It's Alive!

Bioremediating parts washers are in the process of graduating from emerging, experimental technology to efficient aqueous alternative. This method of cleaning is one example of how some manufacturers are minimizing wastewater concerns and, in the process, optimizing cleaning potential.

Despite increasing acceptance in environmental and regulatory circles as a viable tool in pollution clean-up efforts, *bioremediaction* was not a term heard often in the parts cleaning industry until very recently. In the last few years, the technology required to introduce and control biological components in specifically designed aqueous parts cleaners has been perfected and applied successfully. The result is highly effective parts cleaning systems with extremely long bath lives. In fact, it is now possible for some companies to operate properly maintained bioremediating parts washing systems for years without changing the bath at all.

Because of the relative newness of this process within the arena of parts cleaning, questions abound. Is biormediation the same as "biologically active" or "biodegradable"? How does bioremediation work in a parts cleaner? What advantages does it have over other cleaning methods?

Getting Through the lingo

A biologically active product is one that could and should contain live colonies of microbes designed to accomplish some designated task. The difficulty in evaluating such product lies in determining what the product is supposed to do and how that affects cleaning ability. A cleaning product that is biologically active is inherently no more effective than cleaners that are inactive or not "alive."

Though the biological entity in some products may he touted as waging an immediate attack on oil and grease, that may not he pos-

Letting Microbes Do the Dirty Work

sible. If the biological actitvity is to contribute to cleaning, the microbes must go through a process similar to digestion. Just as it takes time for a human being to digest a hamburger--to change the food into unstable components--a biologically active cleaner can impact actual cleaning capability over some period of time, hut not instantly.

Similarly, describing a product as " 100% biodegradable" can he misleading, because it is more unusual for a product to he non-biodegradable than otherwise. After all, mercury is biodegradable over several thousand years; the real question as a basis for differentiation is haul long the process takes. Any product that will break down into component part due to biological action is, by definition, biodegradable. A cleaning product that takes years to break down, however, offers no biological advantage in cleaning and no advantage for the environment.

Eating Away Contamination

So how does bioremediation apply to parts cleaning? Well, the term itself means "to break down environmentally hazardous or potentially hazardous materials through the action of living organisms." Therefore, before the process can take place, there has to he some accumulation of toxic or potentially toxic chemicals that need to he reduced or eliminated.

In the world of parts cleaning, there is no shortage of such substances. Chemicals and toxins from the grime, grease, and oil that coat incoming components are a microbial smorgasbord But,

by Thomas W. McNally

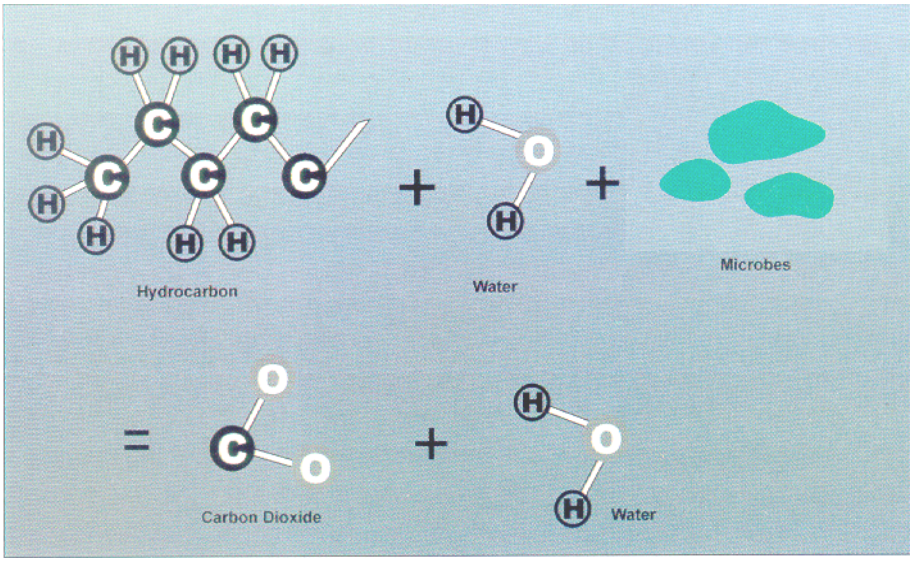


Figure 1. The process of bioremediation.

given the fine degree of cleaning afforded by bioremediation, the base contaminant must be removed from the parts before the process can take place. Microbes do their job best when they can encompass a substance-that is, when it is free-floating rather than attached to a surface.

