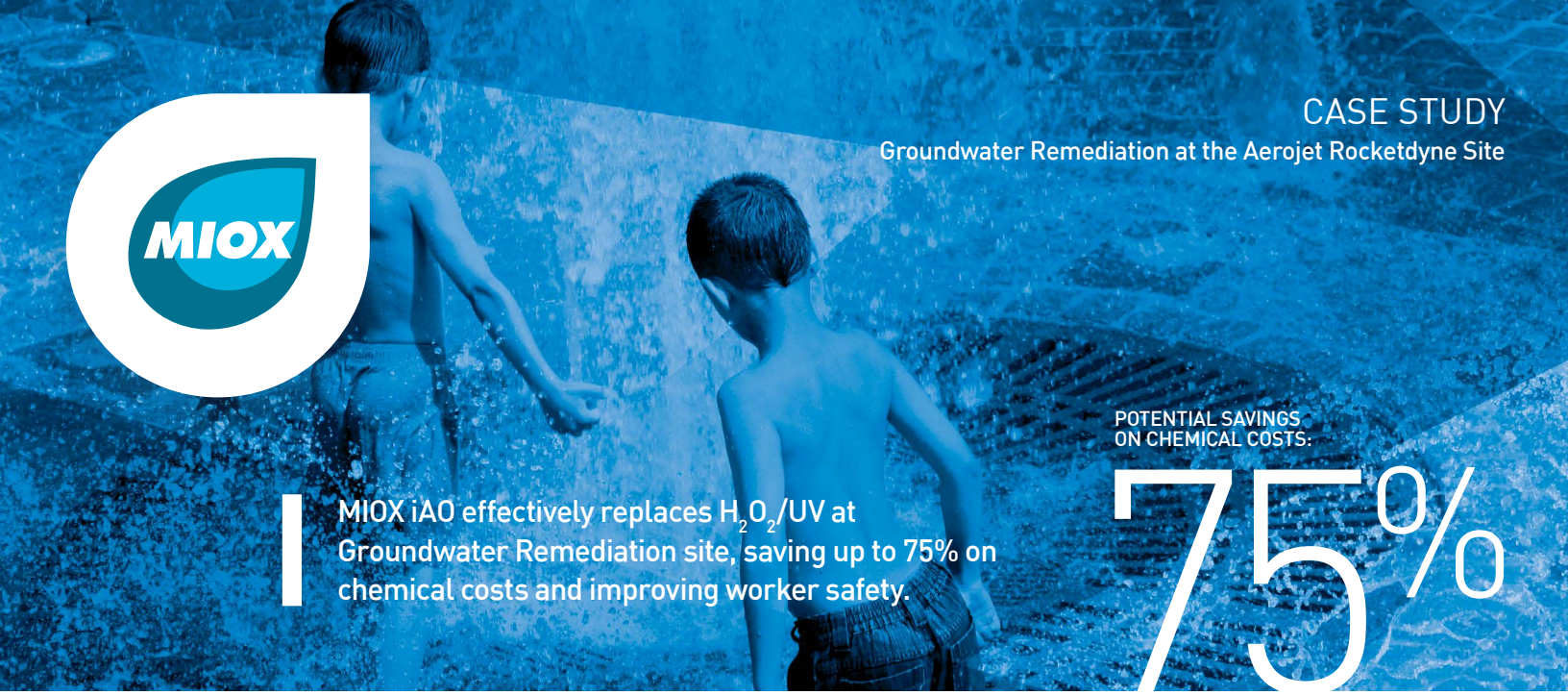


CASE STUDY

Groundwater Remediation at the Aerojet Rocketdyne Site

POTENTIAL SAVINGS ON CHEMICAL COSTS:

75%

MIOX iAO effectively replaces H_2O_2/UV at Groundwater Remediation site, saving up to 75% on chemical costs and improving worker safety.

LOCATION

Aerojet Rocketdyne in California, USA
25 MGD Groundwater Remediation Facility

EQUIPMENT

MIOX Vault on-site generator and UV Light
MIOX's Integrated Advanced Oxidation (iAO)

PREVIOUS AOP TREATMENT

Hydrogen Peroxide (H_2O_2) and UV Light

MIOX'S IAO ADVANTAGE

Cl_2/UV AOP treatment processes are highly complex and dependent on a number of water chemistry and treatment process parameters. With over three years of direct experience, MIOX is in a unique position to apply its expertise towards customer-specific optimization of Cl_2/UV AOP treatment processes with the goal of reducing costs and improving safety. The use of MIOX's On-Site generation systems, which produces aqueous chlorine from non-hazardous sodium chloride brine, offers a safer and superior chemical introduction into AOP treatment trains compared to concentrated hydrogen peroxide or bulk hypochlorite.

SYSTEM DESIGN PARAMETERS

TREATMENT CAPACITY
- Aerojet GET A: 500,000 GPD
- Aerojet GET J: 5 MGD

EQUIPMENT
- MIOX Vault On-Site Chemical Generator
- Calgon UV Reactors

UPSTREAM TREATMENT: Ion Exchange

DOWNSTREAM TREATMENT: Carbon Filter

CONTAMINANTS REMOVED
- Volatile Organic Chemicals (VOCs)
- N-nitrosodimethylamine (NDMA)

