

MPC-499

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Project Title

Reuse of Aqueous Waste Streams in Transportation-Related Applications

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Research Needs

Aqueous waste streams can be produced from many commercial, industrial, and municipal processes or activities. Proper management, treatment and disposal or reuse of these waste streams are necessary to conserve natural resources and reduce their environmental impacts. In South Dakota, aqueous waste streams generating processes include municipal water and wastewater treatment, oil and gas production, ethanol production, food processing (cheese, meat and others), and other industrial processes (ion exchange, reverse osmosis, etc.). These aqueous waste streams can be recycled or reused to reduce the demand on natural water resources. Beneficial reuse of these waste streams will save the cost of waste treatment and disposal, reduce the consumption of natural resources, and minimize the environmental impacts.

Aqueous waste streams have been used by transportation agencies as alternative anti-icing and deicing materials and dust suppressants on unpaved roads to reduce maintenance costs (USEPA, 2002; Michigan DEQ, 2002; Federal Highway Administration, 2013). This practice also reduces the costs associated with management, treatment and disposal of the waste materials. Most departments of transportation (DOTs) rely on chloride-based anti-icing and deicing compounds for treating roadways during winter weather events to ensure the safety of transportation. The most common chloride-based compound is sodium chloride (rock salt). Magnesium chloride and calcium chloride are also frequently used. The traditional method of pavement deicing is applying dry, granular rock salts and sands to the roadway during the storm event. In recent years, there has been growing interest in using salt brine as an anti-icing compound (Minnesota DOT, 2013). Pre-wetting using salt brines has been shown to increase the performance of salts and abrasives, as well as their longevity on the roadway surface, thereby reducing the amount of materials required (Levelton, 2007; Minnesota DOT, 2012).

Oil-field brine is a saline byproduct that is generated during oil and gas drilling, completion, and production operations. This salt brine is permitted by Michigan, New York, North Dakota, Ohio, Pennsylvania, and other states for snow and ice control. Oil-field brine has been proven to be an effective pretreatment for winter storms (Ohio DNR, 2004). Other aqueous waste streams that have been used as anti-icing and deicing agents include corn wet-milling waste byproducts, cheese brewing waste, beer brewing waste, beet juice and others (Iowa DOT, 2010). In Polk County, Wisconsin, liquid cheese brine has been used to mix with rock salts and pre-wet the roadway surface since 2008, which results in approximately 30% reduction in salt usage.

Aqueous waste streams can also be used to control dust on unpaved roads, construction sites and agricultural fields (Federal Highway Administration, 2013). Transportation agencies use dust suppressants to control erosion and reduce maintenance costs on unpaved roads. Materials used as dust suppressants include water, salts, asphalt emulsion, vegetable oils, molasses, synthetic polymers, mulches, and lignin products (USEPA, 2002). Many of the dust suppressants are formulated with waste products recycled from other industries. Approximately 75-80% of all dust suppressants used by transportation agencies are chloride salts and salt brine products (Travnik, 1991). These salt products stabilize the soil surface by absorbing moisture from the atmosphere. Oil-field brine has also been used as a cost effective dust suppressant and road stabilizer, and its efficiency for dust control has been well recognized (Pennsylvania DEP, 2015).

Lime sludge is another waste stream that can be potentially used for transportation-related applications. Lime sludge is produced by the lime softening treatment process where lime is added to the water to reduce the hardness. Disposal of lime sludge remains a major challenge to many municipalities in the Midwest. Lime sludge may be potentially used on gravel roads to reduce dust generation and used as an aggregate in cement production (Iowa DOT, 2004).

Overall, waste brine and other aqueous waste streams have been used by many state DOTs for transportation-related applications. The experiences of these state DOTs suggest that salt brine solutions can be effective ice control agents and dust suppressants. When application rate and volumes are properly controlled, waste brine can be spread on roadways with minimum environmental risks.

