Odor control using chemical dosing, coupled with odor monitoring electronic noses on an aeration basin at a WWTP

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ABSTRACT

Historically the technology to continuously monitor “odors” or odor units in real time has not been available. Since October 2009, the Hampton Roads Sanitation District (HRSD) has been successfully demonstrating new technology that is performing real time odor monitoring of the odors from the uncovered portion of the aeration basin at HRSD’s Chesapeake-Elizabeth wastewater treatment plant in Virginia Beach, Virginia.

The odorous emissions from the aeration tanks are measured continuously by a network of three OdoWatch® electronic noses. The network measures the odors continuously at 5-second intervals (dilution to threshold or odor concentration). The real time odor monitoring allows us to know the level of odors from the aeration tanks and potential off-site impacts with and without chemical dosing, instantaneously or historically. Chemical dosing of peroxide and iron is being performed at the raw influent to provide seasonal odor control of the uncovered portion of the aeration basin. The odor monitoring system includes a weather station so as to use dispersion modeling to map the odor plumes from the aeration basin in real time.

Phase I of the Chesapeake-Elizabeth technology demonstration project focused on profiling the uncontrolled odors emitted by the uncovered portion of the aeration tanks from October 2009 thru May 2010. Phase II of the evaluation, June-November 2010, monitored the reduction in those odors by chemical dosing of peroxide and iron and the corresponding odor plumes. Routine field olfactory reality checks of the odor plumes are discussed along with discrete air sampling events of the aeration tanks. The sampling events included odor panel analysis and field H_2S measurements.

KEY WORDS

Odor, peroxide, Enose, H_2S, real-time monitoring, dispersion modeling, olfactometry

INTRODUCTION

The Hampton Roads Sanitation District (HRSD) operates nine main wastewater treatment plants in Southeastern Virginia that individually treat between 10-40 million gallons per day (MGD) and collectively treat approximately 165 MGD of wastewater. HRSD’s interceptor system covers a 2,100 square mile service area, has an estimated 500 miles of pipe (80% forcemain and

20% gravity) and includes some 80 pump stations. Many of these facilities and processes present unique odor challenges that we address over time in different ways using new technologies.

Historically the technology to continuously monitor "odors" or odor units in real time has not been available. Since October 2009, HRSD has been successfully demonstrating new technology that is performing real time odor monitoring of the odors from the uncovered portion of the aeration basin at HRSD's Chesapeake-Elizabeth wastewater treatment plant (CETP) in Virginia Beach, Virginia.

The CETP is a 24 MGD physical-chemical-biological secondary treatment plant that meets all national pollutant discharge elimination (NPDES) final effluent permit requirements. However, the facility does not have primary clarification. The raw influent flow comes into the plant wet well goes through preliminary treatment facility (PTF), then through two junction boxes, aeration influent split flow channels, and then into the aeration basin. The aeration basin has three sets of 4 tanks each that are 150' long 75' deep, and 25' wide with fine bubble diffusers. The first 50' of the tanks are covered with odorous gases being treated by a conventional chemical scrubbing system. The uncovered portion of these tanks continued to be a source of on and offsite odor even after the most recent plant upgrade. Phase I of the upgrade completed in 2007 included installing a new PTF with odor control and extending the covers out from 25' to 50' on the aeration tanks. Phase II was to completely cover the tanks and control the odors, if necessary. Post-phase I upgrade observations identified that odors were still an issue and phase II was necessary. Unfortunately, competing capital improvement budget projects and the potential for a complete overhaul of CETP to meet future Chesapeake Bay nutrient requirements put phase II on indefinite hold, while HRSD faced uncontrolled nuisance odors.

INTERIM PROCESS SOLUTION

Given the challenges of capital funding and the odors, HRSD evaluated potential interim solutions to control the odors. In the summer of 2009 the use of peroxide and iron was tested to determine if this approach would minimize odors to an acceptable level. HRSD contracted with US Peroxide, LLC (USP) to conduct an odor control demonstration of its Peroxide Regenerated Iron-Sulfide Control process technology (PRI-SC®). The PRI-SC® process is a proprietary (US patents #6,773,604 B2 & 7,147,783) 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 $FeCl_2$/$FeCl_3$/$FeSO_4$) 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. PRI-SC® is an ideal treatment technology within interceptor systems and for integrating sulfide control into the treatment plant.

