National Decentralized Water Resources Capacity Development Project

Executive Summary

Performance of Engineered Treatment Units and Their Effects on Biozone Formation in Soil and System Purification Efficiency

Environmental Science and Engineering
Colorado School of Mines
Golden, Colorado

September 2005

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Submitted by the Colorado School of Mines
Golden, Colorado

NDWRCDP Project Number: **WU-HT-03-36**

National Decentralized Water Resources Capacity Development Project (NDWRCDP) Research Project

Final Report, **September 2005**

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DISCLAIMER

This work was supported by the National Decentralized Water Resources Capacity Development Project (NDWRCDP) with funding provided by the U.S. Environmental Protection Agency through a Cooperative Agreement (EPA No. CR827881-01-0) with Washington University in St. Louis. This report has not been reviewed by the U.S. Environmental Protection Agency. This report has been reviewed by a panel of experts selected by the NDWRCDP. The contents of this report do not necessarily reflect the views and policies of the NDWRCDP, Washington University, or the U.S. Environmental Protection Agency, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

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The final report was edited and produced by ProWrite Inc., Reynoldsburg, OH.

This report is available online at www.ndwrcdp.org. This report is also available through the

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WWCDRE52

This report should be cited in the following manner:

Van Cuyk, S., R. L. Siegrist, K. Lowe, J. Drewes, J. Munakata-Marr, and L. Figueroa. 2005. *Performance of Engineered Treatment Units and Their Effects on Biozone Formation in Soil and System Purification Efficiency*. Project No. WU-HT-03-36. Prepared for the National Decentralized Water Resources Capacity Development Project, Washington University, St. Louis, MO, by the Colorado School of Mines, Golden, CO.

ACKNOWLEDGEMENTS

Appreciation is extended to the following individuals for assistance in the preparation of this report:

Colorado School of Mines, Golden, CO

Sheila Van Cuyk
Robert Siegrist
Kathryn Lowe
Jörg Drewes
Junko Munakata-Marr
Linda Figueroa
John Albert
Kathy DeJong
Charlotte Dimick
Elin Larsson
John Luna
Jim McKinley
Johanna Persson
Tanja Rauch
Kyle Tackett
Ryan Walsh

The following are acknowledged for their support and technical guidance:

Orenco Systems, Inc., Sutherlin, OR
Terry Bounds
Chris Helliwell

SCG Enterprises, Conifer, CO
Angela Helliwell
Mike Scrivner
Roger Shafer

Zenon Environmental Corp., Canada
Hadi Husain
Heather Lossing

United States Geological Survey, Boulder, CO
Dr. Larry Barber

Appreciation is also expressed to the NDWRCDP for their support of this work:

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ABSTRACT

The research described in this report investigated the field performance of onsite wastewater systems (OWSs) using engineered treatment units followed by soil treatment. The goal of this type of OWS is to enable higher—or equivalent—performance at higher hydraulic loading rates (HLRs) and/or less unsaturated soil depth.

The primary objectives of the research were:

- Delineate the effluent quality over time with respect to chemicals and pathogens from treatment units which produce effluents of differing qualities
- Determine the effects of higher effluent quality on soil clogging and biozone development during effluent infiltration and percolation in soil
- Determine the treatment efficiency achieved by tank-based treatment units and soil treatment unit operations for selected chemicals and pathogens

The research was completed through field experimentation at the Mines Park Test Site located on the Colorado School of Mines (CSM) campus in Golden, Colorado.

In this project, the effluent qualities produced by three different treatment units—septic tank, septic tank with textile filter unit (TFU), and septic tank with a membrane bioreactor (MBR)—were characterized in detail. The effects of these effluent qualities on the hydraulic and purification performance achieved during soil treatment in an Ascalon sandy loam soil were studied. Full-scale treatment units and pilot-scale soil test cells were established and started up during spring 2004. Operation of the test cells and engineered treatment units continues.

The effluents generated by the septic tank, TFU, and MBR units, after a period of start-up operations, were consistent in quality for each unit. As expected, the three treatment units achieved different treatment efficiencies for organic matter, solids, nutrients, and bacteria. The relative efficiency ranking shows: septic tank effluent (STE) << TFU << MBR. The relative ranking for operational complexity, operation and maintenance requirements, energy use, and cost, followed a similar pattern: STE << TFU << MBR. Due to the short duration of the performance evaluation completed, it is difficult to estimate the service life, long-term operation and maintenance requirements, or life-cycle costs of the OWSs using a TFU or MBR.

Adding an engineered treatment unit to produce higher-quality effluent than typical STE, can retard soil-clogging development and enable application of higher HLRs to soil and, concomitantly, smaller soil treatment units (assuming purification is reliably achieved over the service life of the system). However, the magnitude of the increases in HLRs enabled by higher effluent quality is likely limited by the hydraulic properties of the natural soil. It may be

reasonable to limit the daily design HLR for a given soil treatment unit regardless of effluent quality, to a small percentage of the soil's saturated hydraulic conductivity (K_{sat}) (for example, design daily HLR = 3 to 5% of the K_{sat}).

The treatment train purification for chemicals such as organic matter and nitrogen was extremely high (more than 99%), and it follows a trend of higher performance: septic tank + MBR + soil treatment is greater than septic tank + TFU + soil treatment, which is greater than septic tank + soil treatment.

The treatment trains including a TFU or MBR, generally perform better with respect to purification. They are less affected by HLR than the treatment train based on only STE and soil treatment. The overall performance of the treatment trains with a TFU or MBR is relatively better with 60 cm of soil. Increasing the vadose zone soil depth (for example, from 60 cm to 120 cm) tends to shrink the differences in performance between the three treatment trains. The ability of an Ascalon sandy loam soil to remove virus was quite high by 60 cm. At that depth it was insensitive to whether the natural soil had received STE, TFU effluent, or MBR effluent at experimental design HLRs of either two or eight centimeters per day (cm/d).

The results of bromide tracer tests and infiltration rate measurements and modeling reveal that some degree of soil clogging and biozone formation is occurring in the Ascalon sandy loam soil, even with higher-quality effluents applied. Also, viruses are being effectively removed (removal in soil of about 6-logs).

During this project, a major field experiment was established and operations were initiated, yielding an array of treatment unit operations and performance data over a period of approximately six months (April to October 2004). This research duration has provided valuable insight concerning the startup and early operation and performance of an OWS, but a longer period of monitoring and assessment is needed to develop long-term data and provide greater insight relevant to full-scale system operation.

Printed on recycled paper in the United States of America.

WU-HT-03-36

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