Remediation of VOC Contaminated Groundwater

Background

Contaminated groundwater has become an ever-increasing problem in the United States and around the world. Treatment and disposal of waste is a serious problem for any industry. The potential for contamination exists regardless of the precautions taken. Most of the current contamination problems are a result of negligence in the past. For example, most Air Force bases pose a threat to the environment where fuels, cleaning solvents, and degreasers have seeped into the ground due to past disposal practices, spills, or leaking storage tanks. Volatile organic compounds are another large problem and are found in most municipal wastewater treatment plant effluents. Leakage from landfills constructed according to laws other than those imposed today is another concern.

Regardless of the nature of the contaminants, sour drinking water has become an increasing concern and has opened the door for new research on removing low-level contaminants from groundwater. This project addresses one of the many combinations of contaminants occurring in groundwater fouling and a possible treatment train which minimizes the production of sludge and material to ultimately be landfilled.

Environmental Significance

treatment of a waste stream

possible recycle or sale of recovered materials

Process Description

The PFD is attached. The waste stream, consisting of water contaminated with small amounts of trichloroethylene (TCE), 1,2-dichloroethane (DCE), hexavalent chromium, and fluoride, enters the process as Stream 1. The waste first enters an air stripper, T-501, where the volatile

organic compounds (VOC's) are transferred from the liquid to the gas phase. The air stripper converts a water pollution problem into an air pollution problem. However, activated carbon can be used to adsorb the VOC's from the air stream exiting T-501. Before the air enters the carbon adsorber, it is fed to heat exchanger E-501 as Stream 3. Low-pressure steam is used to increase the temperature from 20°C to 27°C, thereby decreasing the relative humidity to 40%. By heating the stream and decreasing relative humidity, the overall effectiveness of the adsorption process is improved. The stripper off-gas is then fed to the adsorber, A-501, as Stream 4 and is vented to the atmosphere as Stream 5. There are two adsorbers, placed in parallel, however, only one is in operation at any time. Once one activated carbon column is exhausted it is returned to the manufacturer for regeneration and the other placed on-line.

Leaving the air stripper as Stream 6, the water then enters A-502, the activated alumina column, to treat the fluoride present in the waste. Three columns are present; however, only two are in operation at any given time. The first column is used alone until it reaches the maximum contaminant level, then the second column is placed on-line. The high fluoride concentration in the effluent from the first column when mixed with the low fluoride concentration in the effluent from the second column meets the required discharge concentration. When the first column's effluent level reaches two times the allowable effluent concentration, it is regenerated and the third column is placed on-line.

The regeneration of the activated alumina columns consists of several steps. The column is first backwashed with water to prevent side wall leakage. Next, the column is treated with a 1% NaOH solution followed by a water rinse. The column is then treated with a 2% H_2SO_4 solution followed by another water rinse. The final step is a quick water wash to prepare the column for placement back on-line. The regenerant feed and product streams can be seen on the PFD as

Streams 9 and 10, respectively. The entire regeneration process will result in an annual discharge of approximately 220,000 gallons of wastewater to a lined treatment pond. The waste will contain about 1,200 lb. of sodium fluoride sludge that can be bulk landfilled or possibly recovered.

Leaving the activated alumina columns as Stream 7, the water enters the final stage of treatment. Here ion exchange is used to remove the hexavalent chromium. The waste enters A-503 and leaves the treatment process as "clean water" in Stream 8. A-503 consists of two ion-exchange columns, one in use and one being regenerated. The regeneration of the ion-exchange column is much like that of the activated alumina column. However, the acid rinse used with the activated alumina column is not required when regenerating the ion exchange-column. The column is backwashed, rinsed with NaOH, rinsed with water, quick washed, and then placed back on-line. The regenerant feed and product streams can be seen on the PFD as Streams 11 and 12, respectively. The regeneration effluent will consist of a pure chromate solution that can be utilized by industry.

Necessary Information and Simulation Hints

Vapor/liquid equilibrium data provided by the process simulator did not result in a realistic behavior of T-501, the air stripper. Therefore, published data were used.[1]

References

1. Freeman, Hary M., Standard Handbook of Hazardous Waste Treatment, USEPA Hazardous Waste Engineering Research Laboratory, McGraw-Hill Book Co., 1989.