Because there was no readily available collection system site to install the FeCl3 system, both the FeCl3 and H2O2 storage and dosing systems were installed at CETP headworks structure in order to prove the concept of the PRI-SC® technology.

Figure 1. PRI-SC® Pilot Facilities at HRSD CETP 2009

Although not as efficient when the iron and peroxide are added at the same time, it was decided to run the initial demonstration in this configuration and, if successful, look at optimizing with collection system feed at a later date. The feeding of $FeCl_3$ and H_2O_2 in this manner has the effect of oxidizing the sulfide and reduced sulfur compounds while leaving the iron in a free ferrous form for subsequent phosphorus control in the aeration basins. The current ferric chloride feed downstream of the aeration basins was eliminated during the demonstration, resulting in more efficient and cost effective utilization of the iron.

During the 60-day demonstration, gaseous and liquid sulfide (H2S) plus gaseous mercaptan (RSH) levels were measured at the various dosing scenarios of baseline (no treatment), $FeCl_3$ only and PRI-SC® ($FeCl_3$/H_2O_2) at several different dose levels. Tedlar bag samples were collected by HRSD personnel at various points in the aeration basin structure and sent for GC and odor panel evaluation under all three dose scenarios in order to better assess performance.

Table 1 summarizes the average results at the Junction Box under the key scenarios tested. We can come to several important conclusions based on the data collected.

Table 1. Junction Box H_2S & RSH Summary

Test Condition (gpd)	Total Sulfide, mg/l	Dissolved Sulfide, mg/l	RSH, ppm
Baseline (0)	6.68	5.55	4.82
$FeCl_3$ (720)	5.06	2.61	7.00
PRI-SC $FeCl_3$ (720)/H_2O_2 (203)	2.01	0.81	3.36
PRI-SC $FeCl_3$ (720)/H_2O_2 (319)	0.45	0.14	1.98
PRI-SC $FeCl_3$ (548)/H_2O_2 (319)	0.94	0.42	1.35
PRI-SC $FeCl_3$ (548)/H_2O_2 (330)	0.47	0.19	1.61

The first conclusion is that the use of iron alone (720 gpd $FeCl_3$ condition) at levels required for effective phosphorus removal will not provide the appropriate level of H_2S and RSH removal. The second conclusion is that the dissolved sulfide needs to be reduced below 0.5 mg/L in order to achieve meaningful RSH reduction. PRI-SC® at 720 gpd $FeCl_3$ and 200 gpd H_2O_2 reduced the dissolved sulfide by 85% but only reduced the RSH by 30%. RSH reductions between 59-72% were measured when the dissolved sulfide levels were below 0.5 mg/L. The third conclusion is that the sulfide levels vary greatly depending on the time of day and seem to be in the highest concentration during the highest flow times of the day. This requires a dosing profile that has an H_2O_2 dose four times as high in the late morning versus the early morning hours. The fourth conclusion is that with the proper H_2O_2 profile removing the majority of the H_2S at all times of the day, equivalent phosphorus removal can be achieved with the same amount of iron fed at the front of the plant as compared to the secondary clarifier. This data is summarized in Table 2. The results of the odor panel evaluation are shown in Table 3.

Table 2. Phosphorus Removal Summary

Test Condition (gpd)	Ave T-P Raw Influent, mg/l	Ave T-P Final Effluent, mg/l	Reduction, %
$FeCl_3$ (548) Secondary Clarifiers	5.72	1.45	74.7
$FeCl_3$ (720) Headworks	5.60	1.53	72.8
PRI-SC $FeCl_3$ (548)/H_2O_2 (330)	5.40	1.32	75.5

Table 3. Odor Panel Data Summary

Sample Location	DT Baseline	RT Baseline	DT PRI-SC 720/319	RT PRI-SC 720/319
PTF Scrubber Inlet	4,200	2,300	2,800	1,400
Aeration Influent channel (AIC)	5,200	2,800	6,400	4,800
Tank 12 Cell 1	3,000	1,500	3,400	1,800
Tank 10 Cell 3	2,300	1,200	1,100	700
Tank 10 Cell 4	580	320	330	200
Tank 10 Cell 5	280	160	120	85

Tank 10 Cell 6	230	120	190	110

The shaded cells are the uncovered aeration basin cells. Clear improvements in detection threshold (DT) and recognition threshold (RT) were found by the odor panel. Corresponding improvements were measured by the outside lab GC analysis shown in Table 4 below. The GC RSH data correlates relatively closely to the shake test data in Table 1. A shake test involves the partial filling of a sample container with wastewater shaking it briefly and measuring the resulting headspace gas for the gaseous compound of interest. Similarly HRSD staff observed significant reductions in on and off site odors.

