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Clean Water Council

Public Hearing on PFOS/PFOA

Comments on Regulating Surface Water Dischargers

Jan 21, 2021 Hearing Comments

These comments support my fellow members' comments made by the Association of Environmental Authorities (AEA) and I echo the comments about the need for an approved certified testing method for treated wastewater. While there is a program where NJDEP approves on a lab-by-lab piecemeal approach, there is no national method for analyses contained in Standard Methods for the Examination of Water and Wastewater, which is utilized for all other reporting under our discharge permits. First and foremost, let the drinking water roll out of testing, where there is a recognized certified method, and then possible treatment for PFOA/PFOS, be implemented to reduce these chemicals in source water going to the sewage treatment plants.

Treating wastewater for the removal of these compounds is generally by three methods, reverse osmosis or ultrafiltration's, granular activated carbon (GAC) or ion exchange (IX). RO is not practical for wastewater treatment plants. Large quantities of reject will be created in the order of millions of gallons per day and where will it go? Both GAC and IX are subject to fouling, sliming and clogging, which I would like to explore further. Even after disinfection, final effluent on a daily basis contains millions to billions of bacteria and other microscopic life. Spring, summer and fall, the final clarifiers have algae growth which needs to be washed, scrubbed or brushed off the weirs and other structural components and ends up in the effluent. All of this material will attach, grow and/or clog in the GAC or IX reactors or vessel and bind or blind the media. USEPA has identified these type of problem for decades going back as far as 1981 with media clogging and corrosion from H_2S generation. With all of the biological mass and constant feeding of food and nutrients (effluent) the filter reactors can and will become anoxic or even anaerobic with H2S generation which will lead to corrosion. It is far more complicated that treating portable water.

For example, preliminary engineering estimates to install granular activated carbon would force our facility to issue a bond that exceeds any bond issued in our 70+ year existence. We recently borrowed $25 million in 2016, our largest borrowing to date since 1946, to invest in our infrastructure and upgrade our treatment plant, pumping stations and collection system to keep them operational for at least the next 25 years. PFOA/PFOS removal would more than double our current debt and more than double our present debt service payments. We would be forced to pass these additional costs on to our ratepayers. See the attached letter from our engineer, which estimates the cost for micro filtration, to remove biological material, and GAC filtration to be between $30 to over $43 million, this would be 120-170% increase over our present debt of $24 million. This doesn't include the increase in annual O&M cost for extra electricity to pump to the filtration system, replacement of exhausted GAC and increased sludge production from the microfiltration backwash. Wastewater is different from drinking water and compared to PFOS/PFOA compounds, it contains relatively high levels of organic compounds, which will use the adsorptive capacity of the GAC leading to more often replacement and increased O&M cost. The NJDEP unfortunately has gone on written record stating the cost for a wastewater treatment plant to remove PFOS/PFOA will be about the same as a potable water plant. **This is not true, not factual and not good and sound science or engineering.** There have been decades of USEPA Guidance Manuals which speak to operational problems and increased cost for GAC at wastewater treatment plants, unfortunately all ignored by NJDEP staff. IX also suffers from the same issues of resin fouling from bacteria and algae as well as organic substances. When oxidizing agents such as chlorine or chloramine come in contact with both cation and anion resins, they can damage the resins leading to capacity loss and inhibited performance. NJDEP has also gone on the record when fouling issues were brought up associated with filtration, it should not be a problem after disinfection, which in many cases is chlorine and the resulting chloramine, the exact chemicals which will degrade the media. Not good science, not sound engineering. Cost will be significantly more for wastewater facilities in both capital cost and long-term O&M. (see attached EPA manuals and IX paper).

Parts of our sewerage system, acquired from the City, dates back to 1905 and other areas dated 1928, new portions are from the 1950's to the present day. These systems require capital improvements to update and maintain this infrastructure. Funds unnecessarily diverted for questionable PFOA/ PFOS compliance are dollars lost and not spent on more critical infrastructure needs to provide reliable safe wastewater conveyance and treatment and to provide reliability and resiliency during storms and power outages.

Many of our customers are in census tracts identified as Overburdened Communities as defined in NJSA 13.1 et seq. (P.L.2020, c.92.). These increased costs will unfairly fall upon those least capable of bearing the higher rates. Furthermore, to demonstrate this, we have approximately 12,700 accounts, and for 2020 there were 1,385 accounts placed on notice of tax sale for sewer lien. While this number was reduced in part by mortgage holders stepping up to pay the sewer lien (and assumed then increasing escrow fees) as well as property owners paying up, this is 11% delinquency rate. Any significant rate increase is expected to significantly increase this delinquency. This delinquency rate was not COVID induced, the number of accounts was higher at 1,443 in 2019. If debt service was more than doubled and O&M increased by 20-25% the impact is a 40-45 % increase in user fees and I would expect a significant increase in delinquency in payments and a significant economic burden to our customers.

A question, who will run and operate these facilities? NJDEP requires a licensed operator to be in charge. With the potential for additional treatment and filter equipment that will be required for PFOS/PFOA removal, more wastewater treatment plants will become level S 4 requiring the highest license and generally require a license person of any level on each shift. There was already a shortage of the higher level S3 and S4 operator prior to 2020. **The water and wastewater licensing program is a disaster and a potential future public health problem**. The Board of Examiners held only two meeting in 2020. The regulations require three tests a year and only one was held. **NO licenses**, based upon testing, have been issued in a over a year. Several hundred applicants were approved for the March exam, which was cancelled and eventually were tested in the end of 2020. The Board was to meet January 20, 2021, but it was cancelled and apparently because the public notice was not sent out. At this meeting the Board was to approve the results of the last test, no board action equals no new licenses. Operators are retiring and, more so with COVID, and cannot be replaced. Operators can not advance to a higher level and fill the vacancies of the higher licensed people retiring or to advance their careers or receive higher compensation associated with the higher license. Applications are not being processed., There is a closet with dozens if not hundreds of applications with expired checks that have not been moved forward. As a comparison the Professional Engineer board held eight meetings during 2020 and continued to process applications and tests. It functions in a similar fashion, with licensed professional reviewing applicant's education and experience and staff performing administrative functions. The NJDEP and the Infrastructure Bank have spent billions on infrastructure but cannot provide the resources to support trained and license operators or even review and process applications. NJ has the proud history of being the first and longest licensed operator program going back over 100 years and it now basically vanished, while other state license programs continue under COVID protocol.

I would like to summarize my thoughts:

1.Evaluate the rollout and sampling results for portable water facilities first and implementation of treatment at potable water facilities before moving to surface water dischargers.

2. Likewise, need to have adopted an approved test method for wastewater.

3. Recognize the significant difference between treating potable water and wastewater. NJDEP staff needs to have the science and engineering knowledge base to make informed regulatory

decision based on sound science and engineering. Recognize significantly higher capital and O&M cost for wastewater pants compared to potable water plants.

4. NJDEP must supply the resources to get the licensing of water and wastewater operators' program back up and running.

Very Truly Yours,

Dennis W. Palmer, P.E., P.P.

