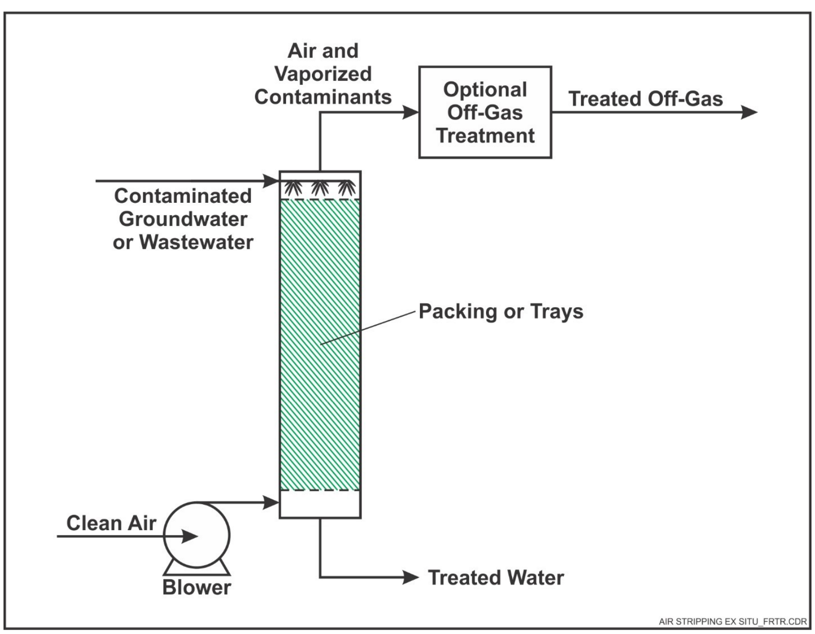
Air Stripping (Ex Situ)

On this page:

Schematic



This information may be reproduced without restriction as long as the source attribution is included.

Typical Air Stripping (Ex-Situ) Process Diagram

Introduction

Air stripping is an ex situ technology that removes volatile organic compounds (VOCs) from pumped groundwater or wastewater by passing the water over a media having a large surface area while exposing the contaminated water to uncontaminated air flow. It is most commonly used as part of a groundwater pump and treat remedy. The VOCs are transferred (i.e., volatilized) from the groundwater or wastewater to the vapor phase in the countercurrent air stream, where the vapor is either directly discharged or routed to an off-gas treatment system.

Other Technology Names

Packed Column Air Stripping
Low-profile Sieve Tray Air Stripping
Diffused Aeration Air Stripping
Counter-Current Air Stripping

Description

There are three main types of air strippers: packed column, low-profile sieve tray, and diffused aeration. All three styles are configured differently but work on the same principle to transfer VOCs from water to air (ACOE, 2001).

For groundwater remediation, this process typically is conducted in a packed column (or tower) or a low-profile sieve tray aeration system. The typical packed tower air stripper includes: a spray nozzle or manifold at the top of the tower to distribute contaminated water over the packing in the column, a blower to force air countercurrent to the water flow, and a sump at the bottom of the tower to collect decontaminated water. Low-profile sieve tray air strippers are available in horizontal tray (also known as shallow tray) or vertical box designs that are equipped with a series of stacked trays. Baffles and weirs inside the stripper trays are used to route contaminated water two or more times along the length of the tray of the box. Air sparged through the bottom of the tray or through a vent pipe in the bottom of the system passes in a countercurrent direction through the water to strip out VOCs. Typically, the tray-style strippers are modular and trays can be added or removed to properly size the system for flow capacity and stripping efficiency. Packed towers and tray systems are generally designed as single pass systems; however, a portion of the effluent water can be split and recirculated back into the air stripper for the purpose of achieving a higher removal efficiency without the need to increase the height of the packed tower or the number of trays in a low-profile system. Diffused aeration strippers consist of aeration tanks in which VOCs are stripped from the process water by bubbling air into a tank through which the contaminated water flows. A forced air blower and an aeration/sparge manifold are designed to create air-water contact.

Auxiliary equipment can be added to the basic air stripper including: air and water heaters to improve removal efficiencies; automated emergency control shutdown systems typically involving level and pressure switches; and air emission control and treatment systems, such as granular activated carbon (GAC) units or catalytic or thermal oxidizers.

