Advanced physiochemical Treatment process "Water Aeration"

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About the presenter

- Member of the Board scientists Egypt.
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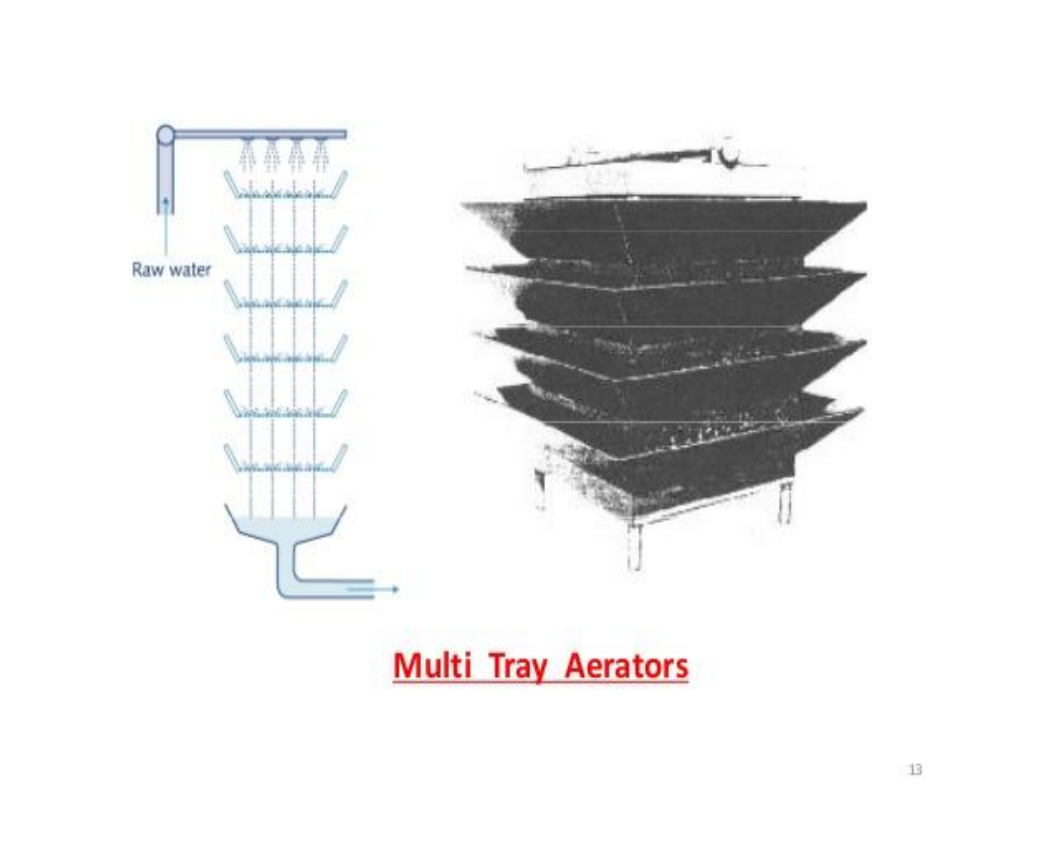
Introduction

