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Biofouling: Key Characteristics

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EDITORIAL

Biofouling in industrial water systems is a significant technological and economic issue. Biofouling is the unwanted deposition of micro- and macro-organisms on industrial cooling equipment, which causes operational failures such as blockage of cooling water conduits and condenser tubes, reduced heat transfer efficiency, and accelerated pipeline corrosion. To comprehend the phenomena of biofouling, it is necessary to understand how microbial biofilms form and how macro-foulants settle in succession. The antifouling techniques used to control biofouling are determined by the type of cooling system used and the fouling organisms present. The author briefly discusses the different types of cooling systems, explains the phases in biofilm development, defines biofouling, discusses fouling issues in a coastal power plant, and lastly discusses the use of chlorine in biofouling treatment.

The marine sector is concerned about biofouling. Biofouling affects the buoyancy of maritime infrastructure such as ships, platforms, and nets by increasing fuel consumption, speeding up corrosion, clogging membranes and pipes, and clogging membranes and pipes. While poisonous biocidal coatings have historically protected maritime infrastructure, new nanomaterial-based anti-fouling coatings are being developed in response to current environmental concerns and laws. Hybrid nanocomposites of organic-inorganic materials allow the features of both groups of materials to be combined, allowing for biofouling prevention. The development of eco-friendly marine coatings including photocatalytic nanomaterials is being aided by bio-inspired surface designs, breakthroughs in polymer science, and developments in nanotechnology. Photocatalysis, antifouling activity, and coating formation employing metal and metal oxide nanomaterials are the key topics covered in this study (nanoparticles, nanowires, nanorods). Furthermore, the use of nanocomposite coatings to prevent micro- and macrofouling in maritime settings.

Membrane performance is degraded by biological fouling by bacteria. Because it protects germs from shear pressures and disinfection agents, a biofilm is difficult to remove. Colloidal matter is made up of microorganisms such as bacteria, algae, fungus, viruses, and higher creatures (average bacterium size is 1–3 m). Due to mutual interactions between different types of fouling, biofouling can be complicated; for example, if iron oxide or a biofilm accumulates on the membrane surface, it prevents the migration of ions (calcium, sulphate) and other solutes back into the bulk solution, resulting in a supersaturated condition, as discussed in Chapter 1. As a result, gypsum (calcium sulphate) scale forms beneath the main foulant and is more difficult to remove than iron scale or biofilm. Surface water has a larger risk of biological fouling than well water.

Key characteristics

Biofilms must be sampled properly in order to detect biofouling. A biofilm has the following characteristics:

(a) High water and organic matter content (70–95 percent),

(b) High numbers of colony-forming units and cells,

(c) High carbohydrate and protein content,

(d) High adenosine triphosphate (ATP) content, and

(e) Low inorganic matter content.

Bacteria are completely rejected by RO membranes. Microorganisms can be discovered in the permeate owing to:

(a) O-ring leakage,

(b) Tiny flaws in the membrane surface,

(c) Microbial contamination of the feed water, and

(d) Microorganism growth from polluted pipework.

Microbes can live and reproduce in low-nutrient environments (5–100 ppb TOC) thanks to the biofilm mode of development. Biofouling is a sluggish process in general.

Membrane biofouling has the following cumulative effects:

(a) Higher cleaning and maintenance expenses,

(b) A notable degradation in product water quality, and

(c) Considerably shorter membrane life.

Biofouling can cause secondary mechanical deformation of SW membrane components (telescoping). Biofouling of membrane surfaces is always accompanied by mineral deposition in some form.

Biofilm may be thought of as a thick gel layer in which dissolved minerals prefer to collect and cause concentration polarisation. Owing to their viscoelastic qualities, biofouling causes flow losses due to constriction of the flow channel, increased surface roughness, and increased drag.

The irreversible adsorption of macromolecules, which results in a "conditioning film," is the initial stage in biofilm development prior to microbial attachment (humic substances, lipopolysaccharides, microbial products). The electrostatic charge and critical surface tension of the membrane may vary as a result of this conditioning layer.