Table 4. H_2S & RSH Data Summary

Location	H_2S, ppb	PRI-SC H_2S, ppb	H_2S Reduction, %	RSH, ppb	PRI-SC RSH, ppb	RSH Reduction, %
PTF Scrubber Inlet	4300	37	99.1	750	200	73.3
AIC	350	160	54.3	3900	2300	41.0
Cell 1	19	26		600	360	
Cell 3	19	34		160	100	
Cell 4	15	6		ND	ND	
Cell 5	8	13		ND	ND	
Cell 6	7	11		ND	ND	

The inlet levels to both the PTF and Aeration scrubbers showed a significant drop in gaseous H_2S levels during PRI-SC® operation. The average gaseous H_2S levels taken from August 17 and August 18 with and without PRI-SC® treatment are shown below in Table 5.

Table 5. PTF Scrubber Inlet H2S Data Summary

Sample Location	Baseline Average H2S, ppm	PRI-SC Average H2S, ppm	H2S Reduction, %
PTF Scrubber Inlet	20.4	5.9	71.2
Aeration Scrubber Inlet	2.5	0.0	100.0

With this successful demonstration of the PRI-SC® pilot for control of the aeration tank odors in the summer of 2009, HRSD carried out its first seasonal application of peroxide and iron in 2010 from May thru October. During this first full season of PRI-SC® utilization, HRSD and US Peroxide worked together to refine the 24-hour dose profiles and re-test the odors from the tanks.

In the fall of 2009 HRSD introduced Odotech's OdoWatch odor monitoring system to CETP for (1) the purpose of a proof of concept technology evaluation of the OdoWatch, (2) additional confirmation of the benefits of the use of PRI-SC®, and (3) the future potential integration of the OdoWatch with PRI-SC® at CETP.

The CETP OdoWatch technology demonstration project focused on profiling the uncontrolled odors emitted by the uncovered portion of the aeration tanks from October 2009 thru May 2010. Phase II of the evaluation, June-November 2010, monitored the reduction in those odors by chemical dosing of peroxide and iron and the corresponding odor plumes. Routine field olfactory reality checks of the odor plumes and discrete air sampling events of the aeration tanks were conducted by field staff. These sampling events included odor panel analysis and field H_2S measurements.

THE MONITORING TECHNOLOGY

The OdoWatch® system has sensors that continuously react to the odorant chemicals being emitted from each odor source. The sensor responses are calibrated with olfactometry measurements in compliance with ASTM E679-04 and EN 13725 to provide measurements expressed in o.u./m^3 or D/T. The data are then automatically input into an odor impact dispersion model that has been specially developed for modeling odors using the US-EPA regulatory approved model AERMOD. At the same time, real time weather data from an on-site meteorological monitoring tower are also automatically fed into the model. The odor model is then run, and the results are plotted onto an aerial image of the facility and surrounding areas. The plot is generated automatically at five-minute intervals, or at a user-selected refresh rate (minimum is five minutes). In effect, the OdoWatch® system is performing the steps described above on a continuous basis with data stored as a one minute average. Figure 2 is a graphic depiction of the system. Several recent odor studies have helped to validate this technology's statistical accuracy and other applications in the field. [2,3,4]