Executive Director/Chief Engineer

CC Peggy Gallos AEA

United States Environmental Protection Agency
Office of Water Washington, D.C.
EPA 832-F-00-017 September 2000

Wastewater Technology Fact Sheet

Granular Activated Carbon Adsorption and Regeneration

DESCRIPTION

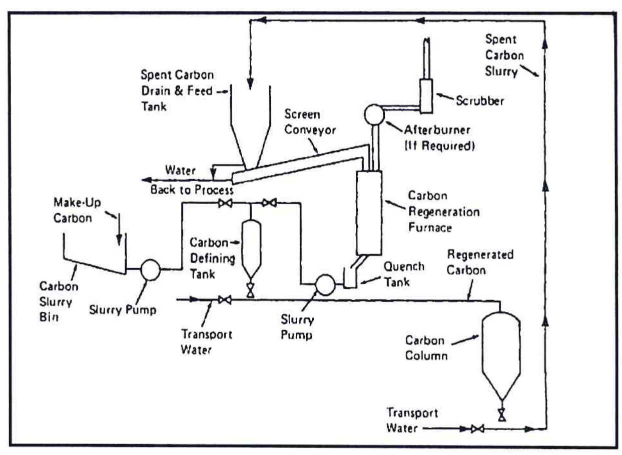
Granular activated carbon (GAC) adsorption has been used successfully for the advanced (tertiary) treatment of municipal and industrial wastewater. GAC is used to adsorb the relatively small quantities of soluble organics (See Table 1) and inorganic compounds such as nitrogen, sulfides, and heavy metals remaining in the wastewater following biological or physical-chemical treatment. Adsorption occurs when molecules adhere to the internal walls of pores in carbon particles produced by thermal activation.

TABLE 1 ORGANIC COMPOUNDS AMENABLE TO ADSORPTION BY GAC

Class	Example
Aromatic solvents	Benzene, toluene, xylene
Polynuclear aromatics	Naphthalene, biphenyl
Chlorinated aromatics	Chlorobenzene, PCBs, endrin, toxaphene, DDT
Phenolics	Phenol, cresol, resorcinol, nitrophenols, chlorophenols, alkyl phenols
Aromatic amines & high molecular weight aliphatic amines	Aniline, toluene diamine
Surfactants	Alkyl benzene sulfonates
Soluble organic dyes	Methylene blue, textiles, dyes
Fuels	Gasoline, kerosene, oil
Chlorinated solvents	Carbon tetrachloride, percholoroethylene
Aliphatic & aromatic acids	Tar acids, benzoic acids
Pesticides/herbicides	2,4-D, atrazine, simazine, aldicarb, alachlor, carbofuran

Source: U.S. EPA, 1984.

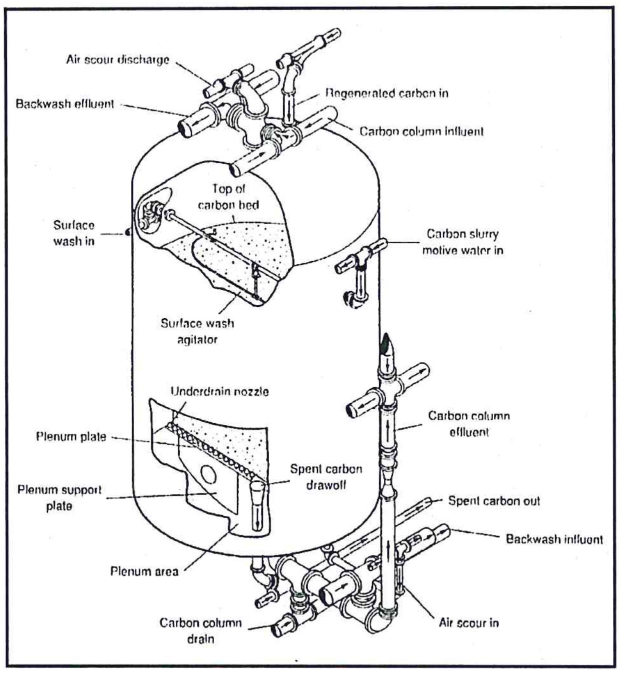
GAC systems are generally composed of carbon contactors, virgin and spent carbon storage, carbon transport systems, and carbon regeneration systems (See Figure 1). The carbon contactor consists of a lined steel column or a steel or concrete rectangular tank in which the carbon is placed to form a "filter" bed. A fixed bed downflow column contactor (See Figure 2) is often used to contact wastewater with GAC. Wastewater is applied at the top of the column, flows downward through the carbon bed, and is withdrawn at the bottom of the column. The carbon is held in place with an underdrain system at the bottom of the contactor. Provisions for backwash and surface wash of the carbon bed are required to prevent buildup of excessive headloss due to accumulation of solids and to prevent the bed surface from clogging.



Source: WEF MOP 8, 1998.

FIGURE 1 GAC ADSORPTION SCHEMATIC

Expanded bed and moving bed carbon contactors have been developed to overcome problems associated with headloss buildup experienced with fixed bed downflow contactors. In an expanded bed system, wastewater is introduced at the bottom of the contactor and flows upward, expanding the carbon bed, much as the bed expands during backwash of a fixed bed downflow contactor. In the moving bed system, spent carbon is replaced continuously so that the headloss does not build up. Carbon contactors may be operated under either pressure or gravity flow. The choice between pressure and gravity flow generally depends on the available pressure (head) within the wastewater treatment plant and cost.



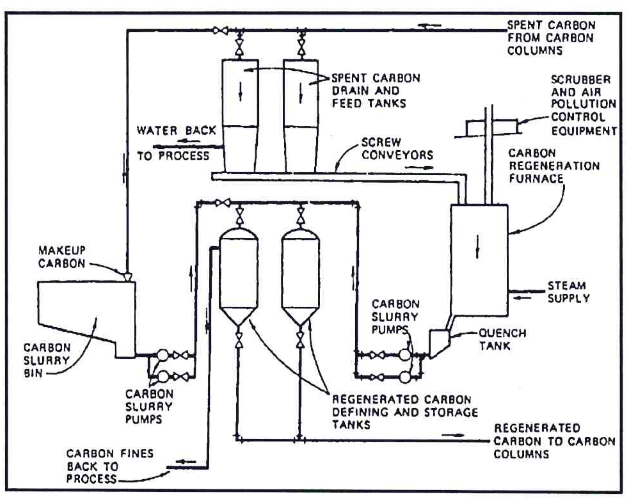
Source: Tchobanoglous and Burton, 1991.

FIGURE 2 TYPICAL DOWNFLOW CARBON CONTACTOR

All carbon contactors must be equipped with carbon removal and loading mechanisms to allow spent carbon to be removed and virgin or regenerated carbon to be added. Spent, regenerated, and virgin carbon is typically transported hydraulically by pumping as a slurry. Carbon slurries may be transported with water or compressed air, centrifugal or diaphragm pumps, or eductors.

When the carbon contactor effluent quality reaches minimum water quality standards, the spent carbon is removed from the contactor for regeneration. Small systems usually find regeneration of their spent carbon at an off-site commercial reactivation facility to be the most convenient and economical method. In this case, the spent carbon is hydraulically transported from the contactor to a waiting truck. Regenerated or virgin carbon is then hydraulically transported from a second truck or from a separate compartment in the first truck to the contactor, then to a commercial reactivation facility. Generally, systems which contain at least one million pounds of carbon find on-site regeneration to be cost effective.