This means that a bioremediating parts washer is initially only as good as the cleaner that removes the contaminant from the part. No matter how effective the technology involved in remediating potentially hazardous materials, if the dirt and grease are still on the part, the system will not work. The effectiveness of any bioremediating parts washer lies in the agent cleaning the part while the microbes clean the fluid.

Clean fluid ultimately means cleaner parts. That is the key to the success of bioremediating systems: the fluid is kept clean, which allows the system to clean more efficiently for a greater length of time. Since microbes feed off the dirt in cleaning fluids, disposal headaches associated with contaminated fluids are also significantly reduced.

Chemistry Compatibility

Early attempts at developing bioremediating parts cleaners were hampered by problems of mutual exclusivity-either the cleaner killed the microbes, or the microbes ate the cleaners. Today, however, there are a few efficient cleaning chemistries being marketed (eg, surfactant/degreasers and emulsifiers) that are compatible with microbe growth. They are generally pH-neutral, nonflammable, aqueous-based combinations of chemicals that contain no hazardous ingredients that could harm workers or interfere with biological development.

Of course, not all pH-neutral cleaning fluids are created equal: fluids designed for bioremediating parts washers should be clearly marked for that type of use in specifically designed parts cleaners. Likewise, within the category of microbe-compatible fluids, different chemistries will be better suited to some applications than others, and some fluids might only work on specific types of contaminants. It is unlikely that one brand of cleaner in a given bioremediation washing system will prove efficient for all types of parts.

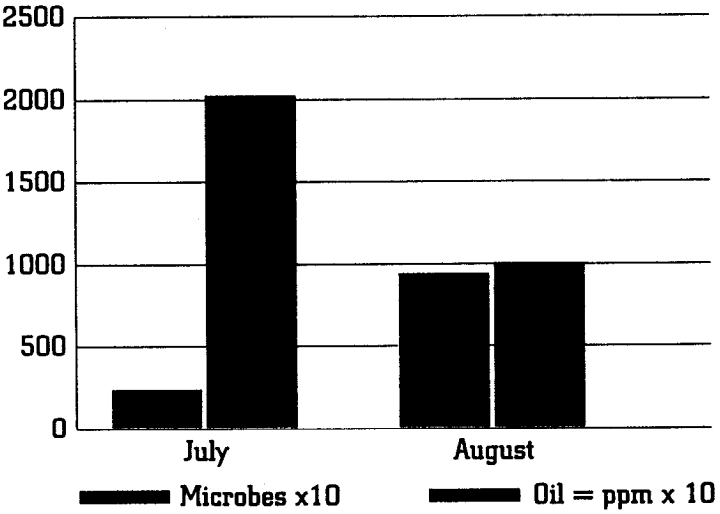


Figure 2. Oil degradation test: washer #1.

Here's How It Works

The sequence of events in most bioremediating parts washers begins when the surfactant/degreaser cleaning agent in the fluid breaks the bond between the contaminants and the part itself, lifting off the dirt like a liquid spatula. The contaminants are then carried by the cleaning fluid through a filtering device, or mat, where particulate matter, such as common dirt, paint chips, and other items larger than 50 microns, are retained.

The action of the fluid flowing through the mat releases a combination of microbes and nutrients into a holding tank positioned below the mat. The microbes released into (and now living in) the fluid exude natural enzymes (eg, lipase [fats, oils], amylase [starches], and protease [proteins]), which cleave the molecular bonds in hydrocarbon molecules (ie, contaminants, like oil and grease). This action releases carbon as a source nutrient for the microbes. In other words, the organisms come to life and "eat" the oil and grease.

Byproducts of this process (with pure hydrocarbons) are water and carbon dioxide (Figure 1). Clean fluid is recirculated from the bottom of the parts cleaner/bioreactor tank so that there is no interruption in the cleaning process.