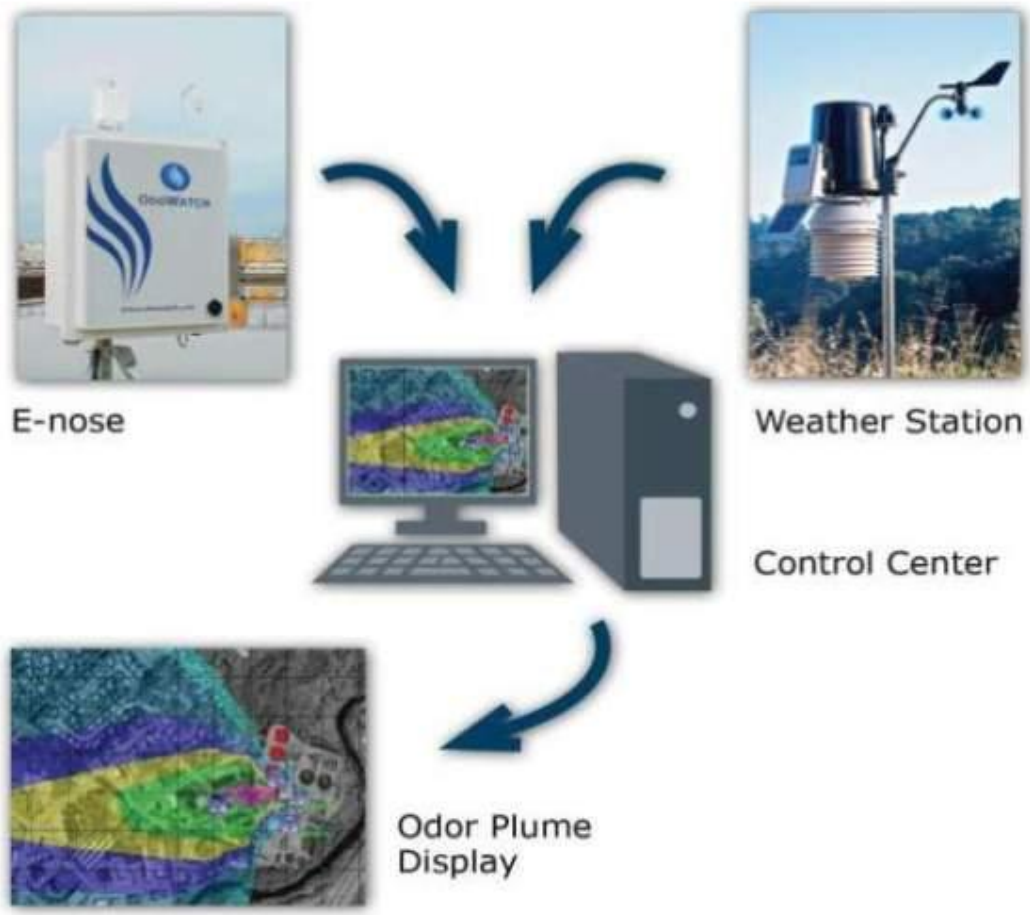

Figure 2. OdoWatch Odor Monitoring System

Since October 2009, the odorous emissions from the aeration tanks have been measured continuously by a network of three electronic noses. As described above, the network measures the odors continuously at 5-second intervals (dilution to threshold or odor concentration). The real time odor monitoring allows us to know the level of odors from the aeration tanks and potential off-site impacts with and without chemical dosing, in real time or historically. Chemical dosing of peroxide and iron is being performed at the raw influent to provide seasonal odor control of the uncovered portion of the aeration basin. The odor monitoring system includes a weather station so as to use dispersion modeling to map the odor plumes from the aeration basin in real time. See Figure 3.