Equipment Descriptions

T-501	Air Stripper
E-501	Heat Exchanger
A-501 A/B	Carbon Adsorber

A-502 A/B/C Activated Alumina Columns

A-503 A/B Ion Exchange Column

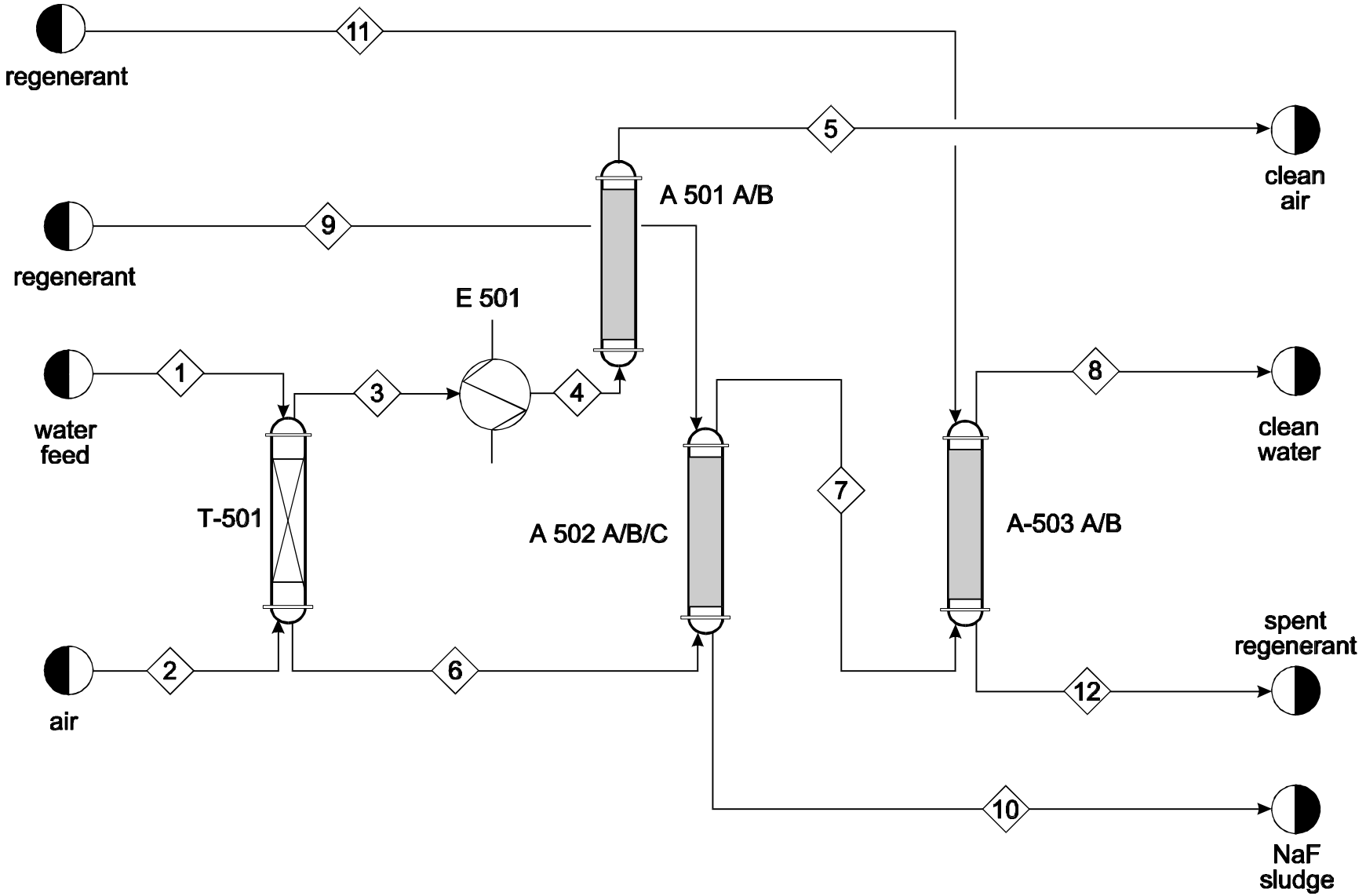
Stream Table for Purification of VOC Contaminated Water

Stream No.	1	2	3	4	5	6	7	8
Temperature (°C)	20.0	20.0	20.0	27.0	27.0	20.0	20.0	20.0
Pressure (kPa)	101.3	101.3	100.0	100.0	100.0	100.0	101.3	101.3
Vapor mole fraction	0.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
Total Flow (kg/h)	2,365.7	125.0	126.7	126.7	125.0	2,365.4	2,365.3	2,364.6
Total Flow (mol/h)	131,341.6	4,317.6	4,393.1	4,393.1	4,317.6	131,266.1	131,263.0	131,256.9
Component Flowrates (mol/h)								
Water	131,329.4	--	72.5	72.5	--	131,256.9	131,256.9	131,256.9
Trichloroethylene	1.8	--	1.8	1.8	--	--	--	--
1,2-Dichloroethane	1.2	--	1.2	1.2	--	--	--	--
Hexavalent Chromium	6.1	--	--	--	--	6.1	6.1	--
Fluoride	3.1	--	--	--	--	3.1	--	--
Air	--	4,317.6	4,317.6	4,317.6	4,317.6	--	--	--

Stream No.	9	10	11	12
Temperature (°C)	20.0	20.0	20.0	20.0
Pressure (kPa)	101.3	101.3	101.3	101.3
Vapor mole fraction	0.0	0.0	0.0	0.0
Total Flow (kg/h)	*	*	**	**
Total Flow (mol/h)	*	*	**	**
Component Flowrates (mol/h)				
Water	--	--	--	--
Trichloroethylene	--	--	--	--
1,2-Dichloroethane	--	--	--	--
Hexavalent Chromium	--	--	--	--
Fluoride	--	--	--	--
Air	--	--	--	--

* Streams 9 and 10 are the feed and product streams, respectively, for the regeneration of the activated alumina column. They are discussed in more detail in the Process Description section of the report.

** Streams 11 and 12 are the feed and product streams, respectively, for the regeneration of the ion exchange column. They too are discussed in more detail in the Process Description section of the report.



Treatment of a Stream from VOC Contaminated Groundwater