Effective bioremediating systems use a combination of aerobic and anaerobic microorganisms that are selected on the basis of carbon utilization potential and environmental hardiness. Aeration provided by the flow of fluid through nozzles and spigots provides adequate additional oxygen to certain strains, while others work below the surface in the holding tank to break down contaminants that may settle to the bottom of the tank.

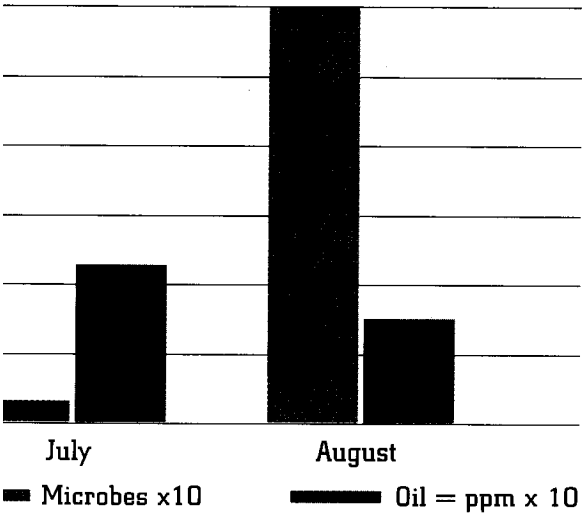
The carbon utilization potential is measured in nanometers of optical density after a process known as an endpoint assay. A combination of microbes and a contaminant (carbon source) is incubated for 24 hours in the presence of a dye, which changes color if the microbes are using a contaminant as a carbon source. The

higher the optical density, the better the strains of microbes are at using a particular carbon source.

Environmental hardiness, or the microbe's ability to survive until needed is measured by statistical sampling of the number of colony forming units (CFUs) present after subjecting microbes to various environmental shocks and then incubating samples under controlled conditions. Nutrients are generally added as part of the cleaning mix to provide emerging microbes with fortification until sufficient amounts of oil and grease have been introduced as carbon sources.

Cannibalism Is a Good Thing

Since the microbes in bioremediating systems are quiescent in the mat until fluid is added, there are no concerns about storage and viability over extended shelf periods. The microbial pads should be changed at least every 30 days, which accomplishes two objectives. Monthly replacement limits the possibility that trace metals trapped in the mat during the cleaning process will build up to hazardous levels, making pad disposal problematic. Also, changing the pad "refreshes" the microbes by ensuring that it fresh, vigorous colony is started every 30 days. The new microbes cannibalize the old colony each time the pad is replaced.



gradation test: washer #2.

Temperature is important in promoting the sequence of events that makes a bioremediation system successful. Fluid in the holding tank should be maintained at approximately 105°F This elevated temperature aids in the cleaning process by raising the efficiency of the cleaning fluid and also providingan optimum environment for microbial reproduction and digestive processes. Straining out solid contaminants before they reach the hold-

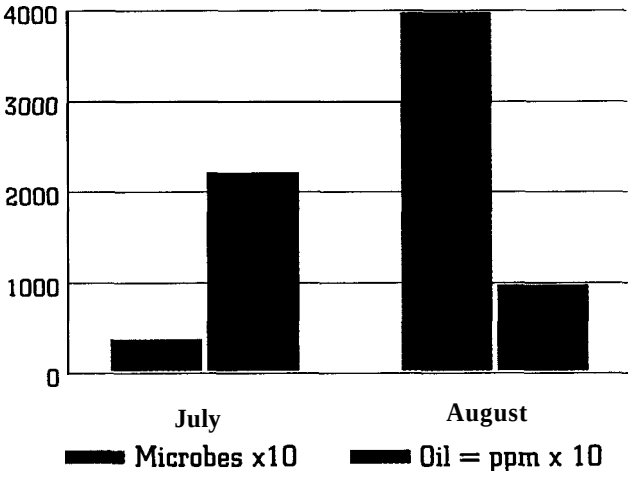


Figure 4. Oil degradation test: washer #3.