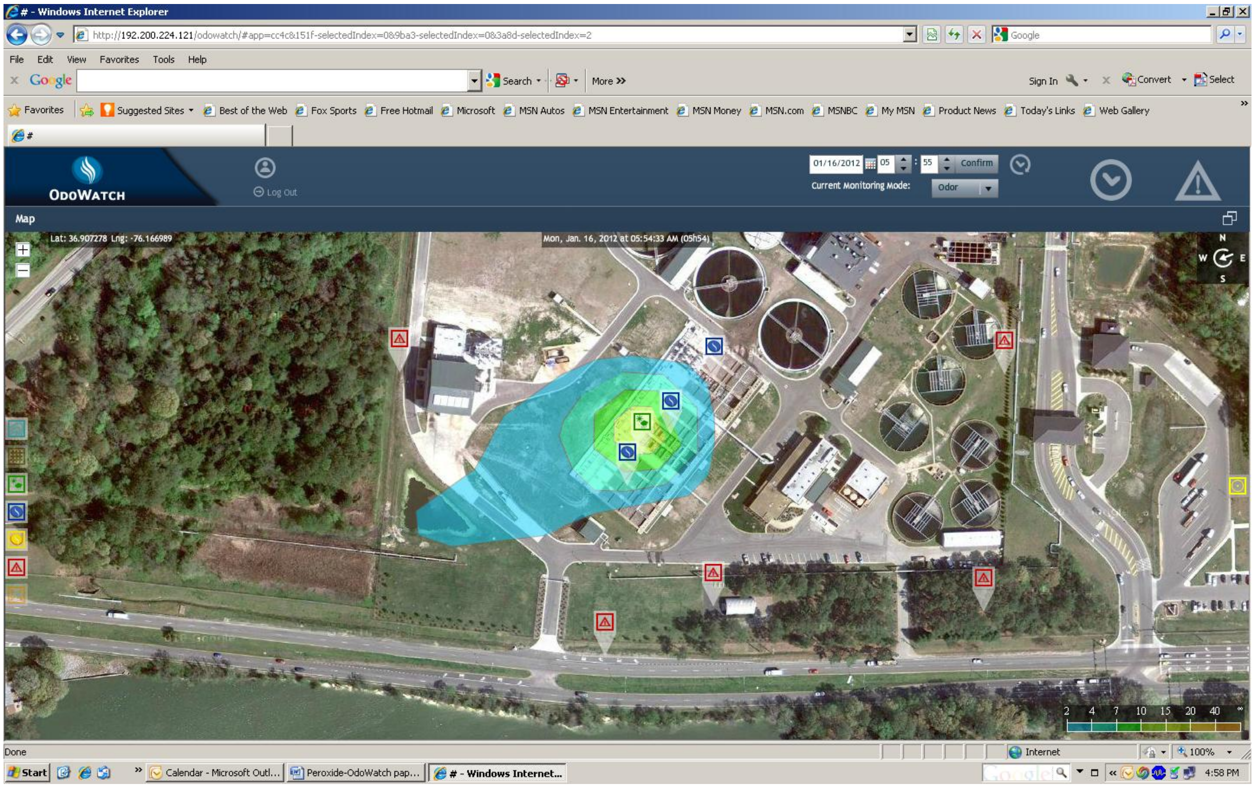

Figure 3. OdoWatch System at HRSD CETP

Early on in the evaluation, HRSD started weekly field "reality checks" of the odor plumes generated by the OdoWatch. Field staff would make an odor observation of the plant that focused on the aeration tank odors noting them at specific locations and times and then comparing them to the modeled odor plumes. The OdoWatch's modeled odor plumes were typically quite accurate an estimated 95% of the time, with odors observed at the same locations predicted by the model. The other 5% of the time, odors were observed that but no plume was present or a modeled plume predicted locations where odors were not observed. Of the 5% or less of the time with a discrepancy between individual observer and the OdoWatch, part of the discrepancy is believed to be at times when the AERMOD dispersion modeling software would change the morning and evening stability classes used in the model. However, at times the monitoring system could be very accurate in odor prediction. For example, on February 4th, an observation was made wherein the observer went to the very tip of the predicted plume and observed faint aeration odors coming and going with the subtle meteorological changes (windshifts). See Figure 4.

