

Enhanced Phosphorus Control Resulting from a Rigorous Odor Control Program at Lexington Kentucky -- The Benefits of Iron Optimization

By

Chester Szczucki, Paris Neofotistos - US Peroxide, LLC.

Patrick McFadden, Tim Bullock, Tiffany Rank, P.E., Rodney Chervus, P.E. – Lexington-Fayette Urban County Government

Summary

This paper will present results of an odor control field study initiated in July 2008 by Lexington-Fayette Urban County Government (LFUCG) to quantify the impacts of iron and peroxide injection in the collection system on liquid and gaseous sulfide levels as well as the secondary benefit of phosphorus removal and sodium aluminate savings at the treatment plant.

Background

Lexington-Fayette Urban County Government (LFUCG) contracted with US Peroxide, LLC (USP) to conduct a hydrogen sulfide odor and corrosion control study using the Peroxide Regenerated Iron-Sulfide Control (PRI-SC™) process technology. LFUCG previously used nitrate in the North Elkhorn/East Hickman collection system segment for hydrogen sulfide control and was interested in evaluating performance and cost improvements to their current treatment program. LFUCG is also required to control phosphorus discharge levels six months out of the year (from May 1 through October 31) to < 1.00 mg/L. To achieve this, the LFUCG West Hickman Plant utilizes an anoxic biological phosphorus process followed by an activated

sludge process. It feeds sodium aluminate into the activated sludge basins to remove additional phosphorus from the wastewater.

Approach

To conduct the study, US Peroxide installed a ferrous chloride (FeCl_2) storage and dosing system at the North Elkhorn pump station and incorporated the hydrogen peroxide dose site at the East Hickman pump station (see *inserted* Figure I). The PRI-SC™ process is a proprietary hydrogen sulfide odor and corrosion control technology that combines the use of iron salts and hydrogen peroxide in a unique fashion, whereby iron salts (either $\text{FeCl}_2/\text{FeCl}_3/\text{FeSO}_4$) are added as the primary sulfide control agent in the upper reaches of the collection system, and hydrogen peroxide (H_2O_2) is added at specific points downstream to “regenerate” the spent iron (FeS). The regeneration step effectively oxidizes the sulfide to elemental sulfur and in the process “frees up” the iron for subsequent sulfide or phosphorus control further downstream.

Results

The results showed almost a total removal of dissolved sulfides for optimized PRI-SC™ performance when compared to the performance of the previous nitrate program. Gaseous sulfide averages were also significantly impacted with 80-90% reductions measured at most sites for PRI-SC™ (See Figure II).

Szczucki, Enhanced Phosphorus Control Resulting from a Rigorous Odor Control Program at
Lexington Kentucky -- The Benefits of Iron Optimization

One impact, which was not totally unexpected, was that the addition of iron to the collection system at North Elkhorn caused a dark color change to the entire plant water. This dark color is the iron sulfide (FeS) precipitate that forms when iron salts react with hydrogen sulfide in wastewater. It was found that the FeS passes through the anoxic zone without changing state and enters the aeration basins. Once in the aeration basins, the FeS is oxidized to ferric (Fe³⁺) iron and, as the Hydrrous Ferric Oxide (HFO) colloid, will aid in building floc structure and binding with phosphorus. This dual functionality (sulfide control and phosphorus removal) distinguishes iron from aluminum and, coupled with the PRI-SC™ red-ox technology, has the potential for improved overall cost-performance. A review of the underlying equations and solubility products are shown in (Figure III)

Once the PRI-SC™ study was started, the plant feed of sodium aluminate into the aeration basins for supplemental phosphorus control was eliminated. Since this program began in July 2008, it has consistently met or exceeded the performance of sodium aluminate, at an expected cost savings of \$27,180 (or 27%) over the six month odor and phosphorus control season, while significantly improving sulfide odor and corrosion control in the North Elkhorn/East Hickman line segment.

