Understanding Suspended Solids in South Dakota's Waterways

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June 2025

Overview

Suspended solids, which refer to the quantity of sediment transported by a river, are posing a significant threat to water quality in South Dakota. The Missouri River, whose waters primarily originate in the Rocky Mountains, is the longest river in North America, draining the largest independent river basin in the United States (Martin et al., 2020). Although it accounts for only a small percentage of the basin, South Dakota alone contributes approximately 80% of the suspended solids in the Missouri River. In contrast, Nebraska contributes only 5% (Jurotich et al., 2021). A waterbody's total suspended solids (TSS) is a key indicator of river stability, overall ecological health, and river channel migration. These clear indicators beg to question the sustainability of South Dakota's current land management practices and the hydrologic effects of such activity. The significant percentage of suspended solids impacting South Dakota waterbodies (Table 1), increased attention and changes to reduce the TSS water quality impairments.

South Dakota is composed of erosive soils in both the western South Dakota Badlands and the southeastern portion of the state, as well as exposed marine shale within the Missouri River Basin, deeming the region naturally susceptible to high suspended solids (South Dakota Department of Natural Resource, 2024). Regional land usage and management practices can either exacerbate or mitigate naturally high suspended solids volumes. Acknowledgment, education, and action are key to implementing the necessary solutions to sway the outcome to the latter.

Causes

The amount of suspended solids in waterways is significantly altered by human activity and weather dynamics. Forest and land clearance for urban, industrial, and agricultural expansion all result in a degree of natural surface cover destruction and surface catchment disturbance (Jurotich et al., 2021). This shift in surface cover changes the volume and intensity of runoff and stream discharge, to which suspended sediment is particularly sensitive.

In South Dakota, the removal of wetlands and depressions reduces watershed storage (South Dakota Department of Agriculture and Natural Resources, 2022). Decreased storage increases stream discharge, and in turn, increases erosive forces on the land.

Table 1: The Impact of TSS on Waterbodies' Ability to Support their Beneficial Uses in South Dakota (South Dakota Department of Agriculture and Natural Resources, 2024)

Surface Water Classification	Miles Not Supporting	Miles Supporting	Number Not Supporting	Number Supporting	Percent Miles Supporting
Streams	2108.7	3756.2	50	121	64

Agricultural practices such as extensive tilling, farming near waterways, and the removal of natural vegetation cover for replacement with row crops, can influence the degree of suspended solids and bank stability concerns further (South Dakota Department of Agriculture and Natural Resources, 2022). The Vermillion River is one such waterway that has faced increased sediment concentration due to the conversion of grassland to row cropland (Jurotich et al., 2021). Additionally, bridges and culverts may direct discharge into rivers where a natural meander occurs, which contributes to failing banks and the elevated river turbidity (South Dakota Department of Agriculture and Natural Resources, 2022). This damage is compounded by the altered flow regime due to unplanned drainage practices. The James and Big Sioux Rivers in South Dakota have faced water impairment concerns from suspended solids caused by bank instability (Jurotich et al., 2021).

An additional significant driver of sediment solids in South Dakota is precipitation, because concentrations remain low when there is insufficient runoff to move sediment and tend to increase with higher discharge (Jurotich et al., 2021). An increased frequency of extreme weather events and shifted weather patterns are contributing to earlier snow melt and stronger summer droughts (Walling, 2008). This impacts the discharge levels, consequently influencing the sediment solids and long-term sediment flux. Rivers in the Midwest and South Dakota regions, specifically, are experiencing increased spring discharge, contributing to the high suspended solids (Jurotich et al., 2021).

Impacts

On a global scale, changes in sediment transfer can affect the fluctuation of elements and nutrient transport with the potential to change the global biogeochemical cycle, as well as threaten the longevity of the global soil resource (Walling, 2008). At a regional level, the impacts of this water impairment can be severe, both ecologically and economically.

High concentrations of TSS can alter aquatic habitats and threaten food security for aquatic species and macroinvertebrates, which has the potential to impact local and national food web dynamics (Jurotich et al., 2021). Decreased light penetration due to the water's turbidity reduces photosynthesis rates of plants and algae, which in turn acts as a catalyst for the disruption of the food chain (U.S. Environmental Protection Agency, 2021). The decreased dissolved oxygen levels can cause both health concerns for fish and other aquatic species, in addition to increasing the threat of eutrophication, which is the excess growth of algae. The threat is compounded by the fact that the suspended solids absorb heat from the sun, raising the temperature of the water and further promoting algae blooms. Furthermore, suspended sediments often act as a vehicle for contaminants like heavy metals, pesticides, and other pollutants to travel through waterways, escalating additional water impairment concerns (U.S. Environmental Protection Agency, 2021). The environmental impacts are not unique to aquatic ecosystems, as the suspended solids transported by the water can accumulate on riverbanks, burying plants or disrupting their growth (Wilkes, 2019). On the surface, soil erosion may also increase because high TSS in water can increase the removal rate of topsoil by flowing water, particularly in areas with high rainfall or significant flooding events.