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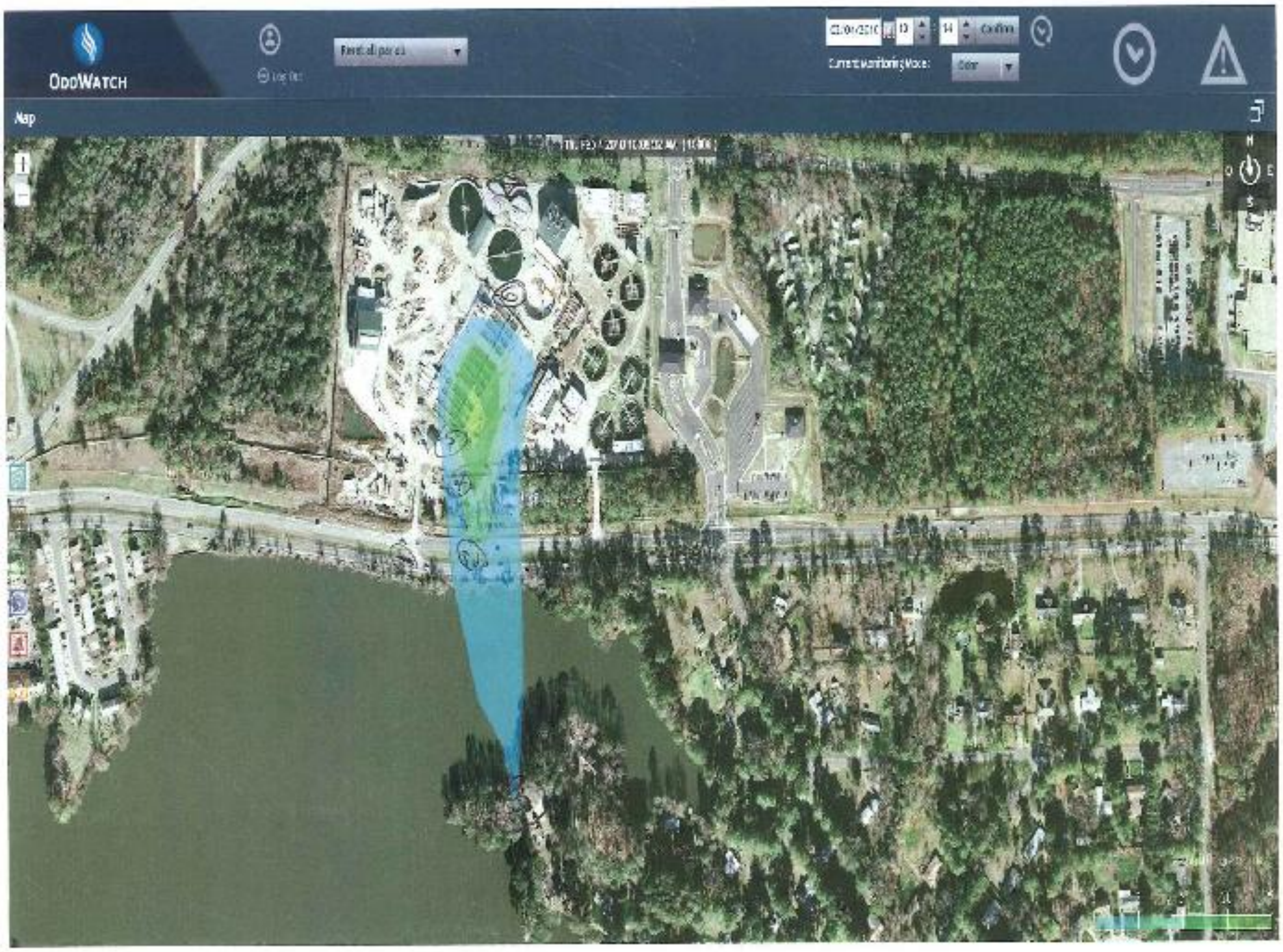

http://192.200.224.98/odowatch/ 2/4/2010

Figure 4. Predicted Odor Plume at CETP February 4, 2010

Another significant observation was made during testing of the PRI-SC® when the peroxide was on and then turned off the next day on for a 24 hour period. The resulting plumes from this test from June 29 and 30th, 2010 are expressed in Figure 5. On both days, the plant process (wastewater dissolved sulfides) and meteorological conditions were roughly similar.