AEROJET'S CHALLENGE

Aerojet Rocketdyne, Inc. (Aerojet Rocketdyne) oversees a groundwater remediation program at their Rancho Cordova facility. Aerojet Rocketdyne was tasked with removing perchlorate, Volatile Organic Compounds (VOCs), and N-nitrosodimethylamine (NDMA) associated with historic Aerojet Rocketdyne operations from the groundwater. As a result, Aerojet Rocketdyne designed, built and operates several Groundwater Extraction and Treatment (GET) facilities to achieve its long-term remediation goals, treating over 25 million gallons of groundwater per day. At several GET facilities, Aerojet Rocketdyne utilizes a treatment technique called Advanced Oxidation Processes (AOPs) to facilitate the removal of VOCs. AOP technology currently deployed at many Aerojet Rocketdyne GET sites generates highly reactive radical species by using UV to break apart hydrogen peroxide (H_2O_2). While AOP methods that employ H_2O_2 are effective at meeting remediation goals, H_2O_2 is a costly chemical that, without proper safety equipment and training, could present a hazard in the work place. MIOX's Applications Research Group anticipated that hypochlorite could replace the H_2O_2 effectively, thereby lowering operational costs and possibly reducing hazards in the work place, key Aerojet Rocketdyne priorities as they improve ongoing remediation processes.

MIOX'S SOLUTION

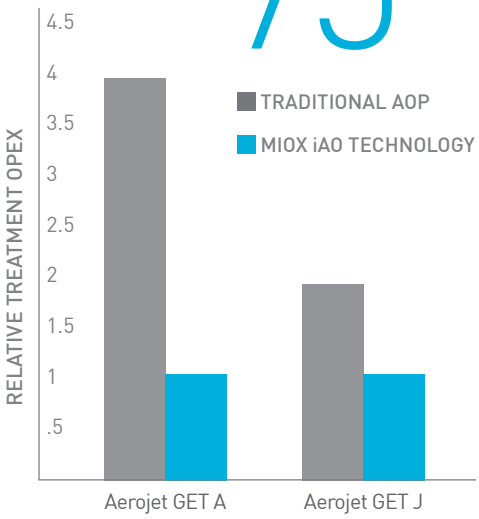
MIOX's Integrated Advanced Oxidation (iAO) technology combines on-site generated aqueous chlorine and ultraviolet light (Cl_2/UV) to produce highly reactive radicals capable of degrading VOCs and other organic chemicals in water. Since on-site generation processes use only water, salt, and electricity in the production of aqueous chlorine, MIOX's iAO technology provides a greener and less expensive source of chemical for the AOP. Previous assessments of MIOX's iAO technology at municipal water treatment sites demonstrated not only cost savings, but also that the Cl_2/UV

MIOX's AOP technology combines the on-site generation of aqueous chlorine and ultraviolet photoreactors to provide Cl_2/UV AOP water treatment. During this treatment process, aqueous chlorine is first added to the water to be treated. This water is then exposed to UV light, which activates the aqueous chlorine and producing hydroxyl and other radicals. These radicals are then harnessed to destroy organic contaminants in the water.

MIOX's iAO technology results in a chemical cost savings of up to 75% compared to traditional AOP treatment.

POTENTIAL SAVINGS ON CHEMICAL COSTS:

75%



AOP water treatment process is as effective as traditional AOPs.[1] Based on this experience, Aerojet Rocketdyne agreed to replace its H_2O_2–based AOP treatment during a well-documented piloting period to assess cost savings, hazards in the work place and ability to maintain discharge limitations for VOCs. To evaluate the technical and economic potential of applying MIOX's iAO technology was evaluated at two GET facilities. The success metrics for these demonstrations included VOC removal to a minimum concentration of 0.5 µg/L, demonstration of a non-toxic effluent, and evaluation the economic value of the technology.

STUDY DESIGN AND RESULTS

Both Cl_2 and H_2O_2 AOP technologies were compared for VOC removal efficacy and potential toxicity using standard EPA methods at Aerojet Rocketdyne's GET A and GET J facilities. Hypochlorite produced by a MIOX VAULT on-site generation system was used to replace H_2O_2 in full scale treatment operations at both facilities. Testing primarily involved the determination of the impact of varying the chlorine dose applied to the water prior to exposure to UV light on the removal of VOCs. At the GET A facility, nearly every condition tested resulted in the removal of all VOCs to below 0.5 µg/L, the remediation goal at both facilities. Cl_2/UV AOP alone was able to remove 80% of the VOCs in the water at GET J under optimized treatment conditions, with the carbon filters that are part of the overall GET J treatment train effectively removing the remaining VOCs. Additional testing demonstrated that the use of Cl_2/UV AOP did not interfere with the removal of NDMA, and Whole Effluent Toxicity studies demonstrated that the Cl_2/UV AOP effluent from both facilities tested was not toxic towards *Ceriodaphnia dubia*, an organism commonly used in EPA toxicity testing methodologies.

ECONOMIC COMPARISON

Aerojet Rocketdyne's in-place AOP treatment was compared to MIOX's iAO technology by evaluating chemical costs. Since both AOP treatments used the same amount of UV energy, costs associated with the UV component were assumed to be the same and were not incorporated in this analysis. Current operational costs were provided by Aerojet Rocketdyne at the time of the pilot. In the case of GET J, the cost of additional filtration capacity required to achieve the target VOC removal was added to the MIOX iAO cost. The graph to the left shows that the chemical costs associated with MIOX's iAO technology was one fourth and one half of the cost associated with the in-place AOP treatment at GET A and GET J, respectively. This shows that there is strong potential for reduced chemical costs when using MIOX Cl_2 instead of H_2O_2 for VOC removal.

[1] Rosenfeldt, E.; Boal, A. K.; Springer, J.; Stanford, B.; Rivera, S.; Kashinkunti, R. D.; Metz, D. H. "Comparison of UV-Mediated Advanced Oxidation" Journal AWWA 2013, 105(7), 29-34.

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ON-DEMAND CHEMISTRY