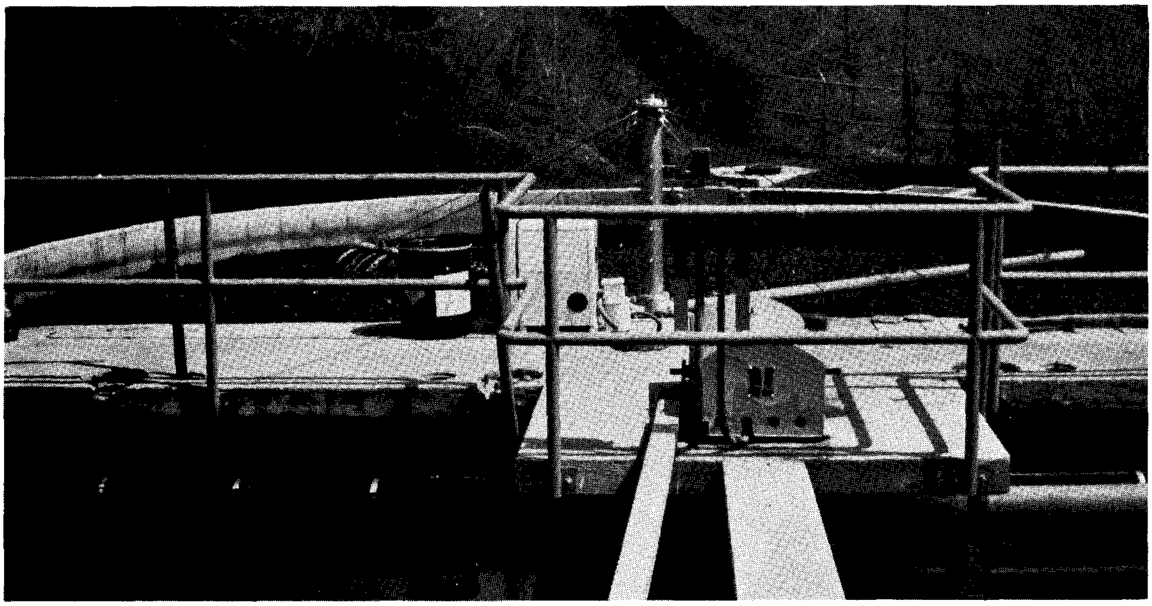

Potassium Permanganate controls sewage odors

Introduction

The terms sewage, sludge, municipal wastewater, and others related to the collection and disposal of human and industrial wastes almost automatically "trigger" a negative reaction by the general public, due primarily to the odors that are coincidental to the transport and treatment of wastewater. It is probably true that every sewage collection system and treatment plant has encountered an odor problem of some type, at some time. If it was not corrected by chemical treatment or mechanical changes in the system, discontent and complaints from nearby neighbors or passersby resulted.[1]

The odors are almost always associated with sulfides (especially hydrogen sulfide) but can also be caused by amines, aldehydes, ketones and other organic compounds. These odors may be a result of industrial discharges; reactions which take place between combinations of industrial and municipal wastes mixing in the system; or bacterial action of the sewage itself.[2] The odors may occur in the collection system, at pumping stations, or at the plant itself.

While there was always a great deal of pressure on industry who operate their waste treatment plants to correct the odor problems, it was not until very recently that municipalities have been pressured to solve their problems. This pressure has led to a search for various chemicals which could assist in controlling odors effectively and economically.

The two main classes of chemicals being investigated are deodorants and oxidants. While deodorants simply mask or "cover up" the odors with "perfume" type substitutes, the oxidants provide chemical destruction of the compounds causing the odors.[2] Other benefits derived from oxidants include reduction of BOD and COD, improved DO, better settling, and improved sludge cake dryness. The addition of oxidants therefore appears to be the solution to a number of problems, including the prevention of corrosion in sewer lines.

Of the oxidants that are commercially available, potassium permanganate is one of the strongest. This chemical provides solution oxygen to the system, chemically destroying sulfides and many of the other compounds causing the odors.