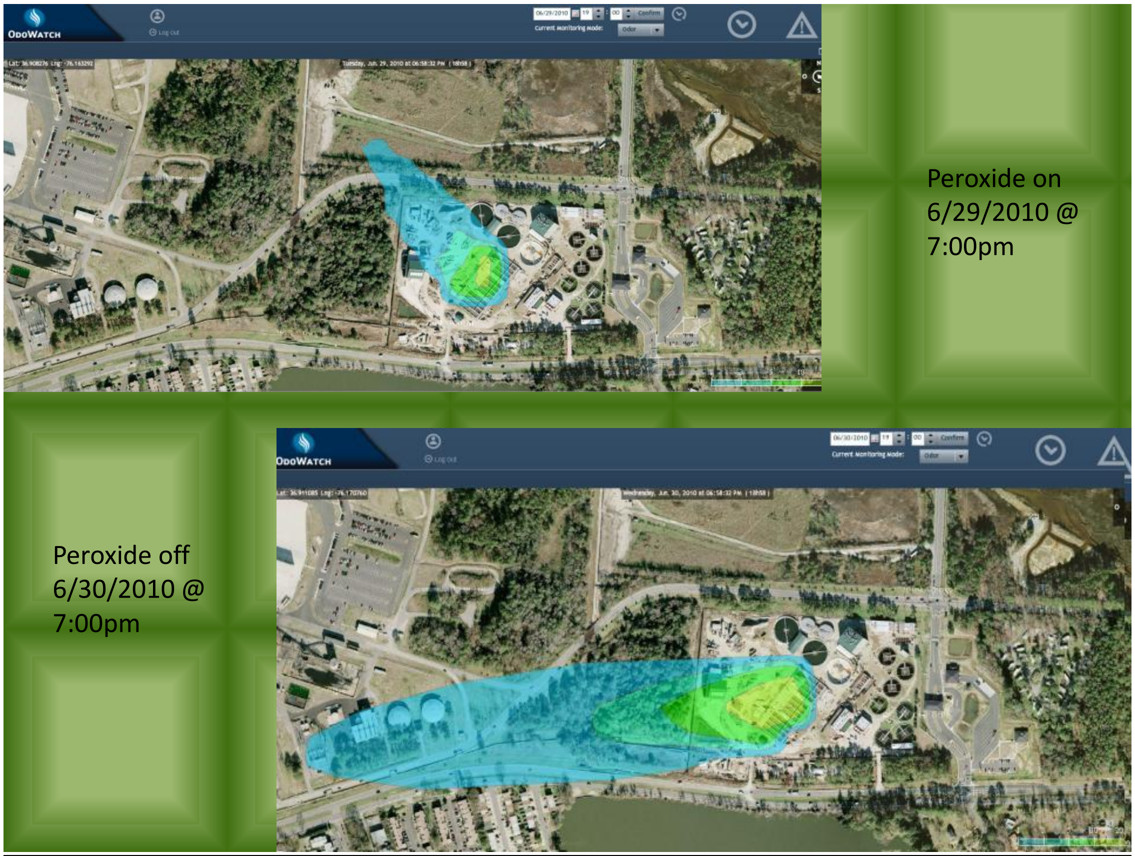

Figure 5. Peroxide On-Off at CETP June 29-30, 2010

Similar results have been observed during other times that the peroxide was turned on and off during the project.

In the process of the optimization of chemical usage and plume control, the plumes demonstrated, and our field observations confirmed the fact that the greater effect on resulting odors and odor plumes was meteorology (wind and solar radiation). Although the mass loading of dissolved sulfide to the plant was highest during the day and starting with the morning diurnal peak of flow at approximately 9 to 10AM, the most odors, largest plumes, and peak odor units were observed outside the period of high sulfide loading. Ultimately, the original peroxide dose profile that followed sulfide loadings was changed to best control the odor plumes by lowering daytime (9AM-3PM) chemical dosing and increasing the chemical dosing during non-daytime periods. Special attention was paid to the early morning and evening periods given atmospheric stability and potential for inversion conditions. Understanding these drivers properly allowed us to optimize chemical usage including about a 10% reduction in peroxide usage, and to provide maximum downwind odor/plume control.

SUMMARY

This project and the marriage of these two technologies continues to date. An ongoing effort is being made to integrate them electronically including the needed development of an algorithm to have the e-nose odor units optimize peroxide feed beyond the base dose profile for greater chemical savings and improved odor control.

The research over the last two plus years confirmed the proof of concept for each technology and successful utilization of them for our odor control needs in this application. The future plan for CETP is the continued use of PRI-SC® until capital decisions are made regarding further odor control improvements to the aeration basins. The Odowatch will be moved to another HSRD plant for another odor control study that will build upon previous engineering work to further develop needed odor control improvements.

ACKNOWLEDGEMENTS

The authors wish to acknowledge HRSD Operations and Water Quality Department personnel; US Peroxide, Odotech, and Kruger for their assistance with this odor control project.

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