage of this is that the organic molecules can serve as a nutrient to the bacteria.

STEP 2 - ADHESION OF PIONEER BACTERIA

Some of the planktonic (free-swimming) bacteria will approach the pipe wall and become entrained within the boundary layer, the zone at the pipe wall where flow velocity falls to zero. Some of these cells will strike and adsorb (stick) to the surface for a short time and then desorb (unstick). This is called reversible adsorption. This initial attachment is based on electrostatic attraction and physical forces, not chemical attachments. Some of the reversibly adsorbed cells begin to make preparations for a lengthy stay by forming structures which may permanently adhere the cell to the surface. These cells become irreversibly adsorbed.

STEP 3 - “SLIME” FORMATION

Biofilm bacteria excrete extracellular polymeric substances, or in simple terms a sticky polymer. This “sticky polymeric material” is in fact called glycocalyx. It is the glycocalyx that holds the biofilm together and sticks it to the pipe wall. Furthermore, its sticky strands trap nutrients and protect bacteria from most biocides, hot water and other toxic substances.

As nutrients accumulate, the pioneer cells proceed to reproduce. The daughter cells then produce their own glycocalyx, greatly increasing the volume of ion exchange surface. Pretty soon a thriving colony of bacteria is established. (Mayette 1992). In a mature biofilm, more of the volume is occupied by the loosely organised glycocalyx matrix (75-95%) than by bacterial cells (5-25%) (Geesey 1994). Because the glycocalyx matrix holds a lot of water, a biofilm covered surface is gelatinous and slippery.
Figure 4. Biofilm is made up of microbes strung together in a “spider’s web” of extracellular polymers (Mittleman 1985).

**STEP 4 - SECONDARY COLONISERS**

As well as trapping nutrients the glycocolyx also snares other types of micro-organisms into the biofilm. These “secondary colonisers” process the wastes from the primary colonisers, whilst their waste is in turn used by other cells. According to Borenstein (1994) “other bacteria and fungi become associated with the biofilm following colonisation by the pioneering species over a matter of days.”

Figure 5. Bacteria and other microorganisms develop co-operative colonies or “consortia” within the biofilm. An anaerobic biofilm may develop underneath the aerobic layer. The biofilm thickness will reach an equilibrium as flowing water detaches cells extending out into turbulent flow. (Borenstein 1994).

**STEP 5 – THE FULLY FUNCTIONING BIOFILM**

A mature, fully functioning biofilm is like a living tissue on a surface. It is a complex cooperative community made up from different species of micro-organisms each living in a customised micro-niche. Biofilms even have a primitive circulatory systems. Mature biofilms are imaginatively described as follows in an article called “Slime City”:

(Coghlan1996): Different species live cheek-by-jowl in slime cities, helping each other to exploit food supplies and to resist antibiotics through neighbourly interactions. Toxic waste produced by one species might be hungrily devoured by its neighbour. And by pooling their biochemical resources to build a communal slime city, several species of bacteria, each armed with different enzymes, can break down food supplies that no single species could digest alone...

“The biofilms are permeated at all levels by a network of channels through which water, bacterial garbage, nutrients, enzymes, metabolites and oxygen travel to and fro. Gradients of chemicals and ions between micro-zones provide the power to shunt the substances around the biofilm.”

**STEP 6 - BIOFILMS GROW AND SPREAD**

A biofilm will spread itself by ordinary cell division, but it will also periodically release “pioneer” cells (such as Legionella) to (re)colonise new downstream sections of pipework. According to Mayette (1992): “These later pioneer cells have a somewhat easier time of it than their upstream predecessors since the parent film will release wastes into the stream which may serve as either an initial organic coating for un-colonised pipe sections down stream or as a nutrient substance.”
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