Insensitive Munitions are Different: Environmental Management and Cost Implications of IM Articles

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Background/Objectives. Full-scale production of munitions containing insensitive munitions (IM) constituents is under way within the Army Industrial Base. Aside from significant soldier safety benefits provided by IM articles, the constituents themselves are distinct from traditional high explosives formulations in other ways that impact production, load-assemble-pack, and demilitarization operations. Specifically, IM formulations contain nitrotriazolone (NTO), which has a water solubility of 12 g/L at room temperature and exhibits low pH (~3) in water. Some formulations also make use of nitroguanidine (NQ), which has a water solubility of 3 g/L at room temperature. The end result is that industrial process water and washdown water from operations involving IM may contain explosives mass loadings 200x greater than those associated with traditional formulations and exhibit an acidic pH. The implications for operating process wastewater treatment systems were anticipated to be significant, but the scale of required operations changes was largely unknown at the outset of production activities.

Approach/Activities. A series of phased investigations delineated the expected operational options and associated costs for switching from production of traditional munitions to IM. These began with surveys of available data and moved to laboratory investigations of available wastewater management technologies. Initial cost estimates guided the selection of some technologies for pilot plant demonstration. The goal was to identify viable management options for process wastewaters, determine the key operational parameters contributing to operating and capital costs, and use simulation based cost estimates to provide defensible technology recommendations to industrial manufacturers of IM articles.

Results/Lessons Learned. Previously published data show that GAC can remove 2,4,6-trinitrotoluene (TNT) with a total removal capacity on the order of 200 mg/g. An industrial wastewater containing NTO and NQ has observed capacities of 63 mg/g and 42 mg/g, respectively. This reduction in capacity along with solubility differences means a water adsorption process that normally costs $0.07 per gallon would now cost $5.09 per gallon. Investigations of a range of advanced oxidation processes identified several options for destructive treatment of dissolved IM constituents in wastewater. Peroxide assisted UV oxidation and persulfate oxidation were capable or degrading IM constituents, but Fenton oxidation was the most cost effective treatment option. Since total dissolved mass was the largest contributor to the total estimated cost, mass removal was also investigated to reduce the total treatment cost. Up to 30% of the total IM mass in an industrial water may be removed by cooling the water to precipitate NTO and NQ as solids. Simulation based costing of IM water management operations was performed to determine the level of uncertainty associated with differing management options. Even given the uncertainty in final operating conditions, implementing precipitative cooling and Fenton oxidation at a high strength IM wastewater source may be expected to reduce the 10-yr life cycle cost by 80% at a single operation.