Sulfides in Wastewater

The "rotten egg" odor of hydrogen sulfide is detectable at very low limits and has a highly disagreeable odor at concentrations as low as 0.025 ppm in the atmosphere.[3] (See Table 1) In addition to having a highly disagreeable odor, hydrogen sulfide is extremely toxic and can present a hazard to health. It rapidly causes death when inhaled in concentrations of several hundred ppm. Besides being toxic, the presence of hydrogen sulfide can be detrimental to the sewage system. Hydrogen sulfide can corrode concrete, masonry, metals, and can also overload the sewage system causing inefficient operations. (See Figure 1)[4]

Sulfur in various forms is absolutely essential for life. Sulfur is usually ingested as the sulfate and is usually unnoticed in water. The sulfur metabolizing bacteria in sewage, sewer line deposits, and slimes, cause this sulfate to be reduced to hydrogen sulfide according to the following formula.[5]

$$SO_4^{=} + \underset{\text{matter}}{\text{organic}} \xrightarrow{\text{bacteria}} H_2S + H_20 + CO_2$$

R. R. Dague in 1972 concluded that:

1. The most common cause of odors in wastewater systems is hydrogen sulfide.
2. The conditions that lead to hydrogen sulfide production also favor the production of odorous organic compounds.
3. The reduction of the sulfate ion ($SO_4^{=}$) is the most significant mechanism of hydrogen sulfide production in wastewaters.
4. The population of sulfate reducing organisms is low in fresh domestic wastewater and higher in sludge.
5. Sulfate reducing bacteria thrive at a low oxidation reduction potential (ORP) of −200 to −300 mv, a pH in the range of 6 to 9, and at warm temperature (86° F).
6. Sludge deposits and slime growths are the major cause of prolific hydrogen sulfide production in sewers.

EFFECT OF HYDROGEN SULFIDE GAS ON HUMANS*

ppm**	mg/m³	Effect on humans
0.025	0.04	Olfactory threshold
0.2	0.5	Can definitely be perceived
20-30	30-50	Strong odor
70-150	110-240	Irritation-eyes, respiratory tract, etc.
170-300	270-480	Maximum concentration for 1 hr. exposure
400-700	640-1120	Loss of consciousness and possible death in 30 min.
700 or more	1120 or more	Quickly fatal

*"Hydrogen Sulfide: New Sources and Potential Impacts," H. Roffman and M. C. Bondor. 68th Annual Meeting of the Air Pollution Control Association, Boston, MA, June 15-20, 1975.
**Volumetric, i.e.: litres/millions liters

TABLE 1

To solve the odor problem it is therefore necessary to:

1. avoid reducing conditions which favor the production of hydrogen sulfide; and
2. provide an oxidizing environment so that hydrogen sulfide once produced, is oxidized back to the sulfate form.

The goal therefore, should be to maintain an oxidizing environment throughout the collection and treatment systems. This can be achieved by the introduction of oxidants such as potassium permanganate to the system.

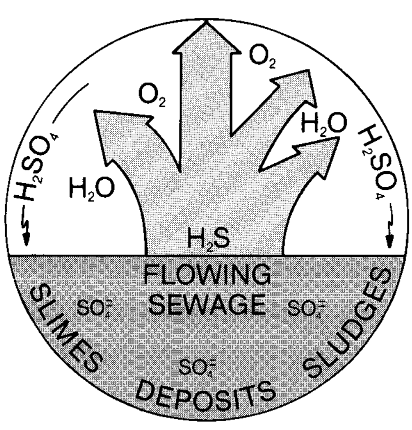

FIGURE I. Sulfuric Acid Attacks Pipe In A Sewer System

The Chemical — $KMnO_4$

Potassium permanganate has been used commercially for the purification of many different products. Its use in potable water treatment to oxidize iron, manganese, and sulfides, and for the destruction of taste and odor producing compounds, is well documented with over 500 municipalities reported on the list of users.[6]

