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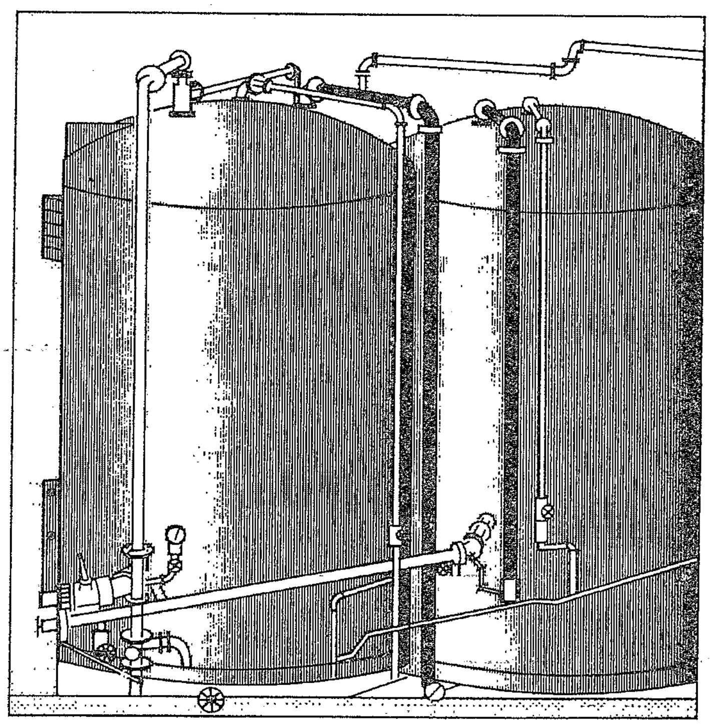
Granular Activated Carbon Systems

Problems and Remedies



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Granular Activated Carbon Sy

Introduction

The granular activated carbon (GAC) system is generally utilized for the removal of soluble organics in wastewater, including refractory organics. GAC can be used either as a tertiary treatment process in advanced wastewater treatment plants, or as a secondary treatment process. It may be used in conjunction with biological treatment processes, or in independent physical/chemical (IPC) treatment plants.

A comprehensive evaluation of selected advanced treatment (AT) facilities was recently completed with the objective of identifying common problems with GAC systems related to design deficiencies, equipment performance, and operation/maintenance. Based on the information obtained from wastewater treatment plant visits and other experiences, remedial measures for minimizing the problems are offered.

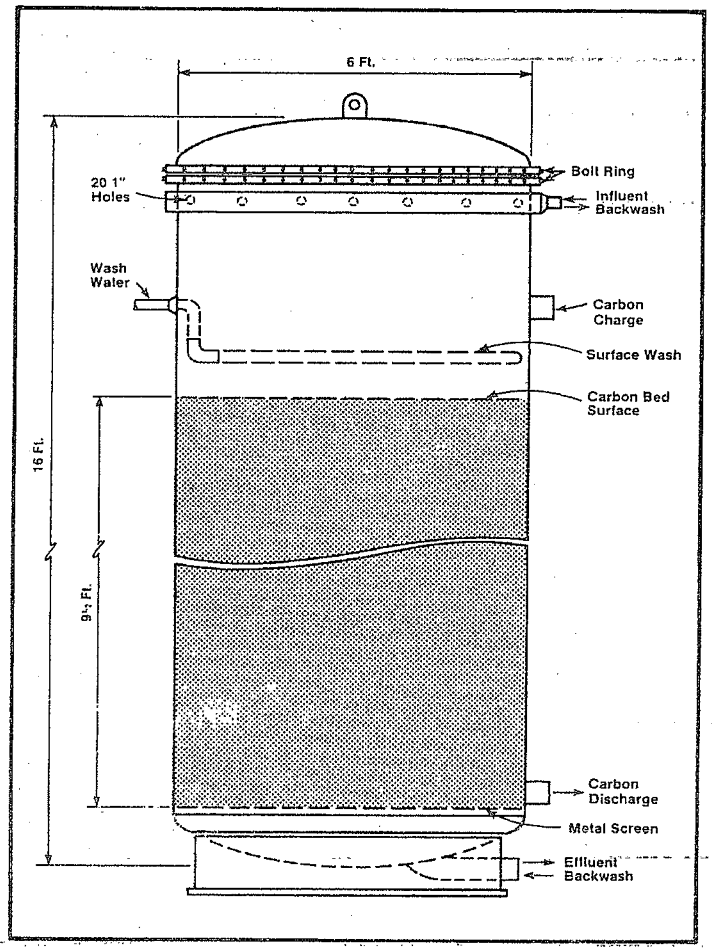

Figure 1 Downflow Type Granular Activated Carbon System

Process Description

Wastewater treatment with GAC consists of the carbon contact system and the carbon regeneration system. Activated carbon removes soluble organics from water in three steps. The first step is the transport of the dissolved substances to be removed (solute) through a surface film to the exterior surface of the carbon. The next step is the diffusion of the solute within the pores of the activated carbon. The third step is the adsorption of the solute on the interior surfaces bounding the pore and capillary spaces of the activated carbon. Alternative configurations for carbon contacting systems include the following:

- Downflow or upflow of the wastewater through the carbon bed.
- Parallel or series operation (single or multistage).
- Pressure or gravity operation in downflow systems.
- Packed or expanded bed operation in upflow systems.

Figure 1 presents a schematic of a typical downflow GAC process unit. As the carbon is exposed to organics in solution it gradually loses its adsorptive capacity because the available adsorption sites become exhausted. The carbon must then be regenerated either at the treatment plant or off-site. Granular carbon is typically regenerated in a furnace by oxidizing the adsorbed organic matter, thus removing it from the carbon surfaces. Fresh carbon is added to the system to replace any that is lost during regeneration and hydraulic transport.

