Removing Pathogens Using Nano-Ceramic-Fiber Filters

Filters remove greater than 99.9999 percent of viruses and bacteria from wastewater.

Lyndon B. Johnson Space Center, Houston, Texas

A nano-aluminum-oxide fiber of only 2 nanometers in diameter was used to develop a ceramic-fiber filter. The fibers are electropositive and, when formulated into a filter material (NanoCeram®), would attract electronegative particles such as bacteria and viruses. The ability to detect and then remove viruses as well as bacteria is of concern in space cabins since they may be carried onboard by space crews. Moreover, an improved filter was desired that would polish the effluent from condensed moisture and wastewater, producing potable drinking water. A laboratory-size filter was developed that was capable of removing greater than 99.9999 percent of bacteria and virus. Such a removal was achieved at flow rates hundreds of times greater than those through ultraporous membranes that remove particles by sieving. Because the pore size of the new filter was rather large as compared to ultraporous membranes, it was found to be more resistant to clogging.

Additionally, a full-size cartridge is being developed that is capable of serving a full space crew. During this ongoing effort, research demonstrated that the filter media was a very efficient adsorbent for DNA (deoxyribonucleic acid), RNA (ribonucleic acid), and endotoxins. Since the adsorption is based on the charge of the macromolecules, there is also a potential for separating proteins and other particulates on the basis of their charge differences. The separation of specific proteins is a major new thrust of biotechnology.

The principal application of NanoCeram® filters is based on their ability to remove viruses from water. The removal of more than 99.9999 percent of viruses was achieved by a NanoCeram® polishing filter added to the effluent of an existing filtration device. NanoCeram® is commercially available in laboratory-size filter discs and in the form of a syringe filter. The unique characteristic of the filter can be demonstrated by its ability to remove particulate dyes such as Metanyl yellow. Its particle size is only 2 nanometers, about the size of a DNA molecule, yet the NanoCeram® syringe filter is capable of retaining the dyes as the fluid is passed through the syringe, without much backpressure. Endotoxins, which are contaminants that are part of the residue of destroyed bacteria, can cause toxic shock and are therefore of major concern in pharmaceutical products. The NanoCeram® syringe filter is capable of removing greater than 99.96 percent of the endotoxins.

This work was done by Frederick Tepper and Leonid Kaledin of Argonide Corp. for **Johnson Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MSC-23478, volume and number of this NASA Tech Briefs *issue, and the page number.*

Satellite-Derived Management Zones

Precision agriculture can be practiced at low cost.

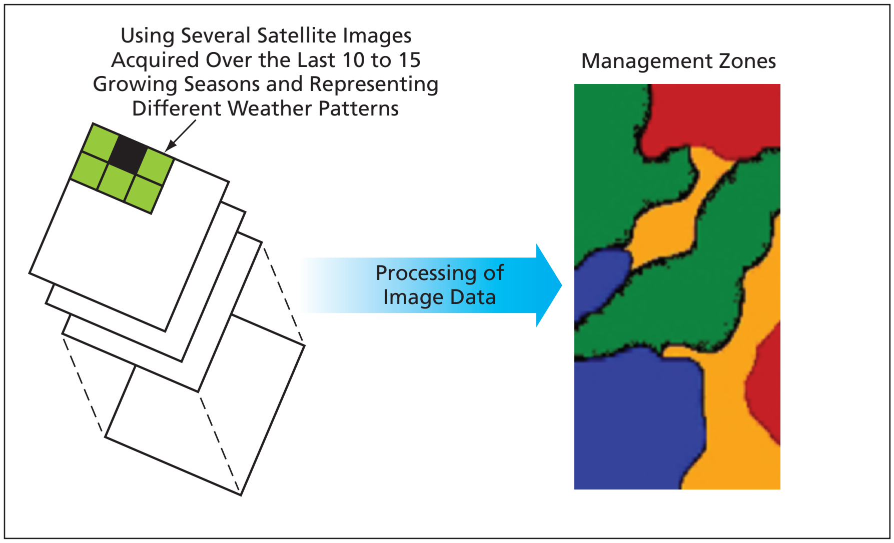
Stennis Space Center, Mississippi

The term "satellite-derived management zones" (SAMZ) denotes agricultural management zones that are subdivisions of large fields and that are derived from images of the fields acquired by instruments aboard Earth-orbiting satellites during approximately the past 15 years. "SAMZ" also denotes the methodology and the software that implements the methodology for creating such zones. The SAMZ approach is one of several products of continuing efforts to realize a concept of precision agriculture, which involves optimal variations in seeding, in application of chemicals, and in irrigation, plus decisions to farm or not to farm certain portions of fields, all in an effort to maximize profitability in view of spatial and temporal variations in the growth and health of crops, and in the chemical and physical conditions of soils.

As used here, "management zone" signifies, more precisely, a subdivision of a field within which the crop-production behavior is regarded as homogeneous. From the perspective of precision agriculture, management zones are the smallest subdivisions between which the seeding, application of chemicals, and other management parameters are to be varied.

In the SAMZ approach, the main sources of data are the archives of satellite imagery that have been collected over the years for diverse purposes. One of the main advantages afforded by the SAMZ approach is that the data in these archives can be reused for purposes of precision agriculture at low cost. *De facto*, these archives contain information on all sources of variability within a field, including weather, crop types, crop management, soil types, and water drainage patterns.

The SAMZ methodology involves the establishment of a Web-based interface based on an algorithm that generates management zones automatically and quickly from archival satellite image data in response to requests from farmers. A farmer can make a request by either uploading data describing a field boundary to the Web site or else drawing the boundary on a reference image. Hence, a farmer can start to engage in precision farming shortly after gaining



Multiple Satellite Images of a Field are analyzed to identify zones for which different precision-agriculture treatments are needed.

access to the Web site, without the need for incurring the high costs of conventional precision-agriculture data-collection practices that include collecting soil samples, mapping electrical conductivity of soil, and compiling multiyear crop-yield data.

Given the boundary of a field, a SAMZ server computes the zones within the field in a three-stage process. In the first stage, a vector-valued image of the field is constructed by assembling, from the archives, the equivalent of a stack of the available images of the field (see figure). In the second stage, the vector-valued image is analyzed by use of a wavelet transform that detects spatial variations considered significant for precision farming while suppressing small-scale heterogeneities that are regarded as insignificant. In the third stage, a segmentation algorithm assembles the zones from smaller regions that have been identified in the wavelet analysis.

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In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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