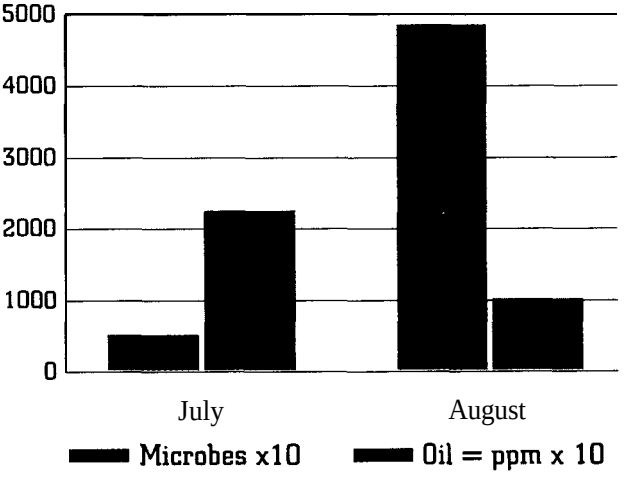


Figure 5. Oil degradation test: washer #4.

ing tank eliminates the components that form sludge; in fact, little or no accumulation of sludge takes place in a properly operating bioremediating parts washer.

Supporting Evidence

Bioremediation is a technique that has been proven to he quite effective in parts cleaning operations. In a working bioremediating parts washer, analysis of oil and grease levels in fluid over time, compared with levels of microbial activity, can he empirically demonstrated to he inversely related. More simply put, the number of microbes increases as parts per million of oil and grease decline.

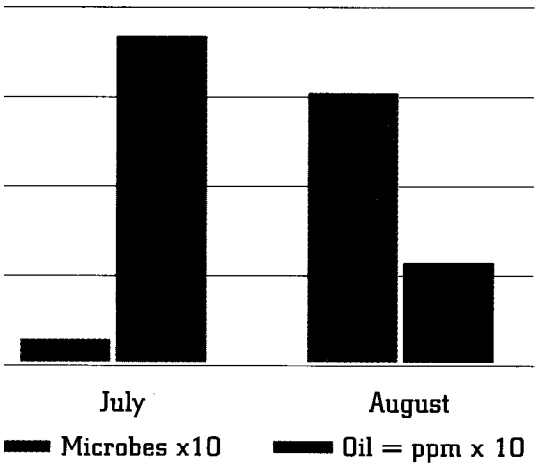
Figures 2-9 show the results of analyses coducted to demonstrate this relationship between the presence of oil and microbial activity. The test methods used in these analyses were based largely on the typical usage of bioremediation parts washers in an industrial environment. An independent biochemist was retained as an outside contractor to conduct the tests. Filters consisted of those shipped with the machines, and samples from eight operating machines were obtained at 30-day intervals.

Not Just Any Class of Microbe

Like many technologies, bioremediation is a technique that incorporates components designed specifically for use in such systems. The microhcs provided in safe bioremediating parts washers should be American Type Culture Collection (ATCC) Class 1 organisms. These organisms are considered to pose no recognized hazard under ordinary conditions and found to be a minimum health risk to humans and animals through numerous studies. The strains used in parts washcrs should he also deemed acceptable for use in environmental applications with respect to United States Environmental Protection Agency (EPA) standards (40 CFR 700, et al).

"The natural bacteria flora in soil and water contain the identified groups (of microbes)," said Dr. Judith Bender, Research Professor at the Center for Science and Technology at Clark Atlanta University. "They're as common as--and no more harmful than--ordinary dirt."

There is no genetic manipulation involved in bioremediation. and since the organisms used in a bioremediating parts washer are isolated from natural sources,



e 6. Oil degradation test: washer #5.

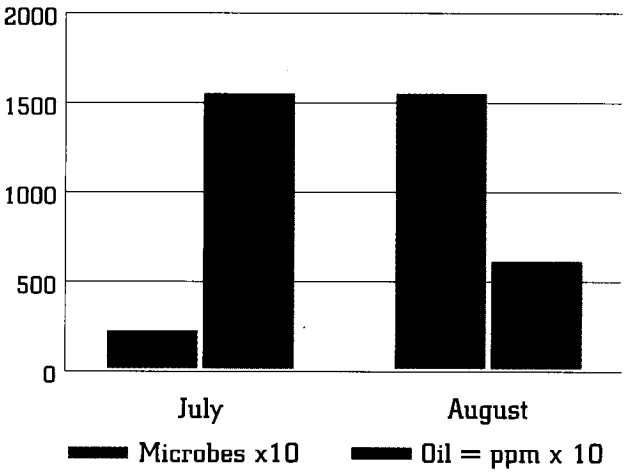


Figure 7. Oil degradation test: washer #6.

they meet the Toxic Substances Control Act (TSCA) definition of "naturally occurring."

