United States
Environmental Protection
Agency

Industrial Environmental Research
Laboratory
Research Triangle Park NC 27711

Research and Development

EPA-600/S2-81-052 Sept. 1981

EPA

Project Summary

Two-Stage Biological Treatment of Coke Plant Wastewater

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The report documents a pilot-plant study of the use of advanced waste treatment methods in upgrading metallurgical cokemaking wastewaters to Best Available Technology (BAT) levels. Mobile treatment units, operable at a flow rate of 19 l/min, were used. Methods used included two-stage activated sludge treatment for removal of organic carbon compounds and ammonia; filtration and activated carbon were also studied as polishing steps. For each treatment studied, samples (including toxic pollutants) and operational data were obtained for later use in assessing and comparing treatment adequacy. The study showed that high levels of organic pollutant removal were achieved in the first stage of biological oxidation. Abnormal operating conditions in the coke plant wastewater pretreatment system during the testing resulted in ammonia levels as high as 2000 mg/l, making it necessary to dilute the second stage feed before nitrification could be achieved. Ammonia reductions of > 97% were achieved in the second stage. Activated carbon and filtration effectively removed suspended solids, total organic carbon, color, and thiocyanate.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

In 1972, the Federal Water Pollution Control Act (PL92-500) was enacted by the U.S. Congress. The Act directed the U S. Environmental Protection Agency (U S EPA) to develop effluent limitation guidelines for all major industrial groups, among them the steel industry. EPA was also mandated to recommend appropriate levels of treatment and estimate costs to meet the proposed limitations. As part of its overall mission, the EPA's Industrial Environmental Research Laboratory (Research Triangle Park, NC) funded this study to determine the feasibility of treating steel plant wastewater to Best Available Technology (BAT) Economically Achievable levels. This particular project was concerned with the biological treatment of coke plant wastewater.

The primary purpose of this project was to investigate the technical and economical feasibility of biological treatment of by-product cokemaking wastewater to Best Available Technology (BAT) levels.* Principal wastewater sources produced from the by-product recovery process at the plant investigated included excess ammonia liquor and benzol plant wastes. Wastewater treatment at this plant consisted of stripping the waste ammonia liquor via steam and caustic solutions, followed by blending with* the benzol plant wastes and biological treatment with a single-stage activated sludge system. The wastewater for the pilot study was obtained after an equalization basin and prior to the existing biological system. The combined wastewater contained pollutants such as suspended solids, oil and grease, ammonia, phenolic compounds, cyanide, sulfide, thiocyanates, and toxic materials.

The study was performed using the mobile bio-oxidation system of the EPA. This pilot plant is contained in a semi-trailer van (van No. 3) as shown in Figure 1. Near the end of the investigation, a second EPA semi-trailer van (van No. 2) containing the activated carbon pilot plant system (Figure 2) was brought to the test site. The purpose of this system was to evaluate the efficiency of activated carbon for removing toxic pollutants present in the coke plant wastewater. A small pilot-size dual-media filter was also set up in the second trailer. Dual-media filtration was investigated as a method of polishing the biological oxidation effluent.

*Because the development of final Effluent Limitation Guidelines was under way during the time of this study, the reference BPT (Best Practicable Technology) and BAT pollutant parameters used throughout this report are those listed in the "Development Document for Proposed Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category - Vol II, By-Product Cokemaking Subcategory," October 1979

The wastewater treatment trains that were investigated on a pilot scale included:

1. AS(C) + AS(N)
2. AS(C) + AS(N) + AC
3. AS(C) + AS(N) + DMF

Key

AS(C): activated sludge (carbonaceous removal)
AS(N): activated sludge (nitrification)
AC: activated carbon
DMF: dual-media filtration

In the first treatment train, plant wastewater from downstream of the coke plant cooling tower was passed through a mixing tank, through the first-stage activated sludge system (carbonaceous removal), and then through the second-stage activated sludge system (nitrogen removal). The second treatment train consisted of the first treatment train (bio-oxidation) followed by activated carbon adsorption. The third treatment train included the components of the first treatment train followed by dual-media filtration. The detailed treatment train arrangements are shown graphically in Figure 3.