Like many environmental concerns, overlooking TSS impairments can have the potential to cause detrimental downfall of both the state and local economies through increased maintenance costs, heightened flood potential, and damaged local industries. Increased water turbidity can cause economic stress due to the accelerated sediment build-up in reservoirs (Walling, 2008). Reservoirs, which already have a finite life span, suffer from the increased rate of sediment deposition and, consequently, expensive expedited maintenance. This acceleration of sediment deposition also interferes with access to some navigable waterways and waterway structures (Walling, 2008). Replacements and increased repair costs of reservoirs, water-based structures, and dredging in lieu of the suspended solids can be substantial. Furthermore, the sediment deposition in excess will lead to bed aggradation, so as to raise the flood water level and the respective structure repair costs inflicted by said flooding (Zhong et al., 2020). The change in river morphology could block natural water channels or drainage pathways, exacerbating flooding potential, too. Finally, areas such as South Dakota, that rely on healthy water systems for agriculture, fisheries, or tourism may experience economic losses due to the degradation of water quality and land. Agriculture and nature-based recreation contribute $32.5 billion and $1.1 billion yearly to the state economy respectively (May, 2021). The decline of fish populations or decreased agricultural productivity from soil erosion and sedimentation could cause considerable harm to these state economic pillars.

Solutions

Despite the impact of TSS, ecosystems can be resilient, and water quality can be repaired with the implementation of feasible but productive changes and the adoption of a sediment budget. Currently, South Dakota has numerous TSS criteria set to protect fish propagation for the support of aquatic life and fishery productivity. The Department of Agricultural and Natural Resources (DANR), which is responsible for assessing total maximum daily loads (TMDLs), specified that TSS criteria for marginal fish propagation regulates that no single sample exceed 263 mg/L, and during a 30-day period, the mean of a minimum of 3 samples collected during separate weeks must not exceed 150 mg/L (South Dakota Department of Agriculture and Natural Resources, 2022). Adopting environmental protection policies that regulate human-ecosystem relationships can promote practices and land-use changes to facilitate restoration at different spatial and temporal scales (Zhong et al., 2020). Such policies, which may impact construction standards, land management, industrial regulations, and agricultural practices, may call for local participation and citizen science. Raising awareness about TSS risks and mitigation strategies among farmers, landowners, recreational users, advocates, and the general public has the potential to drive meaningful local change without the need for government intervention.

For farmers, adopting agricultural practices such as no-till farming, establishing native vegetative buffer strips along waterways, and maintaining crop residue on the land during the winter months can help drive positive change (South Dakota Department of Agriculture and Natural Resources, 2022). The increase of vegetation coverage through the implementation of these changes allows for more precipitation to be intercepted by the vegetation canopy, which decreases that the velocity of surface runoff, increases surface water infiltration, and improves soil erosion capabilities – all of which work to limit the suspended solids in the waterways (Zhong et al., 2020).

Agencies and contractors building or maintaining dams could check on the river degradation and respective suspended solids on dammed waterways by changing flow releases to better mimic the natural flow conditions, adding sediment bypasses, flushing, strategic dam placement, or dredging (Jurotich et al., 2021). Dams prove to be one of the most effective sediment traps to reduce downstream suspended load fluctuations, but the magnitude of effectiveness varies by case. Hydropower or flood control dams allow for high water release rates, and despite some sediment sitting in the upstream reservoir, a sizable percentage of sediment passes through (Walling, 2008). Much of the stored water behind dams in South Dakota is not released and it instead diverted for irrigation purposes, so the flow of the river and its capacity to carry sediment are reduced. One such example is the final dam along the Missouri River, known as the Gavins Point Dam, built north of Yankton, South Dakota. The dam has had a profound impact by restricting the upstream suspended load to such a degree that the river now carries only 0.2% of the pre-dam load (Jurotich et al., 2021). The construction of dams for sediment mitigation, however, is not a perfect solution. In the situation of the Gavins Point Dam, the river experienced streambed incision downstream of the dam, in conjunction with wetland and sandbar habitat destruction. Despite the sediment load directly downstream of the dam being reduced to 264,000 tons/year, the portion of the Missouri River beneath the dam has accumulated 8 million tons/year of sediment 76 km away in Sioux City, IA (Jurotich et al., 2021). This statistic recognizes the additional importance of other sediment sinks, such as lakes and wetlands, and better land management practices to buffer sediment transport more directly.