Carbon regeneration is accomplished primarily by thermal means. Organic matter within the pores of the carbon is oxidized and thus removed from the carbon surface. The two most widely used regeneration methods are rotary kiln and multiple hearth furnaces. Approximately 5 to 10 percent of the carbon is destroyed in the regeneration process or lost during transport and must be replaced with virgin carbon. The capacity of the regenerated carbon is slightly less than that of virgin carbon. Repeated regeneration degrades the carbon particles until an equilibrium is eventually reached providing predictable long term system performance. See Figure 3 for a schematic of the carbon regeneration process.



Source: WEF MOP 8, 1998

FIGURE 3 REGENERATION SCHEMATIC

APPLICABILITY

Typically, GAC adsorption is utilized in wastewater treatment as a tertiary process following conventional secondary treatment or as one of several unit processes composing physical-chemical treatment. In wastewater treatment plants utilizing biological secondary treatment, GAC adsorption is generally located after filtration and prior to disinfection. When utilized in a physical-chemical treatment process, GAC adsorption is generally located following chemical clarification and filtration and prior to disinfection. In addition, GAC adsorption systems have a relatively small footprint making them suitable for facilities with limited land availability.

The successful application of carbon adsorption for municipal wastewater treatment depends on the quality and quantity of the wastewater delivered to the adsorption system. For a carbon contactor to perform effectively, the feed water to the unit should be of uniform quality (suspended solids concentrations less than 20 mg/l) and without surges in flow. Wastewater constituents that may adversely affect carbon adsorption include suspended solids, BOD_5, and organics such as methylene blue active substances or phenol and dissolved oxygen. Environmental factors that must be considered include pH and temperature because they may impact solubility, which affects the adsorption properties of the wastewater components onto carbon (WEF MOP 8, 1998).

ADVANTAGES AND DISADVANTAGES

Before deciding whether carbon adsorption/regeneration meets the needs of a municipality, it is important to understand the advantages and disadvantages of both the adsorption and regeneration process.

Advantages (Adsorption)

C For wastewater flows which contain a significant quantity of industrial flow, GAC adsorption is a proven, reliable technology to remove dissolved organics.

C Space requirements are low.

- GAC adsorption can be easily incorporated into an existing wastewater treatment facility.

Advantages (Regeneration)

C Systems are reliable from a process standpoint.

C Reduces solid waste handling problems caused by the disposal of spent carbon.

C Saves up to 50 percent of the carbon cost.

Disadvantages (Adsorption)

C Under certain conditions, granular carbon beds may generate hydrogen sulfide from bacterial growth, creating odors and corrosion problems.

C Spent carbon, if not regenerated, may present a land disposal problem.

C Wet GAC is highly corrosive and abrasive.

C Requires pretreated wastewater with low suspended solids concentration. Variations in pH, temperature, and flow rate may also adversely affect GAC adsorption.

Disadvantages (Regeneration)

C Air emissions from the furnace contain volatiles stripped from the carbon. Carbon monoxide is formed as a result of incomplete combustion. Therefore, afterburners and scrubbers are usually needed to treat exhaust gases.

C The induced draft fan of a multiple hearth furnace may produce a noise problem.

C The process is most effective when operated on a 24-hour basis, requiring around-the-clock operator attention.

C The process is subject to more mechanical failures than other wastewater treatment processes.

DESIGN CRITERIA

Prior to the design of GAC systems, a pilot plant study should be performed to determine if the technology will meet discharge permit requirements and to quantify optimum flow rate, bed depth, and operating capacity on a particular wastewater. This information is required to determine the dimensions and number of carbon contactors required for continuous treatment.

The sizing of carbon contactors is based on contact time, hydraulic loading rate, carbon bed depth, and number of contactors. The carbon contact time typically ranges from 15 to 35 minutes depending on the application, wastewater constituents and desired effluent quality. Hydraulic loading rates of 4 to 10 gpm/sq.ft are typically used for upflow carbon columns. For downflow carbon columns, hydraulic loading rates of 3 to 5 gpm/sq.ft are used. Carbon bed depth varies typically within a range of 10 to 40 feet depending on carbon contact time (Tchobanoglous, 1991).

The number of contactors should be sufficient to ensure enough carbon contact time to maintain effluent quality while one column is off line during removal of spent carbon or maintenance. The normal practice is either to use two columns in series and rotate them as they become exhausted or to use multiple columns in parallel so that when one column becomes exhausted, the effluent quality will not be significantly affected (WEF MOP 8, 1998).

Regeneration facilities are typically sized based on carbon dosage or use rate. The dosage rate depends on the strength of the wastewater applied to the carbon and the required effluent quality. Typical dosage rates for filtered, secondary effluent range from 400 to 600 lbs/mil.gall., while typical dosage rates for coagulated, settled and filtered raw wastewater (physical-chemical) range from 600 to 1800 lbs/mil.gall.

PERFORMANCE

Niagara Falls Wastewater Treatment Plant
Niagara Falls, New York

The Niagara Falls Wastewater Treatment Plant (NFWTP) has been operating as a physical-chemical activated carbon secondary treatment facility since 1985. With a design average daily flow capacity of 48 mgd, it is the largest municipal physical-chemical activated carbon wastewater treatment plant in operation in the United States. The treatment process consists of chemically assisted primary sedimentation, granular activated carbon adsorption, oxidation, and disinfection. The influent pH can be adjusted to compensate for industrial discharge. The current average daily flow is 35 mgd. Industrial flow to the plant is approximately 17 percent of the total flow.

The activated carbon system at NFWTP includes 28 carbon beds which are 17.3 feet wide by 42 feet long. Each carbon bed is approximately 8.5 feet in depth and contains 180,000 pounds of carbon. Primary effluent percolates downward by gravity through the GAC bed. Each carbon bed provides chemical adsorption of pollutants from the wastewater, physical filtration of solids, and biological degradation from the incidental anaerobic activity that occurs within.

The carbon beds at NFWTP operate in parallel. During dry weather, there are typically 17 carbon beds in operation with a primary effluent application rate of approximately 2.2 gpm/sq.ft. During wet weather, additional beds are placed in operation. All beds are operated at an application rate of approximately 3gpm/sq.ft (Roll, 1996). Backwash of the carbon beds is based on headloss.

Regeneration of the spent carbon is performed on-site in a multiple hearth furnace. Each filter bed is separately removed from service and emptied of carbon. The carbon is fed to the furnace at a rate of about 2,000 lbs/hr. The regenerated carbon is kept in storage until an empty bed becomes available. Normal operating losses, which average 5.5 percent, require the addition of virgin carbon to maintain inventory levels. At present, the four month regeneration process to regenerate all of the carbon is performed once per year.

Three storage tanks are used during on-site regeneration. The spent carbon storage tank has a capacity of 2.5 carbon beds; the regenerated carbon storage tank can hold 1.5 beds of carbon and the virgin carbon storage tank has a capacity of 1 carbon bed. Carbon is moved about the plant in a slurry through an eductor system.

With GAC adsorption, the NFWTP has achieved very low effluent organic compound concentrations. On a daily basis, the facility receives approximately 800 pounds of influent priority pollutants which are reduced by the treatment process to 12 pounds in the effluent to the Niagara River. The effluent discharge permit issued to NFWTP by the New York State Department of Environmental Conservation includes effluent limitations for volatile compounds, acid compounds, base/neutral compounds, pesticides, metals, and cyanide.