The Watertown Municipal Water Treatment Plant operates a magnetic ion exchange (MIEX) system to treat its source water. The MIEX system produces brine wastewater that requires proper treatment and disposal. The City currently discharges the waste stream into a lime sludge pit. The dewatered solids are eventually disposed of in the landfill. The City is evaluating other alternatives to landfilling to reduce the cost of disposal. The brine wastewater produced by the MIEX system is expected to have similar salinity as other salt brine solutions that have been used for ice and dust control. Therefore, the MIEX brine may be used by transportation agencies in South Dakota for winter road maintenance and dust control on unpaved roads. Beneficial reuse of the salt brine will reduce costs of disposing and treating waste materials and purchasing new materials, and lead to more sustainable operations at state and local highway departments and municipal utilities.

Beneficial reuse of waste streams in transportation applications requires a comprehensive evaluation of the benefits and risks, and this depends on several major factors including the effectiveness, safety, economics, environmental benefits and risks, and local, state, and federal regulations associated with transportation-related applications of the waste streams. Guidance should be developed to help state and local agencies determine how to evaluate waste streams for potential reuse in transportation applications and establish sound procedures to manage their reuse.

Research Objectives

In this study, we will investigate beneficial reuse of aqueous waste streams for transportation related applications in South Dakota. The objectives of this study are to:

1. Provide a comprehensive literature review to summarize the current state of knowledge of beneficial reuse of aqueous waste streams for transportation related applications.
2. Identify potential transportation-related applications for aqueous waste streams available in South Dakota.
3. Develop guidance for evaluating the suitability of aqueous waste streams for transportation-related applications.
4. Demonstrate application of the guidance in a case study of the brine waste stream generated by the Watertown Municipal Water Treatment Plant.

Research Methods

This research will be conducted through a literature review, consultation with experts, interviews with stakeholders, and a case study of the brine waste stream generated by the Watertown Municipal Water Treatment Plant to achieve the objectives. The research team will summarize the current state of knowledge about transportation-related applications for aqueous waste streams through a comprehensive review of existing literature and practices at state and national levels. Significant public and private aqueous waste streams produced in South Dakota will be identified based on the information available from the South Dakota Department of Environment and Natural Resources and other agencies. Potential transportation-related applications for the waste streams identified in South Dakota will be summarized and described through a review of the literature, consultation with experts, and interviews with stakeholders.

Guidance will be developed through a review of the literature, consultation with experts, and interviews with stakeholders to describe best practices for evaluating and regulating the use of waste streams in transportation-related applications. The development of the guidance will consider the effectiveness, safety, processing requirements, economics, and environmental benefits and risks of aqueous waste streams. The approval procedures, operating requirements and reporting requirements of reusing waste streams for transportation applications will be included in the guidance.

A formal case study of the brine waste stream generated by the Watertown Municipal Water Treatment Plant for transportation-related applications will be conducted according to the guidance developed for reusing waste streams. The results of the case study will be used to refine the guidance. The case study will also help the City make decisions on necessary plant modifications for reuse and disposal of the brine waste.

Expected Outcomes

This research focuses on developing guidance for beneficial reuse of aqueous waste streams for transportation applications in South Dakota. The expected outcomes of this project include:

1. A guidance on evaluating and regulating reuse of waste streams in transportation-related applications. The SDDOT, local road departments, municipal utilities, and industrial facilities will be able to apply the results of this research to beneficial reuse of waste materials.
2. A formal case study of brine waste stream generated by the Watertown Municipal Water Treatment Plant for transportation-related applications. The City of Watertown will immediately be able to use the results of the case study to guide decisions on use of its waste brine for transportation applications.

Relevance to Strategic Goals

The proposed project and its expected outcomes are directly related to the goals of Environmental Sustainability, Livable Communities, and Economic Competitiveness. This research aims to develop guidance for beneficial reuse of aqueous waste streams for transportation applications in South Dakota. The results of this research could help transform waste streams that are now environmentally and financially expensive to discard into valuable materials for transportation-related applications. The results of this research could be used by the SDDOT to improve the performance of ice and dust control on roadways, reduce the costs of roadway maintenance, and reduce the costs of purchasing new materials (such as rock salt). The improved performance of ice and dust control could increase the safety of transportation in South Dakota. Municipal utilities and industrial facilities will be able to save substantial costs on waste management, treatment and disposal. The environment impacts of these waste materials could be reduced through the collaborative efforts between the SDDOT, SDDENR, and other stakeholders. Therefore, this research could lead to a long-term environmental stewardship, and more sustainable operations at state and local highway departments and municipal utilities in South Dakota.