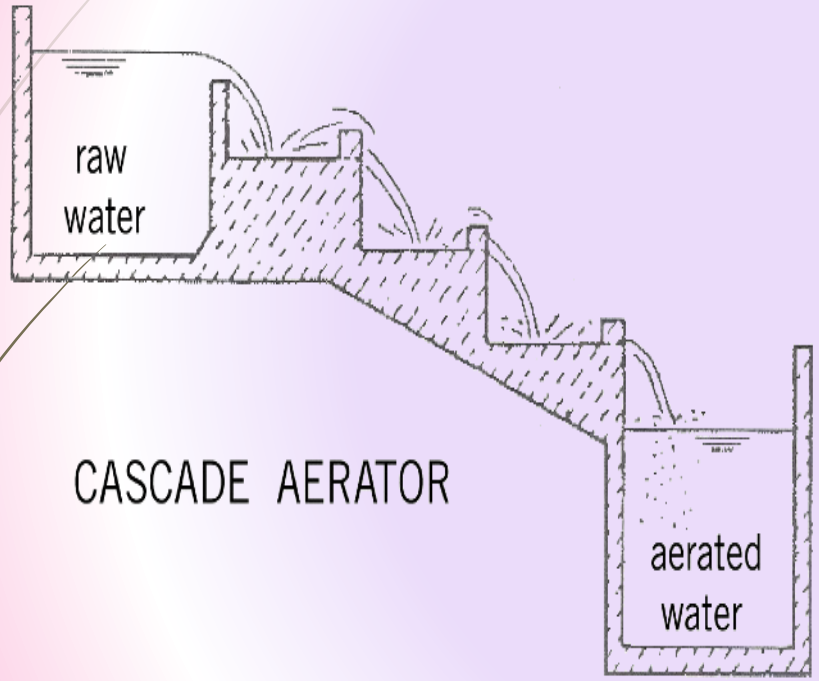
- Water aeration has been long used in water treatment for the removal of odor and WW taste-causing compounds, the oxidation of iron and manganese, as well as corrosion control and aesthetics.
- Since the mid-1970s, however, the process has been used to remove carcinogenic and hazardous chemicals from water.
- These chemicals include volatile organics such as trihalomethanes, radon, trichloroethylene, tetrachloroethylene , 1,1,1-trichloroethane, chloroform, and toluene. As a result, water aeration may be the single most important water treatment process used in the 21st century.

Types of Aeration Process

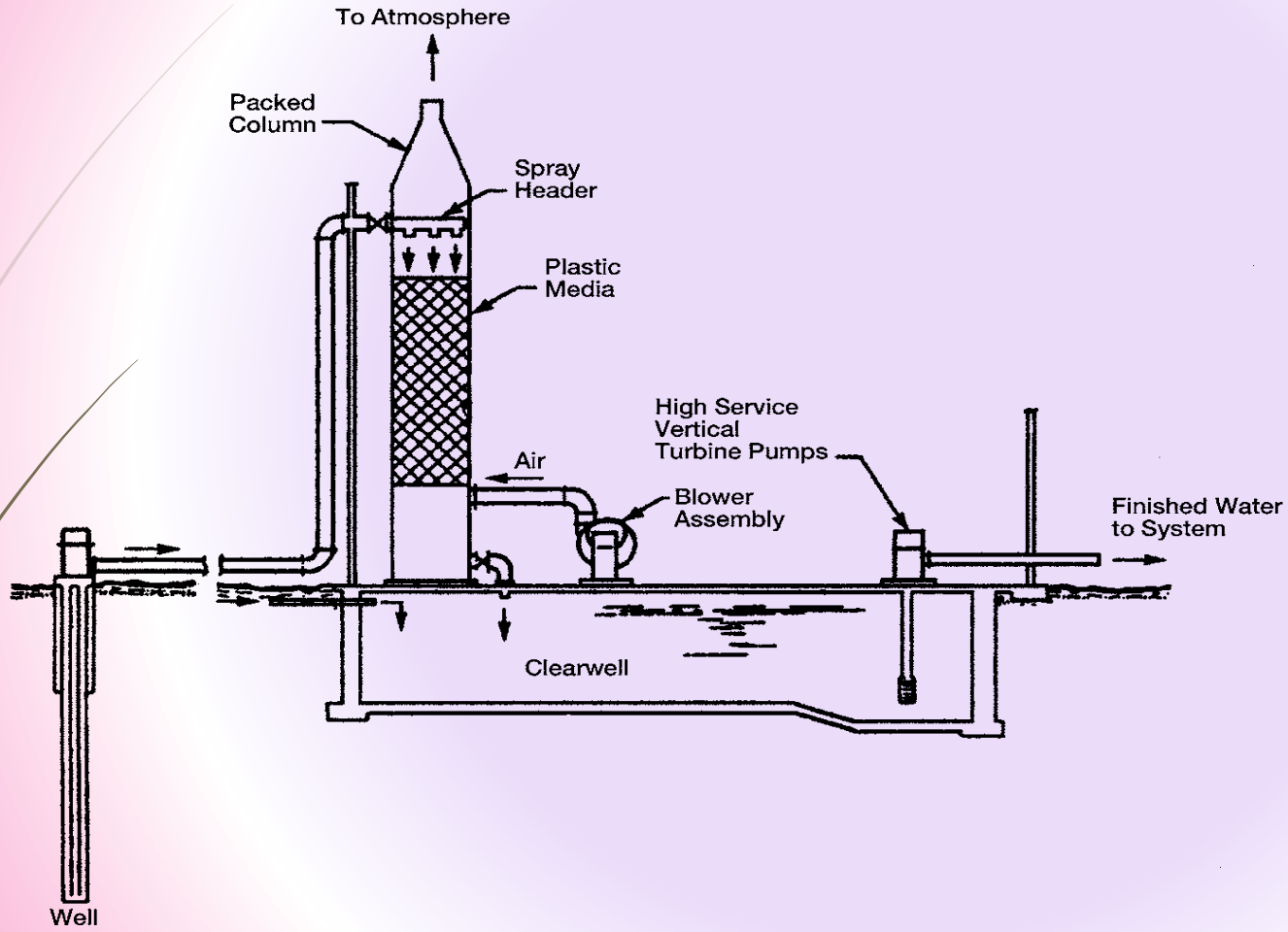
- **1. Falling Water Units** (commonly used in water treatment)