Millard H. Robbins Reclamation Facility, Upper Occoquan Sewerage Authority, Centreville, Virginia

The Millard H. Robbins Reclamation Facility (MHRRF) provides biological, tertiary treatment to an average daily wastewater flow of 24 mgd. Industrial flow to the plant is approximately 10 percent of the total flow. The treatment process consists of primary sedimentation, conventional activated sludge with nitrification, lime addition for phosphorous removal, clarification, two-stage recarbonization, flow equalization, multimedia filtration, GAC adsorption, post filtration and disinfection. The MHRRF discharges its effluent to Bull Run which flows into the Occoquan Reservoir. This reservoir serves as raw water storage for the potable water supply to portions of northern Virginia.

The activated carbon system at MHRRF includes 32 upflow carbon columns which are 10 feet in diameter and 40 feet tall. Each column has a capacity of 1mgd and contains approximately 75,000 pounds of carbon. Flow is pumped through the columns by a pump station which also serves the multimedia filters and post filtration system. Post filtration is provided following the GAC columns to remove carbon fines from the effluent to maintain the Virginia Pollutant Discharge Elimination System (VPDES) permit requirement for turbidity of 0.5 NTU.

The carbon columns at MHRRF are operated in parallel. During average daily flow periods, approximately 24 columns are in operation with the remaining eight columns brought on line during daily peak flow periods. During wet weather, flows in excess of 32 mgd are stored in a 90 million gallon pond.

Regeneration of the spent carbon is performed on-site in a multiple hearth furnace. The regeneration process takes approximately 8 to 10 weeks to regenerate approximately one-third of the carbon in all 32 columns and is performed twice each year. Consequently, it takes approximately 18 months (three regeneration cycles) to regenerate the total quantity of carbon in the columns. Spent carbon is removed from the bottom of each column and transported to the regeneration furnace through an eductor system. The regenerated carbon is then added at the top of each column. The cost for on-site regeneration at MHRRF is approximately $0.35 per pound. Normal operating losses, which average 5 to 7 percent of the total quantity of GAC in use, require the addition of virgin carbon to maintain inventory levels. Most of the carbon attrition occurs during regeneration with approximately 10 to 12 percent of the total carbon regenerated lost during the regeneration process. Carbon is moved about the plant in a slurry through an eductor system.

GAC adsorption is utilized at MHRRF to remove non-biodegradable, soluble organics. COD is used as the surrogate indicator of non-biodegradable organics removal by the GAC columns. Currently, the Virginia Pollutant Discharge Elimination System (VPDES) discharge permit limit for COD is 10 mg/l. Following GAC regeneration, effluent COD concentrations range from 6 to 7 mg/l, which corresponds to approximately 50 percent removal of COD. As the GAC in the columns becomes exhausted, the percentage removal of COD declines to approximately 25 percent. When the effluent COD concentration has increased to 9 mg/l, GAC regeneration is initiated.

OPERATION AND MAINTENANCE

The proper operation and maintenance of GAC adsorption and regeneration systems ensures the efficient removal of soluble organics from secondary effluent. A routine O&M schedule following manufacturer's recommendations should be developed and implemented for any GAC adsorption and regeneration system. Regular O&M includes the following:

- Backwash of carbon contactor based on headloss or flow.
- Flush carbon transport piping to prevent clogging.
- Backwash frequently after loading carbon to minimize clogging of backwash nozzles by carbon fines.
- Store an adequate supply of spent carbon to allow continuous operation of the regeneration furnace.
- Test and calibrate instrumentation and controls on a routine basis.

COSTS

The construction and operation and maintenance costs of carbon adsorption and regeneration depend on the characteristics of the wastewater to be treated, the capacity of the plant, and the plant site. Therefore, the designer is responsible for selecting a system that will meet the National Pollutant Discharge Elimination System NPDES permit requirements at the lowest cost possible. Once the optimum flow rate, bed depth, and operating capacity of GAC for a particular wastewater are determined, comparative costs for different carbon contactor configurations and the cost of on-site regeneration versus off-site regeneration can be estimated. Following a thorough engineering and economic analysis of alternatives, the final equipment configuration can be selected.

Construction costs include the carbon contactors, carbon transport system, carbon storage tanks, carbon regeneration system (if applicable), influent wastewater pumps (if applicable) and contactor backwash system. Operation and maintenance costs include the purchase of virgin carbon, on-site regeneration or purchase of regenerated carbon, electrical power to operate pumps and controls, flushing of carbon slurry piping, and replacement of parts. Currently, the cost of virgin carbon ranges from $0.70 to $1.20 per pound and the cost to purchase regenerated carbon ranges from $0.50 to $0.78 per pound.

Operational costs depend on the characteristics of the influent wastewater and the adsorption capacity of the GAC. For example, influent wastewater which contains suspended solids concentrations greater than 20 mg/l will require more frequent backwashing of the contactor to prevent clogging of the carbon bed.

REFERENCES

Other Related Fact Sheets

Other EPA Fact Sheets can be found at the following web address:
http://www.epa.gov/owmitnet/mtbfact.htm

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Research and Development

EPA-600/S2-81-177 Oct. 1981

EPA

Project Summary

Granular Activated Carbon Installations

Russell L. Culp and Robert M. Clark

Granular activated carbon (GAC) treatment design criteria, performance, and cost data from 22 operating municipal and industrial GAC installations that treat water and wastewater and that process food and beverage products are compiled and summarized. Guidance and an example of how this information can be used to estimate costs for GAC treatment of water supplies is provided. The report should be used in conjunction with a previous series of reports on "Estimating Water Treatment Costs" to obtain project-specific cost estimates. It is not a design manual and does not provide design criteria such as required contact time, probable regeneration frequency, activated carbon reactivation system criteria, or activated carbon transfer guidelines. Rather, the approach to determining such design data for water systems is presented.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, 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

On January 9, 1978, the U.S. Environmental Protection Agency (EPA) proposed the use of GAC as a means of treating drinking water. Since that time, much has been written both for and against using GAC in this manner. Serious challenges and many questions have been raised regarding EPA's cost estimates for GAC use. To respond to some of these questions, EPA's Drinking Water Research Division initiated a carefully designed study to establish water supply unit process cost curves on a consistent and understandable basis.

In an earlier study ("Estimating Water Treatment Costs," EPA-600/2-79-162 a, b, c, and d, performed by Culp/Wesner/Culp under EPA Contract No. 68-03-2516), construction and operation and maintenance cost curves were developed for processes capable of removing those contaminants included in the National Interim Primary Drinking Water Regulations. The final report contains cost curves for 99 different unit processes. These cost curves were divided into two categories: large water treatment systems applicable to flows between 1 and 200 mgd and small water treatment systems applicable to flows between 2,500 gpd and 1 mgd. A computer program for retrieving, updating, and combining the cost data was also developed. During the course of this work, the costs of GAC adsorption and reactivation in municipal water treatment as they relate to the removal of organics from drinking water became a subject of great national interest. Because of this, in 1978, the original project was expanded to include a special study of the unit process costs of GAC adsorption and reactivation in potable water treatment. The special study was directed at visiting as many existing GAC installations as possible to gather and publish data on actual operating experiences, particularly on the costs of building, operating, and maintaining GAC plants.

The report summarized here presents the findings of this special study of GAC installations and the compilation of the information available on the use of GAC in water treatment.