Once a bioremediating parts washer is up and running, it is actually "alive," and introducing bleach, disinfectants, or other biocides could kill the microbes. Trace amounts of biocides left on tooled parts after processing, however, will visually not harm the active solution. Cool or cold temperatures will also not kill the microbes, but this will slow down the biorermedation process. And, of course, high heat (generally over 140°F) will kill microbes, as witnessed in sterilization practices of hospitals for surgical and other instruments.

Urban legends

"I tried one of those things once, and it got cold, the microbes died, and the whole machine started to stink **up** the place." So might have been the remark from an unsatisfied customer back in the early 1990s, when some companies rushed products to market before testing was complete. Some bioremediating machines did have a distinctive "barnyard" odor. That problem is no longer evident in today's bioremediating parts washers that are manufactured by reputable companies. And, as mentioned, cold is not the culprit in destroying microbe colonies.

"I heard that if you don't rinse the part off real good, that the 'bugs' will get into lubricants and eat them all up, ruining the machinery." Another myth. in fact, microbes selected for use in bioremediating parts washers need the water component in cleaning fluids to survive, and they will not live very long in lubricants or oils. Additionally, the temperatures reached in an operating engine or machine would likely kill any microbes that may have survived the journey from the parts washer to the operating machinery.

"If someone with TB or AIDS uses this machine, they'll pass it along to the next person." Not true. While the environment in a bioremediating parts washer is indeed friendly to hydrocarbom-loving "bugs," it is distinctly hostile to the mycobacteria that carry tuberculosis and to most other pathogenic (harmful to humans) bacteria. And, as has been widely stated, AIDS is a virus that is not communicable through casual contact.

Crunching the Numbers

Solvent parts washers work by dissolving hydrocarbon contaminants into the solvent cleaner itself, so that as the parts cleaner works, the solvent becomes progressively dirtier. As it "loads" with contaminants, the solvent becomes leas effective, leaves more dirt on the parts being cleaned, and can become a hazardous waste. By contrast, a properly operating bioremediating parts washer is effective because the cleaning fluid stays clean.

Contaminants such as oil and grease are emulsified into the cleaning solution, where the michrobes go to work breaking the emulsified contaminants into water and carbon dioxide. The water combines with the fluid, and the carbon dioxide escapes into the atmosphere--in volumes so slight as to he almost immeasurable. And even though the bioremediating process takes time, the emulsified oil not yet digested will not redeposit on parts being cleaned because oil in emulsion will not reattach to metal surfaces. The result is a parts cleaner that cleans itself, does not generate streams of liquid hazardous waste, and can provide years of effective service with a limited waste stream.

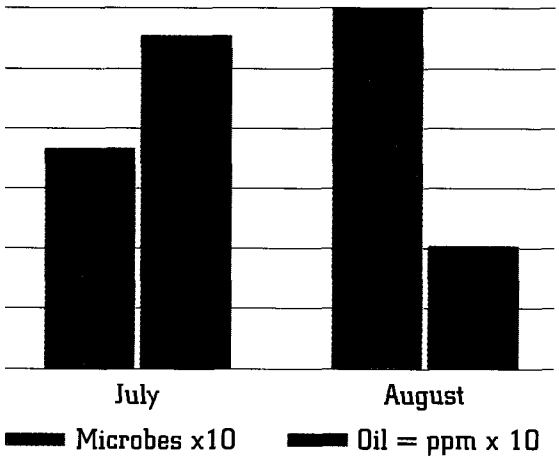
Several sizes and models of bioremediating parts washers are available today. A free-standing, 25-gallon machine with a 21 to 44 inch sink, with all the fluid and filters necessary to get started, will cost about $1500 to $2000 or more. After a unit is in service, it will use approximately five gallons of cleaning fluid every six to eight weeks because of evaporation and "walk-away" (ie, fluid left on parts after they are cleaned).