Figures

Figure I – Simplified system schematic

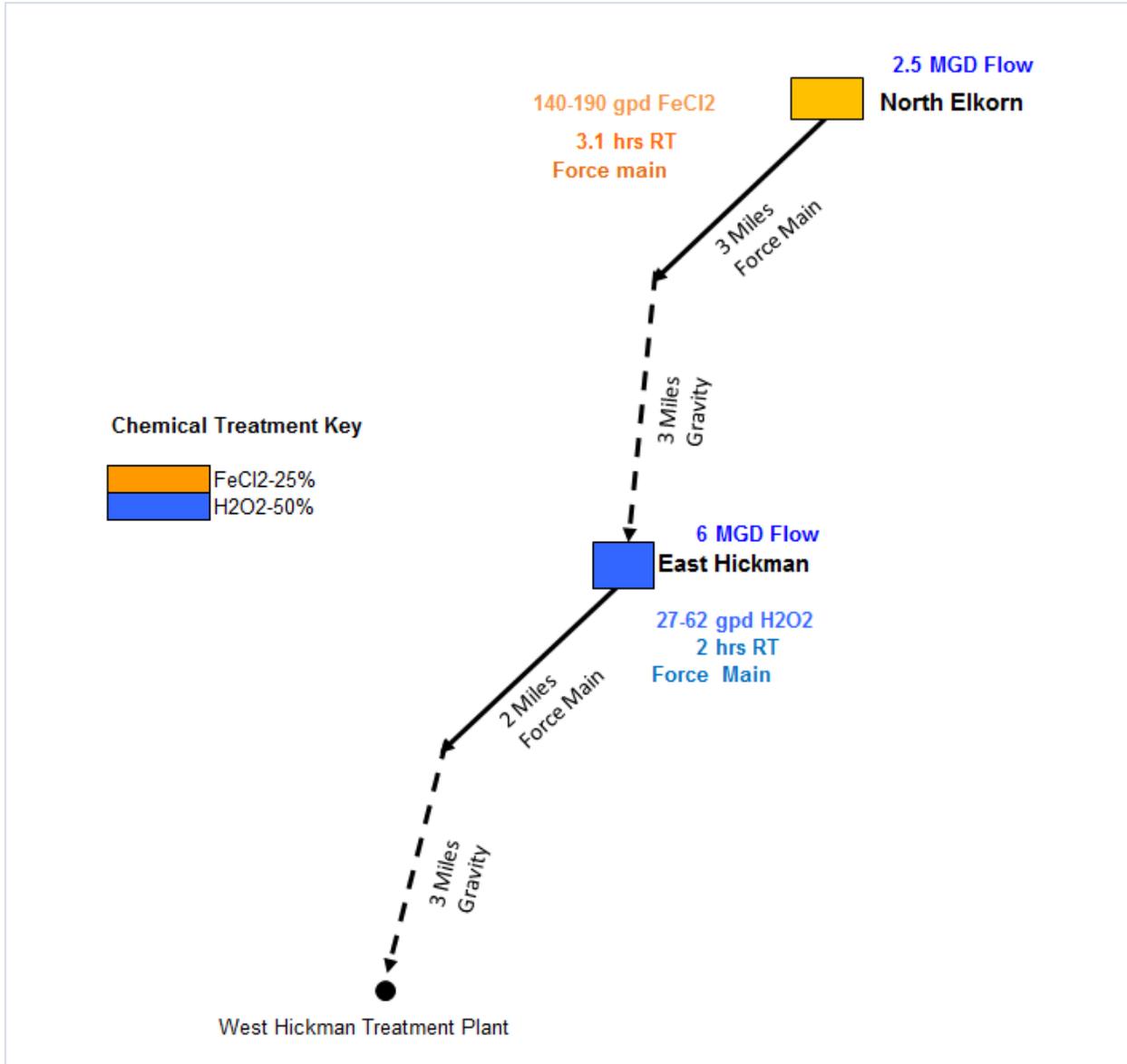


Figure II - Gaseous and Liquid Sulfides—Nitrates vs. PRI-SC™.

	Dissolved Liquid Sulfides		Gaseous Sulfides	
	Phase 5	Phase 8	Phase 5	Phase 8
	7/29 to 8/9	9/19 to 10/2	8/9 to 8/25	9/19 to 10/2
Noth Elkhorn LS	Nitrate 120 GPD	Iron 196 GPD	Nitrate 120 GPD	Iron 196 GPD
East Hickman LS	Nitrate 120 GPD	Peroxide 62 GPD	Nitrate 120 GPD	Peroxide 62 GPD
	Mg/L	Mg/L	Average/Peak (ppm)	Average/Peak (ppm)
North Elkhorn FMD	9.2	0.1	6/24	NA
North Elkhorn Gravity	3	0	229/693	33/242
East Hickman Lift Station	1.6	0	44/130	8/31
East Hickman FMD	4.4	0.1	63/378	68/230

Figure III - Solubility Products and Reaction Equations with Fe²⁺ and Fe³⁺
 Szczucki, Enhanced Phosphorus Control Resulting from a Rigorous Odor Control Program at
 Lexington Kentucky -- The Benefits of Iron Optimization

Solubility Product Constants (at 25 deg-C)

		<i>pK_{so}</i>
Ferrous:	FeS	17.3
	Fe ₃ (PO ₄) ₂	17.9
	Fe(OH) ₂	14.3
Ferric:	Fe(OH) ₃ - amorphous	38
	FePO ₄	33

Reaction equations

Ferrous:

FeS	Fe ²⁺	+	S ²⁻	<==>	FeS
MW	56.5		32		88.5
wt:wt	1.00		0.57		1.57
Fe ₃ (PO ₄) ₂	3 Fe ²⁺	+	2 PO ₄ ³⁻	<==>	Fe ₃ (PO ₄) ₂
MW	169.5		190		359.5
wt:wt	1.00		1.12		2.12
Fe(OH) ₂	Fe ²⁺	+	2 OH ⁻	<==>	Fe(OH) ₂
MW	56.5		34		90.5
wt:wt	1.00		0.60		1.60

Ferric:

Fe(OH) ₃ (amorph)	Fe ³⁺	+	3 OH ⁻	<==>	Fe(OH) ₃		
MW	56.5		51		107.5		
wt:wt	1.00		0.90		1.90		
FePO ₄	Fe ³⁺	+	PO ₄ ³⁻	<==>	FePO ₄		
MW	56.5		95		151.5		
wt:wt	1.00		1.68		2.68		
FeS	2 Fe ³⁺	+	3 S ²⁻	<==>	2 FeS	+	S _o
MW	113		96		177		32
wt:wt	1.00		0.85		1.57		0.28