Use of Activated Carbon in Drinking Water

Powdered activated carbon (PAC) has been used, without harmful effects, for more than 50 years to remove taste and odor from public water supplies, but the use of GAC in treating municipal water in the United States is limited to a few facilities. In most cases, GAC is used to remove taste and odor from drinking water. Its use *may* become more common in light of new information on the occurrence of trace organics in water, the recent regulations limiting the concentration of trihalomethanes in public water supplies, and the possibility of requirements for GAC treatment. European water works have had considerable experience over a long period of time with GAC installations.

Although the use of GAC in municipal water treatment has been limited, GAC has been used in industrial and municipal wastewater treatment and in various industrial process applications. The specific uses of GAC are somewhat different with these applications than with water treatment, but much of the information on design and operations will prove useful to water purveyors. In general, the application of GAC adsorption to drinking water is simpler than to wastewater.

Eighteen of the twenty-two GAC installations visited were industrial process or municipal wastewater facilities, whereas four were municipal water treatment plants. Case histories presenting design, operating, performance, and cost information are presented in the report; the pertinent information has been summarized (Table 1). Single page fact sheets for each of these case histories are given in the report.

A principal function of the site visits was to collect construction and operation and maintenance (O&M) cost information on GAC installations. Plant records were used to obtain available construction costs, the dates for these costs, and the most recent O&M costs. The basic data are presented in the individual case study reports, but no attempt was made to update construction or O&M costs to present day prices or to extrapolate the costs to water treatment plants. This report does, however, refer to procedures whereby data from existing GAC projects can be adjusted or modified (based on the results of pilot-plant test results of the water to be treated) so as to be useful to experienced professionals making preliminary estimates of costs for future potable water projects involving GAC adsorption and reactivation or replacement.

Extrapolating Municipal Wastewater Experience to Water Treatment

The first plant-scale use of GAC in a municipal wastewater treatment plant was at South Lake Tahoe, California, in 1965. This plant has operated continuously since that time and now has 15 years of operating experience with GAC; the GAC system has processed more than 12 billion gallons of pretreated municipal wastewater. The reclaimed water COD ranges from 10 to 30 mg/L. The South Tahoe installation was an EPA Demonstration Plant. For 3 years, EPA funded the collection of very detailed and complete plant operating data and cost information.

Other Wastewater Installations

Water reclamation plants constructed at the Orange County (CA) Water District (Water Factory 21), the Upper Occoquan (VA) Sewer Authority, and the Tahoe-Truckee (CA) Sanitation Agency (Nos. 6, 3, and 2, respectively) have the same configuration as the South Tahoe plant both in respect to the type of GAC facilities provided and the high degree of pretreatment afforded. All of these plants operate successfully with few GAC system problems. As might be expected with second and third generation designs, these later plants embody some improvements over the original South Tahoe installation, although no major changes or deviations were initiated.

Although many other successful applications of GAC in advanced waste treatment (AWT) plants exist, the GAC experience in some AWT plants has, unfortunately, been poor. These failures in AWT applications have not stemmed from deficiencies in the basic GAC processes or in organics adsorption and thermal reactivation, but, rather, from mechanical problems.

Operational Problems

In discussing the operational problems encountered with GAC systems, those problems associated specifically with sewage must be distinguished from general problems that might be encountered with any type of GAC system. Many problems with GAC in wastewater treatment will not occur in water purification. For example, in water treatment, few or no problems could be expected with excessive slime growths, hydrogen sulfide gas production, or corrosion from adsorbed organics released during carbon reactivation.

Some of the types of problems encountered with GAC systems in wastewater treatment include:

- inadequate GAC transfer and feed equipment,
- undersized slurry and transfer lines,
- failure to provide for venting air from backwash lines with destruction of filter bottoms and disruption of GAC,
- failure to house or otherwise protect automatic control systems from the weather,
- inadequate means for continuous, uniform feed to furnace; this results in temperature fluctuations, inconsistent reactivation efficiency, and wasted energy,
- location of furnace and auxilliary drive motors in areas of very high ambient temperature (e.g., above top of furnace), and
- the use of nozzles in filter and carbon contactor bottoms; this produces major failures in carbon systems just as they have for many years in water filtration plants. Their use is risky.

The common problems related to wastewater treatment (biological organisms in the activated carbon contactors and development of anaerobic conditions with the production of corrosive hydrogen sulfide) have been successfully circumvented by providing adequate flow through the columns or frequent backwashing. Failure to provide adequate pretreatment has caused column clogging and mud balls with the need for more frequent backwashing.

Corrosion has been a problem with some of the GAC systems. The furnace system, transfer piping, and storage tanks are susceptible components. Many operations require frequent replacement of the rabble arms and teeth and replacement of the hearths every few years. At one installation, titanium or ceramic coated rabble teeth were no more resistant to corrosion than were stainless steel teeth. In one case, the corrosion problem in the furnace was solved by eliminating the use of auxiliary steam during reactivation. In another, corrosion was linked to fluctuating temperatures in the hearths caused by irregular feed to the furnace and frequent startup and shutdown. These problems can be partially remedied by better operation and avoided by better engineering design.

In several industrial applications, the wastewater itself has been highly corrosive. In these cases, the contactors have been subject to corrosion. At Spreckles Sugar, the epoxy linings in the columns must be replaced every 3 years; Republic Steel also replaces its column linings on a regular basis. Public water supply sources would not be expected to consist of corrosive water.

By properly applying the best current engineering design knowledge and practices for GAC systems, these rather serious problems might be avoided. When water works engineers apply GAC to produce high quality drinking water, they should make the most of the experiences of the consultants for industry and wastewater agencies.

Extrapolating Industrial and Wastewater Data to Water Supply

Caution must be observed in extrapolating GAC cost data from operating industrial installations and municipal wastewater treatment plants to the design of water works. The purpose for using GAC in each of these types of applications is generally the same — to remove organics. Important differences do exist, however. In industry, the GAC serves to remove a rather narrow band of organics — color molecules — from a viscous liquid. In wastewater treatment, the GAC removes (with or wihout biological activity) a broad spectrum of organic substances from water as measured by BOD, COD, and TOC. In water treatment, the objectives of GAC treatment are not completely defined at this time. For raw waters with color or taste and odor problems, using GAC unquestionably improves drinking water from an aesthetic standpoint. In many cases, the cost of GAC may be warranted for either of these purposes alone. For the great number of water systems without color or taste and odor problems, the only concern with respect to organics is the possible health effects over long periods of time from ingesting trace quantities of organics that may cause cancer.

Public health officials and water works managers still disagree as to whether the health risks that may be involved in the presence of minute traces of organics in drinking water are sufficient to warrant the cost of GAC treatment. A major problem is that the potentially harmful organics in drinking water have not all been identified at this time, and many of those that have been tagged as suspect have widely different adsorptive characteristics. Some adsorb readily on GAC; others do not.

GAC loading rates at exhaustion of adsorptive capacity vary widely among the different potentially hazardous organics. This affects the length of service life of GAC before reactivation or replacement is necessary — a determining factor in GAC treatment costs. Similarly, the reactivation times and temperatures for thermal reactivation of GAC saturated with different organics also differ, and all are not known at this time. Again, this has an important bearing on GAC treatment costs. Because of the widely varying adsorptive and reactivation characteristics of trace organics on GAC in water supplies, pilot plant tests of both adsorption and reactivation are mandatory preludes to treatment system design at this time.