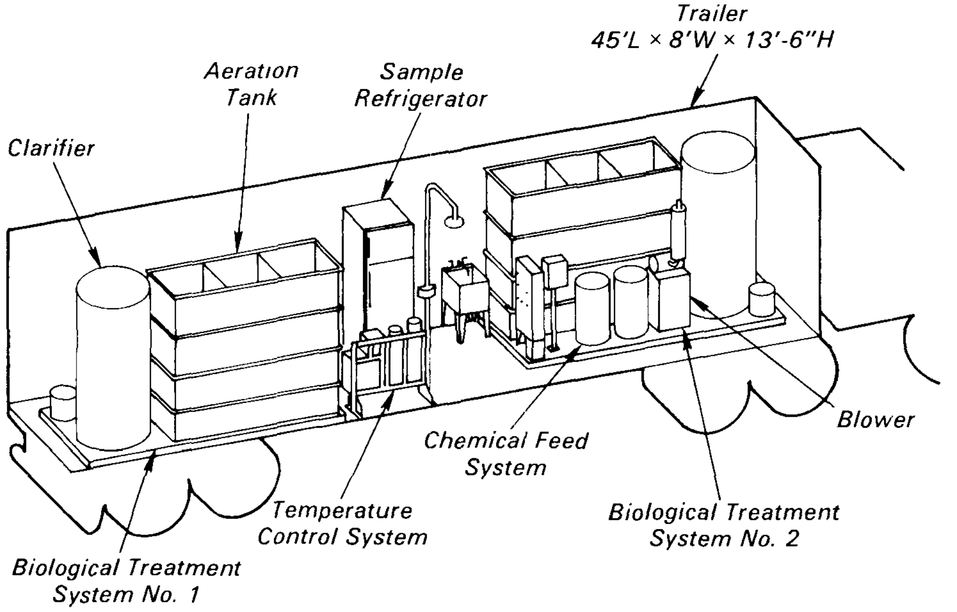

Figure 1. *Steel plant mobile bio-oxidation treatment system--trailer No. 3.*

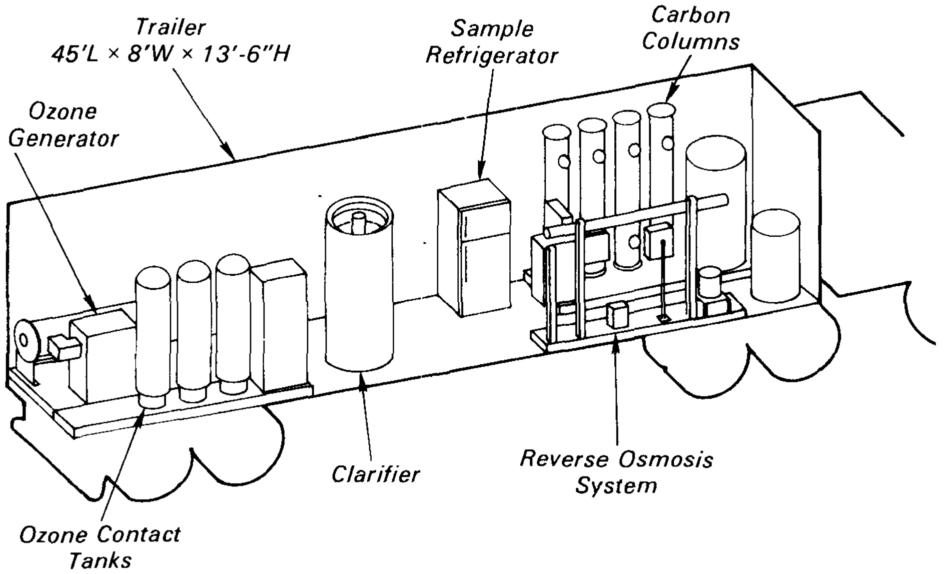

Figure 2. *Steel plant mobile treatment system--trailer No. 2.*

The small sump tank shown in Figure 3 was used for pH adjustment, dilution, and chemical dispersal. As the waste water flowed through the first-stag activated sludge system, carbonaceou material (BOD, phenol, etc.) was re moved. Effluent from the first-stag clarifier was pumped through th second-stage activated sludge systen where ammonia nitrogen was oxidize