The following discussion of the problems and remedial measures of the GAC system is subdivided according to the different components of the system. The specific areas discussed are: (1) carbon contactor, (2) backwash system, (3) carbon regeneration system, and (4) instrumentation and control system.

Carbon Contactor

Carbon contactors constructed of mild steel tend to become pitted and corroded from exposure to wet granular activated carbon. Corrosion is also caused by hydrogen sulfide that is generated when sulfates present in the wastewater are biochemically reduced by bacteria under anaerobic conditions in the carbon column. The carbon contactors should have protective coatings, such as coal tar epoxy, to prevent corrosion. Potential remedies for controlling hydrogen sulfide generation include the addition of chemicals to the influent, such as sodium nitrate or chlorine, and maintaining aerobic conditions in the column. Preaerating the influent and reducing the detention time (if possible) are other methods for controlling the generation of hydrogen sulfide.

Microbial growth in the carbon bed creates media clogging problems. Media clogging problems could be minimized by increasing the backwash frequency and using a surface wash system.

Carbon Transport System

Clogging of the carbon slurry transport pipes occurs at many plants. The problem is caused by undersized piping, short radius bends, insufficient velocity, and lack of cleanouts in the carbon transport system. Abrasion wear of slurry transport pipes is also a common problem in unlined mild steel and fiberglass reinforced plastic (FRP) piping, particularly at sharp bends. Increasing the size of the piping (a minimum pipe diameter of 2 inches is recommended), transporting a more dilute carbon slurry, using long radius piping, and providing a sufficient number of cleanouts would help to minimize the clogging problem.

Abrasion of the pipes could be reduced significantly by using glass or rubber lined steel piping or coated cast iron piping for carbon slurry transport. The use of long radius piping and extra-heavy elbows and tees is recommended.

Backwash System

Clogging of backwash and surface wash nozzles is a common problem. This is caused by migration of carbon and solids to the underdrains where they are picked up by the incoming backwash water and clog the distribution nozzles. Screens installed at the bottom of the carbon bed prevent media migration to the underdrains. Frequent backwashing, especially after loading the carbon, removes the fines from the bed, thus decreasing the clogging of the nozzles.

Carbon Regeneration System

The regeneration system is a source of carbon loss due to incorrect furnace operation. Preventing excess furnace operating temperatures and timely removal of the regenerated carbon from the furnace are essential in order to minimize carbon loss during regeneration. An adequate quantity of spent carbon should be stored to permit continuous operation of the regeneration furnace. Plant operators should carefully follow operating instructions offered by the equipment manufacturer and design engineer.

Instrumentation and Control System

The maintenance of instrumentation and control equipment at many treatment plants is not adequate, resulting in ineffective automatic process control systems, and consequently, the discharge of poor quality effluent from the GAC process unit. It is critical that certain operating parameters be accurately monitored. These include wastewater flow, pH of influent, head loss across the carbon columns, and effluent BOD, TOC, and COD.

Conclusions

The performance of GAC systems in wastewater treatment plants indicates that many of the plants have problems in operation, and also in achieving the required quality of effluent from the GAC unit. The causes of these problems are varied and relate to design deficiencies, improper operation, influent characteristics, and the efficiency of the carbon adsorption process itself. It is possible to rectify many of these deficiencies at existing facilities, but the cost effectiveness of incorporating remedial measures should be considered on a case-by-case basis. Some of the remedial measures could be incorporated in the design of new GAC systems at a reasonable cost. A summary of major problems experienced with GAC systems and suggested recommendations for improvement are given in Table 1.

The overall performance of the GAC systems could be improved by implementing the suggested remedial measures. However, in certain applications some compounds may not be removed by the GAC process. This points out the importance of conducting extensive treatability studies prior to utilizing GAC in a particular application. Specific design parameters (i.e., type of carbon, wastewater temperature and pH) should also be determined on the basis of treatability studies. Such studies should also demonstrate the overall effectiveness of the proposed treatment system, including processes preceding and following the GAC unit.

Problem
Carbon Contactor
• Hydrogen sulfide generation in the carbon contactor.
• Corrosion of the carbon contactor.
• Media clogging.
Carbon Transport System
• Clogging of the carbon slurry transport pipeline.
• Abrasion of the carbon slurry pipeline.
Backwash System
• Clogging of backwash nozzles.
Carbon Regeneration System
• Excessive carbon loss.
Instrumentation and Control System
• Nonfunctioning instrumentation and control systems.

Table 1 **Granular Activated Carbon System: Problems and Sug**

Suggested Remedy

- Maintain aerobic conditions in the carbon contactor; aerating the influent; adding chemicals such as sodium nitrate to influent; and increasing the frequency of backwashing.
- Carbon contactors should have protective coatings; (e.g., coal tar epoxy); use nonmetallic connectors within the contactor; eliminate the potential for hydrogen sulfide generation.
- Use a surface wash system; increase backwash frequency.
- Increase transport line size (minimum suggested diameter is 2 inches); decrease carbon slurry concentration; use long radius piping.
- Use black steel or lined steel pipe; use long radius piping, along with extra-heavy elbows and tees.
- Install screens at the bottom of the carbon bed to prevent media migration; backwash frequently, especially after loading the carbon to remove carbon fines.
- Operate the carbon regeneration furnace at the specified conditions; store enough spent carbon to permit more continuous operation of the regeneration furnace.
- An adequate maintenance program should be established and followed.