Over a period of years, general, average design parameters may emerge from the results of pilot plant studies and demonstration projects, but this time is not yet at hand. Once the GAC design parameters for water treatment have been established from pilot tests for a particular water source, then the knowledge and experience from other GAC installations in industry and wastewater plants can be put to good use. GAC dosages, contact times, and spent carbon reactivation times and temperatures can be determined. Contactor sizes can be calculated and furnace sizes and fuel requirements can be determined. Transport facilities for GAC in water treatment can be the same as for other types of GAC installations provided differences are taken into account — differences in quantities and possible differences in the viscosities of activated carbon slurries because of any slime growths. Also, with GAC design parameters pinpointed as a result of pilot plant studies, construction costs can be accurately estimated based on costs of existing installations in AWT and Industry. The estimates cannot, however, be based on a million-gallon-per-day capacity basis; rather, they must be based on adsorption and reactivation data applicable to each specific installation.

Selecting the most economical numbers of contactors for a water system of a certain size involves the same principles that are used for other systems. Because of shipping regulations, factory-fabricated contactor vessels are generally limited to about 12-ft maximum diameter. For large capacity installations, a smaller number of field-erected steel vessels or poured-in-place concrete vessles may be less costly.

Because upflow contactors provide all of the advantages of countercurrent operation with respect to GAC savings, they are favored for most types of service. The exception is water treatment. In this case, downflow is used because of the discharge of carbon fines in the effluent (a characteristic of upflow columns) is avoided.

Cost estimates must be evaluated on the same basis as all other estimates of construction cost; there is no reason that they should be more or less accurate than estimates made for the rest of the treatment plant. Fifteen percent is generally accepted as being an allowable difference between costs estimated from construction plans and the best bid received from contactors. With good pilot plant data and with proper application of cost data from existing GAC installations, preliminary cost estimates for GAC treatment of public water supplies should be accurate enough for planning purposes.

The extrapolation of wastewater treatment experience with GAC to the design of water treatment systems is a task for trained, experienced, engineering professionals. Even then, the following discussions are intended to be no more than an introduction to the subject.

Designing GAC Systems for Water Treatment

The following discussion is devoted to some of the procedures and details for developing the design basis and costs for GAC water treatment systems from pilot plant test results and information from full-scale applications.

GAC System Components

Systems utilizing GAC are rather simple. In general, they provide for contact between the GAC and water to be treated for the length of time required to obtain the necessary removal of organics; reactivation or replacement of spent carbon; and transport of makeup or reactivated carbon into the contactors and transport of spent carbon from the contactors to reactivation or hauling facilities.

Pilot Plant Tests

Despite the simplicity of GAC systems, laboratory and pilot plant tests are needed to select the carbon and the most economical plant design for both water and wastewater treatment projects. Pilot column tests make it possible to determine treatability; select the best carbon for the specific purpose based on performance; determine the required empty bed contact time; establish the required carbon dosage that, together with laboratory tests of reactivation, will determine the capacity of the reactivation furnace; determine the necessary activated carbon replacement costs; and determine the effects of influent water quality variations on plant operation. During pilot plant testing, the influence of longer carbon contact time on reactivation frequency can be measured; these measurements allow costs to be minimized through a proper balance of these two design factors.

Design of Pilot GAC Columns

Detailed information, including a list of materials, on the design and construction of pilot GAC columns is presented in Appendix C of EPA's "Interim Treatment Guide For Controlling Organic Contaminants in Drinking Water Using GAC" (out of print). Appendix B of the "Interim Treatment Guide" describes the analytic methodology for monitoring pilot column tests. Also included are data on the adsorbability of various organic compounds; the performance of GAC in their removal; information on the use of multiple-hearth, infrared, fluidized bed, and rotary kiln furnaces for reactivating spent GAC; and example calculations for balancing added costs of increased contact time versus savings (if any) from less frequent reactivation.

Use of GAC in Water and Wastewater Treatment

Frequency of Reactivation

One of the principle differences in costs between water and wastewater GAC treatment is the more frequent reactivation required in water purification caused by earlier breakthrough of the organics of concern. In wastewater treatment, GAC may be expected to adsorb 0.30 to 0.55 lb COD/lb activated carbon before the GAC is exhausted. From the limited amount of data available from research studies and pilot plant tests (most of it unpublished), some organics of concern in water treatment may breakthrough at carbon loadings as low as 0.05 to 0.25 lb organic/lb carbon. The actual allowable carbon loading or carbon dosage for a given case must be determined from pilot plant tests. Costs taken from wastewater cost curves, which are plots of flow in million gallons per day versus cost (capital or O&M costs), cannot be applied directly to water treatment. Allowance must be made in the capital costs for the different reactivation capacity needed and in the O&M costs for the actual amount of carbon to be reactivated or replaced.

Because the organics adsorbed from water are generally more volatile than those adsorbed from wastewater, the increased reactivation frequency resulting from lighter carbon loading may be partially offset, or more than offset, by the reduced reactivation requirements of the more volatile organics. The times and temperatures required for reactivation may be reduced because of both the greater volatility and the lighter loading of organics on the carbon.

From the experimental reactivation to date, reactivation temperatures *may* be less than the 1,650° to 1,750°F required for wastewater carbons. The shorter reactivation times required for water purification carbons may allow the number of hearths in a multiple hearth reactivation furnace to be reduced. Also, less fuel may be required for reactivation. These factors must be determined on a case-by-case basis.

GAC Contactors

Selection of the general type of contactor to be used for a particular water treatment plant application may be based on several considerations including economics and the judgment and experience of the engineering designer. The choice generally would be made from three types of downflow vessels:

1. Deep-bed, factory-fabricated, steel pressure vessels of 12-ft maximum diameter. The size of these vessels might vary from 2,000 to 50,000 ft³.
2. Shallow-bed, reinforced-concrete, gravity-filter-type boxes may be used for carbon volumes ranging from 1,000 to 200,000 ft³. Shallow beds probably will be used only when short contact times are sufficient or when long service cycles between reactivations can be expected from pilot plant test results.
3. Deep-bed, site-fabricated, large (20- to 30-ft) diameter, open concrete or steel, gravity tanks may be used for GAC volumes ranging from 6,000 to 200,000 ft³, or larger.

These ranges overlap, and the designer may very well make the final selection based on local factors, other than total capacity, that affect efficiency and cost.

The AWT experience with GAC contactors may be applied to water purification if some differences in requirements are taken into account. The required contact time must be determined from pilot plant test results. Although contactors may be designed for a downflow or upflow mode of operation and upflow packed beds or expanded beds provide maximum carbon efficiency through the use of countercurrent flow principles, the leakage of some (1 to 5 mg/L) carbon fines in upflow column effluent make downflow beds the preferred choice in most municipal water treatment applications. At the Orange County Water Factory 21, upflow beds were converted to downflow beds to successfully correct a problem with escaping carbon fines. This full-scale plant operating experience indicates that leakage of carbon fines is not a problem in properly operated downflow GAC contactors.

Single beds or two beds in series may be used. Open gravity beds or closed pressure vessels may be used. Structures may be properly protected steel or reinforced concrete. In general, small plants will use steel, and large plants may use steel or reinforced concrete.