Replenishing the fluid will cost from about $12 per gallon to over $20 or more per gallon, depending on the grade of cleaner required for the application being considered. Replacing the microbial mat every 30 days should cost anywhere from $10 to $20 for each replacement.

Success Stories

As of the end of 1998, there were tens of thousands of bioremediating parts washers in use throughout the United States and in several foreign countries, and favorable reports abound. A major aeronautical firm purchased 23 bioremediating parts washers to replace cold parts cleaners that were using chlorinated solvents to remove grease and oil from parts in maintenance, transportation, tooling, experimental, and research and development divisions. The firm concluded that using the bioremdiating parts washers in all of those locationa reduced the use of hazardous solvents by more than 900 gallons and saved the company more than $80,000 during the first year of use.[1]

The Texas Army National Guard invested approximately $15,000 in August 1995 to purchase 10 bioremememiating parts washers to replace mineral spirits parts washers in motor pool operations. They calculate that, in 1996, they eleminatd 600 gallons of solvent waste, saved $5130 in waste disposal requirements, and saved $4200 per year in solvent purchase costs, for an estimated payback period in hard dollars of about 18 months. At the same time, however, they eliminated manifesting requirements, significantly reduced waste streams and VOC emissions, and dramatically improved the health and safety environment for their personnel.[2]



re 8. Oil degradation test: washer #7.

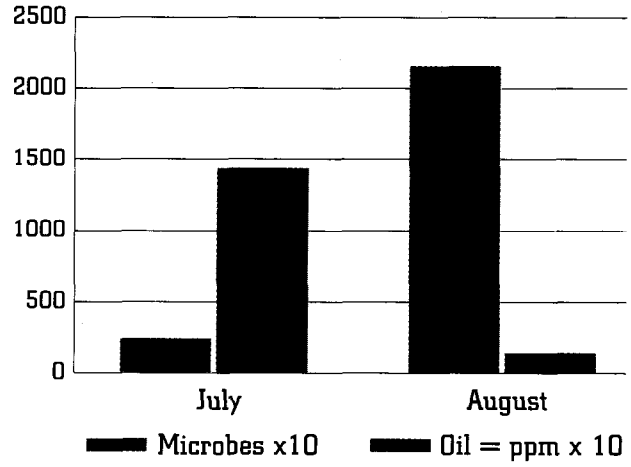


Figure 9. Oil degradation test: washer #8.

A Cadillac, Buick, and Land Rover dealer in the Southwest installed four biorermediating parts cleaners "for three main reasons: to reduce our generator status to Conditionally Exempt Small Quantity generator (and never have to file those EPA forms for the hazardous waste report); to have more control over solvent costs and management; and to find an alternative cleaner that posed less of a health threat to our technicians." Their initial investment was about $5000, with first-year costs of $416 for the replacement fluid and $288 for replacement mats. The firm estimated their annual savings at about $3330 per year after the first. [3]

Is It Worth It?

Biorermediating parts washers are in the process of graduating from emerging, experimental technology to an efficient aqueous alternative. While they may not yet be approximate in all cases, their efficacy is demonstrable in many applications. The technology is one of many new cleaning methods developed to meet the ever-increasing demand for environmentally safe processes in the manufacturing industry. Given the current regulatory trends in this country and abroad, minimizing wastewater concerns and maximizing recycling efforts are--and will remain--primary goals of those in the field of parts cleaning. Bioremediation is one technique designed to bring manufacturers closer to these goals. ■

References

1. *Engineers Digest,* July 1997, p 37.
2. Texas Army National Guard, National *Defense Industrial Association Proceedings, August, 1996.*
3. The Nevada Waste Reporter, Spring 1996.

About the Author

Tom McNally is vice president and general manager of ChemFree Corporation. He is an inventor on several patents pending and allowed for processes and designs incorporated into the ChemFree SmartWasher®, a bioremediating parts washing system marketed worldwide. Mr McNally attended Hamilton College in Clinton, NY, and graduated from Old Dominion University in Norfolk, Va. He also serves as chief executive officer and a director of Microbial Aquatic Treatment Systems (MATS), *an emerging technology company in the phytoremediation field.*