- Spray aerators—water sprayed into the air. Problems include evaporation and freezing.
- Cascade aerators and hydraulic jumps—these operate using waterfalls over a structure.
- Fountain aerators or spray—water cascaded or sprayed over rocks or other types of material.
- Multiple tray aerators with and without coke (often used for iron and manganese removal) water cascaded over manufactured tray constructed from slats and coke.
- Packed column aeration—air flows up, water is sprayed down (these are efficient and the most common type)





CASCADE AERATOR



Spray Aerators: Nozzles

2- Surface Aerators (commonly used in the wastewater industry)

a. Brush: a series of circular brushes partially submerged are rotated through the water surface to cause turbulence. A support structure is required to suspend the brushes over the water.

b. Floating: Floating aerator pumps the water from beneath it up through a draft tube to the surface , which disperses water into the air.

- **3- Submerged Aerators** (commonly used in the wastewater and water industries)

a) Injection of air with blowers by static tube or diffuser (fine bubble and coarse bubble).

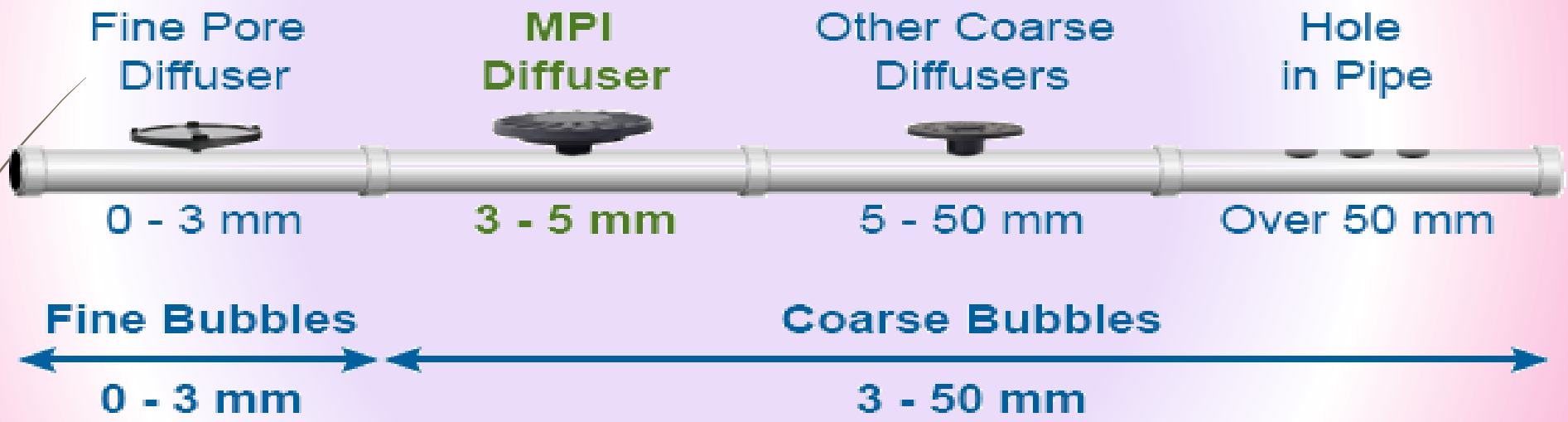
b) Jet aeration (the injection of air into pumped water).