Sand in rapid filters has, in some instances, been replaced with GAC. In situations where contact times are short and GAC reactivation or replacement cycles are exceptionally long (several months or years, as may be the case in taste and odor removal), this may be a solution. With the short cycles anticipated for most organics, however, conventional concrete-box-style filter beds may not be well suited to GAC contact. Deeper beds may be more economical in first cost and provide more efficient use of GAC. In converted filter boxes, possible corrosion effects of GAC on existing metals, such as surface wash equipment and metal nozzles in filter bottoms, must be taken into account. Beds deeper than conventional filter boxes, or contactors with greater aspect ratios of depth to area, provide much greater economy in capital costs. The contactor cost for the needed volume of carbon is much less. In a water slurry, carbon can be moved easily and quickly and with virtually no labor from contactors with conical bottoms. Flat-bottomed filters of a type that require labor to move the carbon unnecessarily add to carbon transport costs. The labor required to remove carbon from flat-bottomed beds varies considerably in existing installations from a little labor to a great deal, depending upon the design of the evacuation equipment.

For many GAC installations intended for precursor organic removal or synthetic organic removal, specially designed GAC contactors should be installed. Contactors should be equipped with flow measuring devices. Separate GAC contactors are especially advantageous where GAC treatment is required only part of the time during certain seasons because they then can be bypassed when not needed, possibly saving unnecesary exhaustion and reactivation of GAC.

Tremendous cost savings can be realized in GAC treatment of water through proper selection and design of the contactors. The design of contactor underdrains requires experienced expert attention.

GAC Contactor Underdrains

Although good proven underdrain systems are available, often they have not been used, and there have been numerous underdrain failures due to poor design. Some designs used in the past for conventional filter service have failed in many installations, yet they continue to be misapplied to GAC contactors as well as filters.

GAC Reactivation or Replacement

Spent carbon may be removed from contactors and replaced with virgin carbon, or it may be reactivated either on-site of off-site. The most economical procedures depend on the quantities of GAC involved. For larger volumes, onsite reactivation is the answer. For small quanitites, replacement or off-site reactivation will probably be most economical.

GAC may be thermally reactivated to very near virgin activity. Burning losses may, however, be excessive under these conditions. Experience in industrial and wastewater treatment indicates that carbon losses can be minimized (held to 8 to 10 percent per cycle). To remove certain organics, no decrease in actual organics removal may occur despite a 10 percent drop in iodine number.

Thermal Reactivation Equipment

GAC may be reactivated in a multiple-hearth furnace, a fluidized bed furnace, a rotary kiln, or an electric infrared furnace. Spent GAC is drained dry in a screen-equipped tank (40 percent moisture content) or in a dewatering screw (40 to 50 percent moisture) before being introduced to the reactivation furnace. Dewatered carbon is usually transported by a screw conveyor. Following thermal reactivation, the GAC is cooled in a quench tank. The water-carbon slurry may then be transported by means of diaphragm slurry pumps, eductors, or a blow-tank. The reactivated carbon may contain fines produced during conveyance; these fines should be removed in a wash tank or in the contactor. Maximum furnace temperatures and retention time in the furnace are determined by the amount (lb organics/lb carbon) and nature (molecular weight or volatility) of the organics adsorbed.

Off-gases from reactivation present no air pollution problems provided they are properly scrubbed. In some cases, an afterburn may also be required for odor control.

Despite recent advances in the design area of infrared and fluidized bed reactivation furnaces, the multiple hearth furnace is still the simplest, most reliable, and easiest to operate for GAC reactivation. The infrared and fluid bed units still have problems to be worked out; experience with the multiple hearth equipment has already solved these problems. Still, it is necessary with all four types of furnaces to specify top quality materials to suit the conditions of service and to see that these materials are properly installed. Corrosion resistance is important in the furnace itself and especially in all auxiliaries to the furnace.

Required Furnace Capacity

The principal cost differences between GAC treatment of water and wastewater may lie in the capital cost of the furnace and in the O&M cost for carbon reactivation. As already explained, the two principal differences between carbon exhausted in wastewater treatment and carbon exhausted in water purification are that water purification carbons are likely to be easier to reactivate (less time in furnace and lower furnace temperatures) and more lightly loaded (greater volume of carbon to be reactivated per pound or organics removed). Accurate estimates of GAC costs require knowledge and consideration of these two factors. To repeat, it is not possible to use AWT cost curves based on million gallons per day throughput or plant capacity to obtain costs for water treatment. Differences in reactivation requirements must be taken into account.

GAC Transport and GAC Process Auxiliaries

The large differences in O&M costs for GAC systems depend on the method selected for carbon transport. Hydraulic transport of GAC in water slurry by gravity or water pressure uses very little labor and is simple, easy, and rapid. Moving dry or dewatered activated carbon manually or with mechanical means involving labor can be very difficult, time consuming, and costly.

Cost of GAC in Water Treatment

Developing Cost Curves

Little information is available concerning the cost and performance of GAC for drinking water treatment. As discussed in the previous sections, most of the data available on GAC performance have been acquired from wastewater and industrial applications. An attempt has been made, however, to extrapolate from these existing systems and to develop standardized and flexible cost data that can be used to prepare cost estimates for GAC systems that treat drinking water.

Design Cost Information —

Much of the analysis and cost information contained in this section of the full report are based on the four-

Table 1. Summary of GAC System Characteristics

Case No.	Owner	Type of Facility	Flow, mgd	Pretreatment	Carbon Contactors: Contact Time, min	Carbon Contactors: Hydraulic Loading, gpm/ft	Rated Capacity, lb/carbon/day
1	South Tahoe	Municipal wastewater	7.5 (max)	Extensive	17	6.5	6,000
2	Tahow-Truckee	Municipal wastewater	4.83 (max)	Extensive	20		3,840
3	Upper Occoquan	Municipal wastewater	15.0 (avg)	Extensive	22	8.4	12,000
4	American Cyanamid	Champrocess	20.0 (avg)	Extensive	30	8.0	122,000
5	Vallejo	Municipal wastewater	13.0 (avg)	Moderate	25	6.0	29,000
6	Orange County	Secondary effluent	15.0 (max)	Extensive	34	5.8	12,000
7	Niagara Falls	Municipal w/ significant industrial	48.0 (avg)	Moderate	40	1.67	—
8	Fitchburg[c]	Municipal w/ significant industrial	15.0 (avg)	Moderate	15	8.00	—
9	Arco Petroleum	Process waters w/significant industrial	4.32 (max)	Minimal	56	1.74	8,500
10	Rhone-Poulenic	Herbicide production wastes	0.15 (max)	None	87	2.00	8,500
11	Reichhold Chemicals	Chemical production wastes	1.0 (max)	Moderate	100	1.55	32,500
12	Stepan Chemicals	Surfactant production wastes	0.015 (max)	None	500	—	6,480
13	Republic Steel	Coke process wastes	0.95 (max)	Minimal	116/58	2.3/4.6	68,000
14	LeRoy	Municipal	1.0 (max)	Extensive	12	—	12,000
15	Manchester	Water supply	40.0 (max)	Moderate	14	—	12,000[d]
16	Passaic Valley[a]	Water supply	2.2 (max)	Extensive	8	—	2,400
17	Colorado Springs	Secondary effluent	2.0 (max)	Extensive	17	4.5	1,800
18	Hercules	Chemical production wastes	3.25 (max)	Moderate	48	6.6	33,600
19	Industrial Sugar	Decoloring sugar	—	Minimal	1080	—	12,000
20	Hopewell	Water supply	3.0 (mg)	Moderate	—	2.0	None
21	Davenport	Water supply	30.0 (max)	Moderate	7.5	2.0	None
22	Spreckles Sugar	Sugar thick juice	—	None	20	—	15,000

[a]Not available. [b]Data not collected. [c]Facility under construction. [d]Fluidized bed.