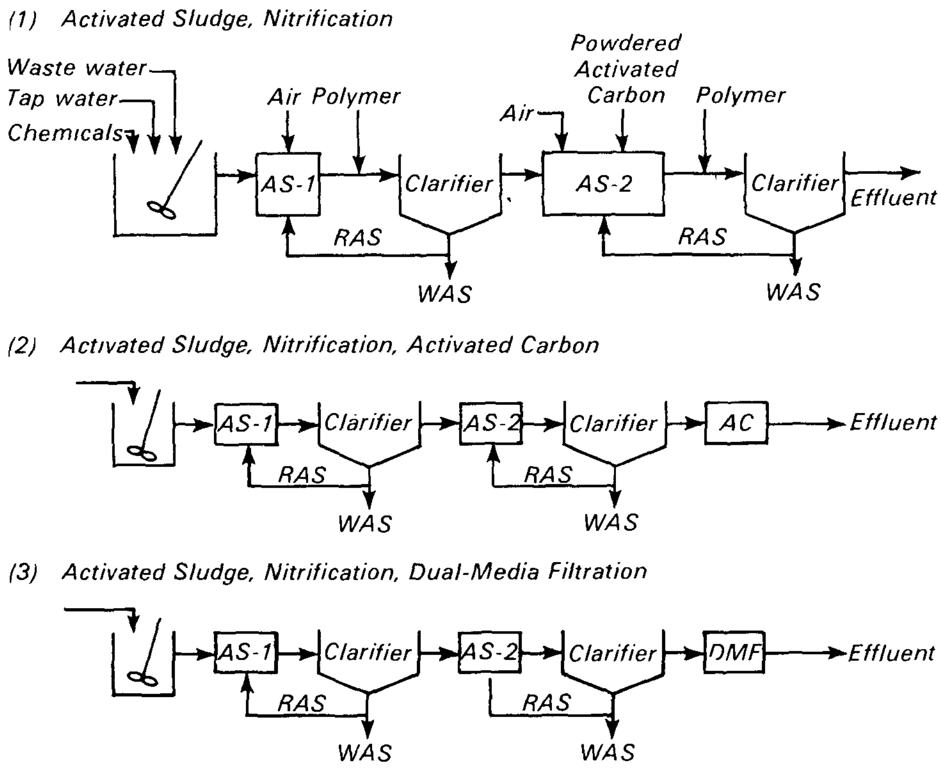

Figure 3. *Process trains investigated for treatment of by-product coke plant wastewater.*

by the nitrification process. The use of powdered activated carbon was investigated for removal of toxics and to improve settling. Final effluent from the second-stage activated sludge system was passed through the activated carbon/dual-media filtration system late in the test program to complete the second and third treatment train arrangements, respectively

During the pilot study, samples were collected for both conventional and toxic pollutants. Operational data were also recorded on a daily basis to evaluate the effectiveness of the respective treatment trains. The pilot study results were evaluated using three primary criteria·

1. Process and/or treatment train performance.
2. Capital and operating costs.
3. Space requirements.

Conclusions

The two-stage activated sludge treatment train was successful in reducing influent concentrations of coke plant pollutants. Because of upsets in the coke plant pretreatment system during the pilot study period, high dilution of the waste stream was necessary. Significant reductions in pollutant concentrations were still achieved, however.

The treatment train consisted of. (1) diluting the raw coke plant wastewater in a ratio of 1 part service water to 3 parts coke plant wastewater; (2) blending the mixture for pH control and phosphorus addition; (3) removing carbonaceous material in the first-stage activated sludge system, followed by clarification of the wastewater with polymer addition; (4) further wastewater dilution in a ratio of 3 5 parts service water to 1 part first-stage activated sludge effluent; (5) addition of sodium carbonate, powdered activated carbon, and pH control chemicals to the second-stage mixed liquor; and (6) oxidation of ammonia in the second-stage activated sludge unit to nitrate, followed by clarification with polymer addition. Late in the study, filtration of the second-stage activated sludge effluent was investigated.

1. The first-stage activated sludge unit was capable of removing 95 percent of the influent BOD and 90-100 percent of the incoming phenol. Thiocyanate and TOC reductions were also achieved. An estimated capital cost of $2,654,000 and annualized cost of $4 51/3,785 l ($4.51/1,000 gal) would be realized for a 1,892 m^3/day (0.5 mgd) treatment facility, assuming current wastewater pollutant concentrations If ammonia still (fixed and free) efficiency could be improved, capital costs could be reduced to $2,427, 000 and annualized costs to $4 21/3,785 l ($4.21/1,000 gal.), assuming a similar design flow

2. Influent ammonia to the second (nitrification)-stage activated sludge system was quite variable, ranging from 230 mg/l to 2,090 mg/l It was necessary to dilute the first-stage activated sludge effluent to maintain a consistent feed ammonia strength before nitrification could be achieved After a sufficient population of nitrifiers were in the system, ammonia reductions of > 97 percent were consistently achieved. Due to the large quantity of dilution water required, it was not possible to determine the effect of other contaminants on the nitrification process Suspended solids, oil and grease, thiocyanate, and phenol were also reduced to low levels. To treat a 1,892 m^3/day (0 5 mgd) wastewater stream as received during the pilot study would require an estimated capital investment of $3,209,000 The expected annualized cost would be $14.17/ 3,785 l ($14 17/1,000 gal) For comparison, if the feedwater were from an efficiently operating ammonia still, a similar size design would have a capital cost of about $1,238,000 and an annualized cost of only $4.12/3,785 l($4.12/ 1,000 gal.).).

3. Activated carbon, when used as a polishing step for the nitrified effluent, was capable of removing 53 percent of the influent TOC, 60 percent of the color, 40 percent of the BOD, and 79 percent of the remaining thiocyanate.

4. Dual-media filtration was found to remove about 50 percent of the suspended solids present in the second-stage activated sludge nitrified effluent. The expected

capital cost for a 1,892 m^3/day (0.5 mgd) design is $237,000 The corresponding annualized cost is $0.27/3,785 l ($0.27/1,000 gal.).

5. Priority pollutant analyses were performed on 13 samples taken from various points in the treatment system All priority pollutant metals were reduced to less than 100 μg/l except selenium and zinc. The biological treatment train was efficient in removing all volatile organics, base/neutral extractable organics, and acid-extractable organics to non-detectable levels.

References

1. Development Document for Proposed Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category--Vol. II, By-Product Cokemaking Subcategory, October 1979, EPA-440/1-79/02400.

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The complete report, entitled "Two-Stage Biological Treatment of Coke Plant Wastewater," (Order No PB 81-240 798, Cost: $18.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
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Telephone: 703-487-4650

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U.S Environmental Protection Agency
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