Development Status and Availability

The following checklist provides a summary of the development and implementation status of air sparging:

☐ At the laboratory/bench scale and shows promise

☐ In pilot studies

☒ At full scale

☒ To remediate an entire site (source and plume)

☐ To remediate a source only

☒ As part of a technology train

1

☐ As the final remedy at multiple sites

☐ To successfully attain cleanup goals in multiple sites

Air stripping systems are available through the following vendors:

☒ Commercially available nationwide

☐ Commercially available through limited vendors because of licensing or specialized equipment

☐ Research organizations and academia

Applicability

Contaminant Class Applicability Rating for Ex Situ Air Stripping

(Rating codes: ● Demonstrated Effectiveness, ◐ Limited Effectiveness, ○ No Demonstrated Effectiveness,
◊ Level of Effectiveness dependent upon specific contaminant and its application/design, I/D Insufficient Data)

Nonhalogenated VOC	Halogenated VOC	Nonhalogenated SVOC	Halogenated SVOC	Fuels	Inorganics	Radionuclides	Munitions	Emerging Contaminants
●	●	◐	◐	◐	○	○	○	●

Air stripping is an established technology for the treatment of VOCs and has been used for several decades to support full-scale site remediation. Air stripping is used to separate halogenated and nonhalogenated VOCs, as well as oxygenates, from water, even when low levels of these contaminants are present. The Henry's law constant is used to determine whether air stripping will be effective. Generally, organic compounds with Henry's law constants greater than 0.01 atmospheres-m^3/mol are considered amenable to stripping. Some compounds that have been successfully separated from water using air stripping include benzene, toluene, ethylbenzene, and xylenes (BTEX); methyl tertiary butyl ether (MTBE); chloroethane; trichloroethylene (TCE); dichloroethylene (DCE); and perchloroethylene (PCE) (ACOE, 2001). However, it is typically ineffective for contaminants with low vapor pressure or high solubility such as inorganic salts, ketones, alcohols, 1,4-dioxance, and perchlorate. Removal efficiencies for the more soluble VOCs can be improved by preheating the water that is treated with the air stripper and using larger towers (or a greater number of stripping trays). Air stripping has limited effectiveness for removal of semi-volatile organic compounds from the water stream. This technology is not applicable for treatment of water that contains light non-aqueous phase liquids (LNAPL) because LNAPLs can quickly coat the packing and inside components of an air stripper.

Cost

Air stripping costs primarily are dependent on the type of unit used, the size, and treatment duration. The cost drivers provided in this section are limited to the ex situ air stripping components only, and do not include any costs associated with a complementary groundwater extraction feed system. Air stripping treatment, alone, typically does not have many moving parts or control requirements, so capital and routine operation and maintenance (O&M) costs are generally low. The major cost drivers and corresponding factors that influence the cost of air stripping include:

Upfront Costs

- Permitting. May be required for the discharge of the vapor and water streams following treatment with the air stripper. These costs are typically relatively low, but may be moderate or high if the system is complex.
- Equipment. Capital equipment costs typically include the air stripper system, vapor treatment system, and plumbing. Common equipment costs include an equalization tank, transfer pump(s), solids filtration pre-treatment, stripper unit and blower, transfer and discharge piping, air treatment system (if required), and ancillary measurement and controls. Capital costs are dependent on the size or capacity of the system, complexity of the controls requirements, and need for pretreatment or air treatment.
- System installation. Costs include housing and pad construction, electrical installation, and plumbing of the air stripper with the extraction and discharge infrastructure. Installation costs are dependent on the size of the air stripping system.

- Enclosure/building. Air stripper systems can be designed for outside use; however, inclusion of an enclosure or building may be preferred for ease of O&M, especially in winter climates or for long treatment life cycles.
- Air treatment. Vapor treatment, consisting of GAC or thermal oxidation may be required based on the nature of the contaminants being removed and local regulatory requirements. The generation of highly corrosive hydrochloric acid vapors from the thermal treatment of off-gas emissions containing chlorinated VOCs could require inclusion of a wet scrubber neutralization tower, which would further increase the capital and O&M costs for treatment.

Operation and Maintenance Costs

- Lease rates. If the air stripper and/or the air treatment systems are leased, there will be periodic costs for these items. Costs may be high depending on the size of the equipment.
- Labor. Labor requirements will be greater if pretreatment and/or air treatment systems are required. Metals scaling or biofouling can pose chronic O&M issues. Thus, additional labor and supplies (chemicals such as acids and biocides) may be required to maintain the equipment.
- Packing maintenance. Stripper tower packing may require complete change-out on a periodic basis if fouling becomes severe. Heavy equipment and multiple personnel over two or three days may be required to complete the change out, in addition to material and disposal costs for the packing.
- Air treatment. If air treatment is required, O&M costs would increase for media replacement in the case of vapor phase GAC, or additional labor and utilities to operate thermal or catalytic oxidizer systems.
- Water disposal. Costs for the disposal/discharge of the effluent water is dependent on fees (including regulatory fees) that may be incurred based on the method of disposal/discharge, treatment volumes, and the contaminant levels in the discharge water.
- Power. Electrical power is needed to operate the air stripper system and any air treatment equipment. Electrical cost is much higher for larger capacity pumps and blowers and if electrical heating is provided for outdoor components.
- Water treatment. Liquid phase GAC treatment may be needed as a polishing step to meet regulatory limits, which would incur disposal costs for periodic media changeouts. GAC treatment, alone, also could become more cost effective than air stripping later in the treatment life cycle as the influent concentrations and/or pumping rates decrease, which would significantly decrease O&M costs.