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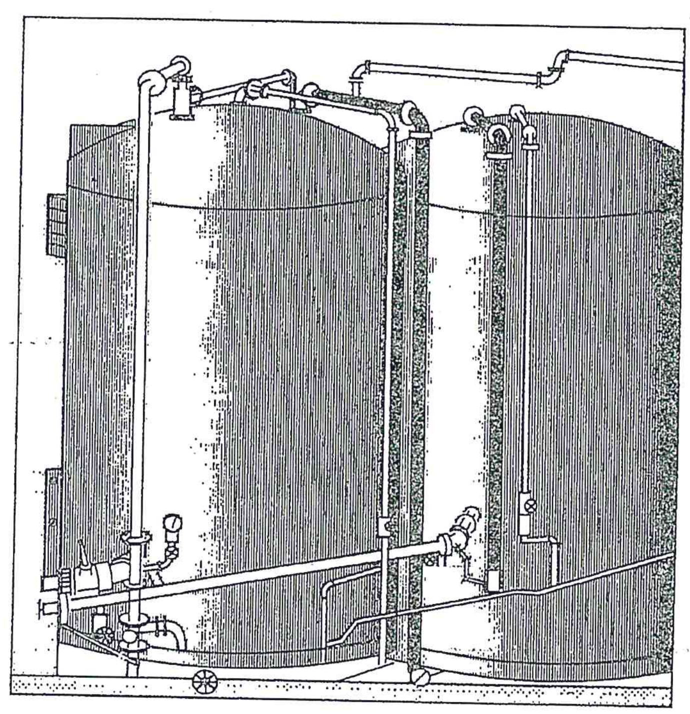
Granular Activated Carbon Systems

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.

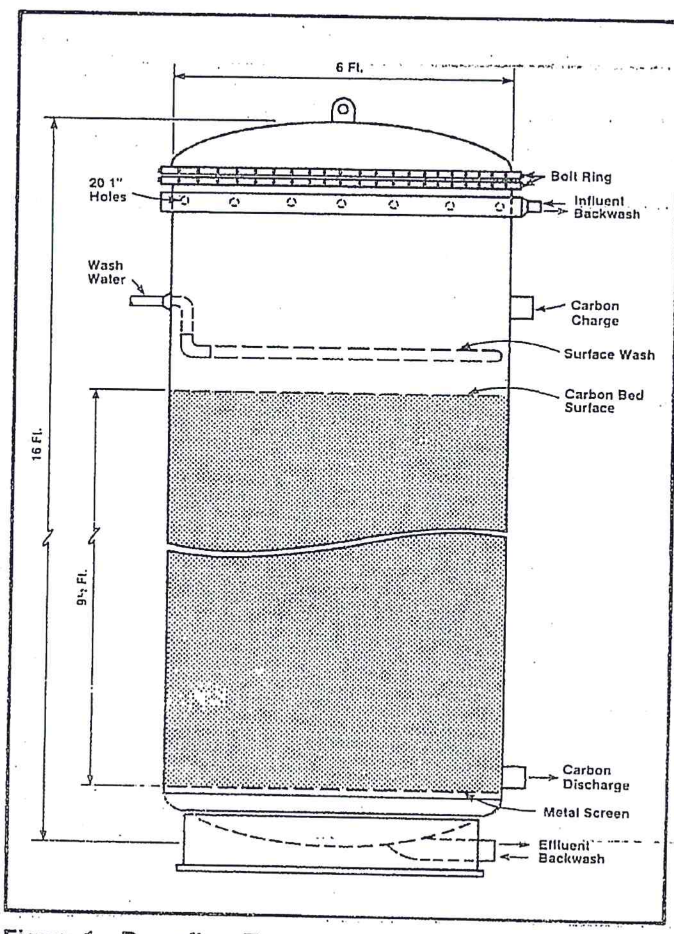

Figure 1 Downflow Type Granular Activated Carbon System

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tems - Problems and Remedies

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.

(H)

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

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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.

·ted Remedies

6

Common Problems with Ion Exchange Resins and How to Avoid Them

FEBRUARY 6, 2018

Ion exchange resins are useful for many industrial water treatment and separation needs when utilized for suitable application (https://www.samcotech.com/different-types-ion-exchange-resins-applications-serve/)s. In these cases, the technology can be highly efficient with relatively low cost and energy requirements. If they are properly maintained, resin beds can last years before requiring replacement, and for highly selective removal needs in process streams, ion exchange resins can prove ideal.

Despite the many benefits of using ion exchange resins (https://www.samcotech.com/ion-exchange-resin-work-process/) in the appropriate separation processes, challenging issues can arise. In this article, we generally discuss a list of some **"common problems with ion exchange resins and how to avoid them,"** ensuring your facility can keep one step ahead and remain as productive as possible.

Resin fouling

When your ion exchange treatment system begins to require more rinsing, becomes more sensitive to temperature and flow rate variations, or exhibits a decrease in effluent quality and operating capacity at a quicker-than-anticipated rate, fouled resins could be to blame.

Over time, it is natural to lose some percentage of operating ability (which varies widely depending on the type of resin and application), but if fouling is suspected, there can be several causes.

Some of the most **common resin foulants include:**

- suspended solids such as silica, iron, and manganese, these can be particles or colloidal
- oils and greases
- bacteria and algae
- organic substances

Once resins are fouled, it can be difficult and risky to clean them as some of the chemical agents and methods used in these processes can degrade the resins, making them unusable. In general, caustics are used to remove foulants from anion resins, while acids or strong reducing agents are used to remove foulants from cation resins. Similarly, surfactants are typically used to clean oil from fouled resins, though it is necessary to use care in selecting a surfactant that will not itself foul the resin, and sometimes an aggressive backwash with air scour helps.

Organic fouling is both extremely common and can be difficult to correct, although using a brine squeeze on anion resin at elevated temperatures may be effective. Preventative strategies for organic fouling include prechlorination and clarification, activated carbon filtration, applying a multistep IX with weak and strong base resins, and use of specialty IX resins.

Generally, the best way to avoid resin fouling is to ensure **proper pretreatment** removes the foulants before they can become an issue in addition to using **appropriate cleaning, storage, and regeneration measures** in the day-to-day operation of the ion exchange system to make sure no problematic foulants will accumulate over time.

These procedures vary widely depending on the type of resin being used as well as the purity of the feed water, etc., so be sure to consult your water treatment specialist to learn the proper steps to keeping your resins suitably maintained (https://www.watertechonline.com/protect-the-resin/).

Oxidation

When oxidizing agents—such as **chlorine, chlorine dioxide, chloramine, and ozone**—come into contact with both cation and anion resins under certain conditions, they can damage the resins, leading to **capacity loss and inhibited performance.** When present in a feed stream, **oxidants degrade IX resin polymers, causing them to deform and compact over time.** This compaction obstructs the flow of liquids through the resin bed, which can compromise the overall effectiveness of the IX unit, and lead to inconsistent effluent quality due to channeling in the resin bed.

While oxidation damage to IX resins **cannot be reversed, it can be prevented** through various pretreatment measures. Common preventative measures for oxidation degradation include application of activated carbon filtration, ultraviolet irradiation, or chemical pretreatment through the application of a reducing agent.