Potassium permanganate is applied in some chemical manufacturing processes for the oxidation of sulfur compounds present in plasticizers and other compounds. It has also been applied in wet scrubbers to remove sulfur from odorous airstreams.[7]

Potassium permanganate reacts with hydrogen sulfide according to the following equations:

(1) $3H_2S + 2KMnO_4 \rightarrow 3S + 2H_2O + 2KOH + 2MnO_2$

(2) $3H_2S + 8KMnO_4 \rightarrow 3K_2SO_4 + 2KOH + 2H_2O + 8MnO_2$

In general, several reactions ranging between these extremes may take place yielding not only elemental sulfur and/or sulfates, but also thionates, dithionates, and manganese sulfide as possible products. The actual products will depend on the reaction conditions. Therefore, each set of conditions must be tested separately to determine the most effective and economical dosage to solve a given problem.

In reaction (1), the weight ratio of $KMnO_4$ to H_2S is 3:1, while the ratio in reaction (2) is 12.4:1. On occasion, good odor control has been reported with a permanganate to sulfide ratio of 1:1.

$KMnO_4$ is a relatively easy compound to evaluate in a sewage system. Its characteristic pink or purple color is rapidly reduced by hydrogen sulfide, to the yellow or brown color of manganese dioxide. Simple laboratory jar tests will indicate very quickly what dosages would provide the degree of odor control desired.

Analytical Techniques and Interferences

It is important to use the proper techniques for measuring sulfides when evaluating potassium permanganate. The current test kits commercially available rely on measuring methylene blue as the indicator. Manganese dioxide present in the solution will interfere with this test and yield false readings. Filtering the sample before attempting to measure the sulfide may lead to volatilization and loss of sulfides, especially if vacuum filtration is used.

A test kit which uses lead acetate paper and Alka Seltzer to volatilize the sulfides, while not as scientific, is acceptable. The manganese dioxide does not interfere with this test.

Other methods may be acceptable, but they should be thoroughly scrutinized for possible interference by the presence of manganese dioxide.

The Odor Sources

Odor problems can develop in any section of the sewage collection and treatment system. The most objectionable are those problems which develop in interceptor sewers and lift stations, as they are normally located in residential areas.[1]

Sludge in drying beds, in vacuum filtration processes, or sludge dryers is also a source of odors. We will look at the different phases of the sewage system and discuss the application of potassium permanganate for each, along with some case history information.

Lift Station — Collection Interception Sewers

Hydrogen sulfide is easily produced in lift stations or interceptor sewer lines, especially if they are over-sized. An interceptor sewer which has long retention time provides the necessary conditions for H_2S production. Sewage which sits in a lift station for several hours or more during low flow periods can also be responsible for producing H_2S and other odors. These may be noticeable, not only in the lift station itself, but also where the force main empties either into the plant or another gravity section of interceptor sewer line.

A sewerage system in Long Island had several miles of force main which were required to pump the sewage to the plant. The odors of sulfide when this sewage was pumped to the plant not only caused problems of discomfort, but created a potentially hazardous condition for the sewage plant personnel on duty when the lift stations were operating. Potassium permanganate was added to the sewage at the lift station, using a BIF 25-01 dry feeder. Permanganate oxidized the organics and also provided an oxidizing environment in the station and the force main. At a dose of about 15-25 lbs/day, depending on conditions, the odors were completely controlled.[8]

In California, because the low flow periods were from 5 p.m. to 7 a.m., the sewage which sat in the lift station not only caused problems in the area around the station, but also caused problems in the morning when it was pumped to the treatment plant. Hydrogen peroxide was tested, but was later replaced by potassium permanganate which the Superintendent said was easier to apply and more effective. A proportioning pump is used to feed the permanganate solution. A timer controls the feeder, turning it on at 5 p.m. and off at 7 a.m. the next morning. Complete odor control is being achieved in both the lift station and the plant. Since the flow rates pick up during the day from 7 a.m. to 5 p.m., the sewage does not have the opportunity to go septic and cause odor problems. At the time of this paper, they were using 8-10 lbs. of permanganate/day which figures out to 30-50 mg/l.[8]

At another location near San Diego, odors were particularly bad at the influent of the treatment plant. The addition of permanganate with a dry feeder at a dose of 5-6 mg/l is controlling the odors in this residential area.[8]

Sludge Handling

Permanganate can be applied to any part of the plant to improve the conditions. Since it is a convenient form of oxygen — a dry crystalline material — a dry feeder or solution pump can be set up very quickly to feed the chemical at any point in the system.