The list above highlights those cost dependencies specific to air stripping and does not consider the dependencies that are general to most in situ remediation technologies. Click here for a general discussion on costing which includes definitions and repetitive costs for remediation technologies. A project-specific cost estimate can be obtained using an integrated cost-estimating application such as RACER® or consulting with a subject matter expert.

Duration

Air stripping is used to treat pumped groundwater or wastewater from a treatment process. The duration of O&M depends on the duration of the primary process operation (i.e., groundwater extraction and contaminant removal). Pump and treat systems can often operate for decades, which must be accounted for in the design and O&M planning.

Implementability Considerations

The following are key considerations associated with implementing air stripping:

- The selection of a packed tower versus low profile or diffused aeration unit is dependent on flow capacity, influent concentrations, and removal requirements. Low profile and diffused aeration units take up much less space and are easier to maintain. Packed towers offer higher capacities and greater removal capabilities for more complex treatment needs.
- Consideration should be given to the Henry's law constant of the VOCs in the water stream, and the type and amount of packing used in the tower. Other key design variables that influence contaminant removal efficiencies include air and water flow rates (air:water ratio) and the height of the stripper tower (or number of trays for low profile strippers).
- Design and construction flexibility is critical for air stripper systems projected to operate for long durations. Blower and pump motors should include variable frequency drives (VFDs) to adjust operation and optimize energy savings as water pumping rates and contaminant influent concentrations decrease over the operating life cycle. Adequate access must be provided to allow for equipment and piping maintenance and replacement (including the need for

heavy equipment access), as well as the possible need to add other treatment components for future needs or contingencies.

- LNAPL should be removed from the aqueous stream prior to treatment using an air stripper.
- Fouling of stripper units can be caused by high levels of suspended solids or the precipitation of dissolved iron, manganese, or dissolved calcium. Pre-design testing should be performed to identify potential fouling issues that could require some type of pretreatment for solids, metals precipitation/removal, and/or an acid backwashing/cleaning or sequestration system.
- Biological growth can foul stripper units, particularly when treating hydrocarbons. Periodic backwashing/cleaning using a biocide or chlorine-containing agent (sodium hypochlorite, chlorine dioxide) or heated water may be required.
- Discharge piping systems can become fouled/plugged because of precipitated metals or biological growth, which would require periodic jetting/pigging of the lines or similar types of backwashing/cleaning as described above. Treatment at the discharge of the air stripper (e.g., solids filtration system, such as injection of carbon dioxide/pH adjustment) can be employed. Discharge piping may need to be replaced if the fouling/plugging becomes too severe and causes excessive pressures or reduced flow rates.
- Compounds with low volatility at ambient temperature may require preheating of the groundwater (e.g., ketones).
- Vapor will require treatment if the mass emission rate exceeds regulatory limits. The individual contaminants and total mass emission loading dictate the type of air treatment that would be required.

Resources

ACOE. Engineering and Design Air Stripping (2001)
This design guide provides design and construction information for implementation of air stripping systems.

EPA. A Citizen's Guide to Air Stripping (2012)
This fact sheet provides a basic overview of the ex situ air stripping process geared toward a public citizen audience.

EPA. Cost Effective Design of Pump and Treat Systems (2005)
This report includes practical design considerations for various components of pump and treat systems including air strippers.

EPA. A Citizen's Guide to Pump and Treat (2012)
This fact sheet provides a basic overview of pump and treat groundwater remediation including air stripping geared toward a public citizen audience.

NAVFAC. Management of Secondary Treatment Trains (2001)
This fact sheet offers a quick guideline on how to manage a secondary treatment train, identify the best remediation technology for the contaminants of concern, and then to determine what treatment technology is applicable at the site. The four technologies most commonly used for secondary treatment processes are air stripping, GAC, advanced oxidation processes (AOPs) and biological treatment.

NAVFAC. MTBE Remediation using Hollow Fiber Membrane and Spray Aeration Vacuum Extraction Technologies (2000)
This report summarizes the results of a demonstration of selected technologies used to treat groundwater contaminated with dissolved MTBE and other VOCs.

---

1. Air strippers are used as part of a treatment train to treat water generated by other types of remediation technologies, such a pump-and-treat and total fluids recovery systems. ↩
2. Air strippers are used as part of a treatment train to treat water generated by other types of remediation technologies, such a pump-and-treat and total fluids recovery systems. ↩