It would be advisable to research river management and remediation, and to emphasize a study on the sediment regimes and their interrelation with the well-understood flow regime (Jurotich et al., 2021). This research could support local government and environmental agencies to develop a sediment budget that compares a river basin's sediment input or output to track and identify sources of sediment, sediment storage, and sediment yields more effectively. The accuracy of such budgets could be improved through increased sediment monitoring. The United States Geological Survey (USGS) has 23,000 gaging stations with over 10 years of discharge data, but only 1,640 stations record long-term sediment data (Jurotich et al., 2021). Increased sediment monitoring and expanded research could improve more accurate water-based decisions, land management practices, and sediment budgets.

Conclusion

Suspended sediments in South Dakota's waterways is a result of many practices, such as tilling, wetland removal, and altered drainage systems, that have disrupted natural flow and sediment patterns, while increased flooding and runoff further heighten the issue. These changes impact water quality, aquatic life, and the state's economy; however, solutions like improved land management, public education, a sediment budget, and better sediment monitoring offer a path forward. Coordinated action from local communities, policymakers, and researchers can reduce suspended sediment, protect valuable water resources, and ensure the long-term health of South Dakota's rivers. To support monitoring efforts and promote water quality awareness, individuals and organizations in South Dakota can have water samples tested for sediment-related pollutants through certified laboratories. The South Dakota DANR provides a list of state-certified laboratories equipped to test sediment concentrations and other water quality parameters (South Dakota Department of Agriculture and Natural Resources [DANR], 2025). Additionally, the South Dakota Department of Health's State Public Health Laboratory offers environmental water testing services that include analysis of surface water for sediment and other contaminants (South Dakota Department of Health [DOH], 2025). These resources enable landowners, researchers, and concerned citizens to participate in local water monitoring efforts and contribute to long-term strategies for reducing sediment pollution across the state.

Acknowledgements

This material is based upon work supported partially by the U.S. Geological Survey under Grant/Cooperative Agreement No. G24AS00537 and SDSU Extension Seed Grant.

References

Jurotich, M., Cardona, N., Vázquez, B., Wetzel, R., Cowman, T., & Sweeney, M. (2021). Contributions of suspended load from Missouri River tributaries, southeast South Dakota, and northeast Nebraska: Building a sediment budget. River Research and Applications, 37(4), 511-521. [Available at: doi.org/10.1002/rra.3767]

Martin, J. T., Pederson, G. T., Woodhouse, C. A., Cook, E. R., McCabe, G. J., Anchukaitis, K. J., ... & King, J. (2020). Increased drought severity tracks warming in the United States' largest river basin. Proceedings of the National Academy of Sciences, 117(21), 11328-11336. [Available at: doi.org/10.1073/pnas.1916208117]

May, C. K. (2021). Institutional panarchy: Adaptations in socio-hydrological governance of the South Dakota Prairie Pothole Region, USA. Journal of Environmental Management, 293, 112851. [Available at: doi.org/10.1016/j.jenvman.2021.112851]

South Dakota Department of Agriculture and Natural Resources. (2024). The 2024 South Dakota integrated report for surface water quality assessment. [Available at: danr.sd.gov/OfficeOfWater/SurfaceWaterQuality/docs/DANR_2024_IR_final.pdf]

South Dakota Department of Agriculture and Natural Resources. (2022). Total Suspended Solids Total Maximum Daily Load Evaluation for Brule Creek, Union and Lincoln Counties, South Dakota. [Available at: danr.sd.gov/Conservation/WatershedProtection/TMDL/docs/TableDocs/tmdl_bruletss.pdf]

South Dakota Department of Agriculture and Natural Resources. (n.d.). Certified laboratories for drinking water analysis. [Available at: danr.sd.gov/OfficeOfWater/DrinkingWater/LaboratoryCert.aspx]

South Dakota Department of Health. (n.d.). Environmental testing services. [Available at: doh.sd.gov/laboratory/environmental-testing/]

U.S. Environmental Protection Agency. (2021, July). Turbidity [PDF]. U.S. Environmental Protection Agency. [Available at: epa.gov/system/files/documents/2021-07/parameter-factsheet_turbidity.pdf]

Walling, D. E. (2008). The changing sediment loads of the world's rivers. Annals of Warsaw University of Life Sciences-SGGW. Land Reclamation, (39). [Available at: iahs.info/uploads/dms/14531.49-323-338-42-325-walling.pdf]

Wilkes, M. A., Gittins, J. R., Mathers, K. L., Mason, R., Casas-Mulet, R., Vanzo, D., ... & Jones, J. I. (2019). Physical and biological controls on fine sediment transport and storage in rivers. Wiley Interdisciplinary Reviews: Water, 6(2), e1331. [Available at: pure.coventry.ac.uk/ws/portalfiles/portal/26563027/Wilkes_et_al_Physical_Biological_controls.pdf]

Zhong, X., Jiang, X., Li, L., Xu, J., & Xu, H. (2020). The Impact of Socio-Economic Factors on Sediment Load: A Case Study of the Yanhe River Watershed. Sustainability, 12(6), 2457. [Available at: doi.org/10.3390/su12062457]

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