Educational Benefits

A master's level student will work on this project under the direction of the PIs. The graduate student will develop a master's thesis based on the results of this study.

Work Plan

Task 1 Literature review of beneficial reuse of aqueous waste streams for transportation-related applications

A comprehensive literature review will be performed to summarize the current state of knowledge about transportation-related applications for aqueous waste streams. The research team will consult with experts at the state and national levels to summarize the experiences of reusing waste streams for ice and dust control and other applications.

Task 2 Identify potential transportation-related applications for waste streams in South Dakota

The research team will work with the South Dakota Department of Environment and Natural Resources to identify and describe significant public and private aqueous waste streams produced in South Dakota. The sources for these waste streams may include drinking water and wastewater treatment, oil and gas production, ethanol production, food processing, and others. The quantity and quality of each significant aqueous waste stream will be summarized according to the available information. The existing treatment and disposal practices will also be described.

The research team will identify potential transportation-related applications for significant waste streams in South Dakota. We will also conduct interviews with state stakeholders including SDDNER, SDDOT, local governments, municipalities, industries and others to gather inputs on waste stream reuse for transportation applications.

Task 3 Develop draft guidance for evaluating and regulating use of aqueous waste streams in transportation-related applications

Guidance will be developed through a review of the literature, consultation with experts, and interviews with stakeholders to describe best practices for evaluating and regulating use of waste streams in transportation-related applications. The development of the guidance will consider the effectiveness, safety, processing requirements, economics, and environmental benefits and risks of aqueous waste streams. The approval procedures, operating requirements and reporting requirements of reusing waste streams for transportation applications will be included in the guidance.

Task 4 Apply the draft guidance in a formal case study of the brine waste stream generated by the Watertown Municipal Water Treatment Plant

After the draft guidance is approved by the SDDOT technical panel, the research team will apply the guidance in a formal case study of the brine waste stream generated by the Watertown Municipal Water Treatment Plant. The research team will first evaluate the quantity and quality of the brine waste stream produced by the plant. Site visits will be made by the research team to investigate the operation of the MIEX system and the production of the waste stream. Brine samples will be collected and sent to EPA certified labs for the analysis of inorganic and organic parameters. The researchers will evaluate the applications of brine waste for dust control on gravel roads, ice control on roadways, and anti-freezing for sand stockpiles. Detailed cost analysis including waste management, transportation, application, and materials savings will be performed to evaluate the cost benefits of this reuse practice. The permitting procedures,

operating requirements for spreading brine (frequency, rates, restrictions, and others), and reporting requirements will be developed for the MIEX brine.

Task 5 Develop final guidance for evaluating and regulating use of aqueous waste streams in transportation-related applications

Based on findings of the case study of brine waste stream reuse and comments from the project technical panel, the research team will refine the draft guidance. The comments from the technical panel will be incorporated into the final guidance.

Task 6 Project Reporting

A comprehensive final report will be prepared by the research team to summarize the research activities, findings, conclusions, and recommendations for this project. Specifically, the final report will include the guidance and recommendations on implementation of reusing aqueous waste streams for transportation-related applications in South Dakota. The PIs will submit the final report to MPC.

Table 1 presents the proposed project schedule.

Tasks	2015						2016	
	7	8	9	10	11	12	1	2
1.								
2.								
3.								
4.								
5.								
6.								

Project Cost

Project Costs: \$65,000

MPC Funds Requested: \$30,000

Matching Funds: \$35,000

Source of Matching Funds: South Dakota DOT

TRB Keywords

Snow and ice control, Dust control, Brines, Waste utilization

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