An area of particularly bad odor problems is in sludge handling and processing. In a New Hampshire sewage plant,[8] the sludge holding tanks are a source of obnoxious odors. This municipality was trying to cope with the problem by spraying a masking agent into the tank and on to the conveyor belt in the centrifuge room.

A permanganate feeder was set up to feed into the suction side of the sludge pump that feeds the centrifuge. The masking agent was turned off and the permanganate feeder turned on. Measurements of the sulfide directly over the sludge cake and the conveyor belt were taken.

Without the permanganate the H_2S measured at 50 ppm directly above the sludge cake on the conveyor belt. After permanganate addition the H_2S could not be detected and the odor of the cake was minimal.

The permanganate feed rate was originally set at 4.7 lb/hr. This was eventually reduced by 50% or to 2.35 lb/hr with good results. In a lab test at this location, the following additional benefits resulted.

1. A dryer sludge —
   After permanganate, the typical total solids content of the cake was increased from the usual 15-22% to 32%.
2. Less solids in the centrate —
   After permanganate, the typical centrate total solids decreased from 0.5% to approximately 0.2%.

Another test at this plant indicated that by spraying a 1-2% permanganate solution directly over the sludge in the holding tank, the odor could be controlled not only over the conveyor belt, but also in the centrifuge room. H_2S levels were measured at 100 ppm before treatment, and could be controlled to 0 ppm with sufficient $KMnO_4$.

Similar results were obtained at a location in Massachusetts.[8] The H_2S level above a sludge blending tank was measured at 100 ppm. The permanganate feeder was set at a rate of 37½ lbs/hr. This feed immediately controlled the odors over the hopper in the conveyor room. Experimentation showed that it took about 10 minutes for the H_2S levels above the conveyor to show the effects of permanganate feed. In one series of experiments the following was recorded:

Time	Comments	H_2S above conveyor ppm
12:45	Begin Centrifuging	0
12:48	Centrifuging	8
12:49	Centrifuging	10
12:50	Turned on $KMnO_4$ 37½ lbs/hr	25
12:51	Centrifuging	12
12:53	Centrifuging	5
1:00	Centrifuging	0

Again, the sludge cake solids increased by 28% and the centrate solids decreased.

The use of permanganate is not limited to the sludge processing. A municipality in Texas encountered an odor problem from some "sour" sludge in their drying beds.[8] A permanganate solution of 1-2% was sprayed over the surface of the sludge at a rate of 100 lbs dry permanganate/acre of sludge bed.

The odors were completely controlled and this municipality now keeps several hundred pounds of permanganate on hand in case this situation reoccurs.

Summary:

The use of chemical oxidants to solve odor problems in municipal sewage systems is becoming more popular. Potassium permanganate is one of the strongest and most versatile oxidants commercially available. Its application to sewage systems not only controls sulfides but also improves sludge cake solids and centrate. While the control of odors relieves a dangerous situation, improves employee working conditions, and improves public relations, the added benefits of potassium permanganate injection into a municipal sewage system can also provide definite economic advantages over alternate methods of odor control.

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By: Kenneth J. Ficek
Manager, Technical Services
Marketing Dept.
Carus Chemical Company
La Salle, Illinois

carus CHEMICAL COMPANY

Division of Carus Corporation
1500 Eighth Street
La Salle, IL 61301

Call Toll Free (800) 435-6856 In Illinois (800) 892-6831