DIFFUSED AERATION

- Another aeration method for the removal of VOCs is the diffused aeration system.
- This system utilizes a blower (centrifuge or positive displacement type) and air diffusers, which bubbles air through the water in a contact chamber for aeration.
- The blowers supply air under pressure to the diffusers, which are located near the bottom of the contact chamber.

- Most of the pressure requirements are to overcome the static pressure of the water over the diffusers.
- The diffusers are used to create fine bubbles that impart water–air mixing turbulence as they rise through the chamber

- ***Design Criteria***
- Design considerations for a diffused aeration system are
  - Depth of contact tank: 1.5–3 m (5–10 ft)
  - Air: water ratio: 5:1 to 15:1
  - Detention time: 10–15 min


Fine Pore Diffuser
MPI Diffuser
Other Coarse Diffusers
Hole in Pipe
0 - 3 mm
3 - 5 mm
5 - 50 mm
Over 50 mm
Fine Bubbles
0 - 3 mm
Coarse Bubbles
3 - 50 mm

Applications

- ***Taste and Odor Removal***
  - Some of common odor - and taste-causing compounds include hydrogen sulfide(H2S), methane, algae, oils, phenols, cresols, and volatile compounds.
  - The process is suitable for H2S, methane, and volatiles, but not for algae and oils, phenols, and cresols.
  - The compounds must be volatile for aeration to be effective.
  - Aeration is appropriate for many industrial compounds.
  - A classic installation is at Nitro, WV, which utilizes aeration and granular activated carbon (GAC).

Iron and Manganese Oxidation:

- When the total concentration of iron in water is 0.3 mg/L or greater, the iron will cause the water to have an unpleasant taste and redden in color this may result in the staining of plumbing fixtures and clothes, and accumulations of iron deposits in the water mains.
- The aeration process oxides iron by changing the iron from the ferrous state (fe2+) to the ferric state (feff3+), which converts the iron from a soluble form(fe2+) to a non-soluble form (fe3+) that precipitates from the water.
- Manganese concentrations greater than 0.3 mg/L in water will result in dark brown staining. Oxidation will convert the manganese from Mn2+ to Mn4+when the pH is above 9. Below a pH of 9, the process is negligibly slow.

- ***Air Injection into Groundwater for Iron Control***
  - In order to lower the iron concentration in groundwater, air is injected into the groundwater source.
  - The injected air oxides the iron in the groundwater.
  - This process involves the periodical injection of air into groundwater via a series of wells that surrounds a production well.

Hydrogen Sulfide and Carbon Dioxide Removal

- Hydrogen sulfide and carbon dioxide (as carbonic acid and free carbon dioxide) are commonly found in well water.
- Even a low concentration of hydrogen sulfide can cause odor and taste problems.
- Hydrogen sulfide is a colorless gas which has a foul odor similar to rotten eggs and is slightly heavier than air (SG =1.192)
- The H2S species are volatile; as a result, the aeration process effectively removes it from the water.
- Therefore, the removal efficiency of sulfide depends on pH.
- As the pH increases, aeration becomes less effective because there are fewer sulfides in the form of H2S, which is readily removed by aeration.
- This process is utilized by both municipalities and chemical industries. In water treatment, the process is called **degasification** , and is effectively used to remove both H2S and carbon dioxide from well water and product water from the reverse osmosis process.

Carbon Dioxide Removal

- H_2CO_3 is a weak acid.
- As the water CO_2 concentration is increased, then both the H_2CO_3 concentration and corrosion potential increase.
- Aeration drives off CO_2 and lowers the H_2CO_3 levels, which reduces the corrosion potential of the water.
- When both H_2S and CO_2 are present in water, aeration will remove both. As water is aerated, both CO_2 and H_2S are removed, but as the pH of the water increases due to the removal of CO_2, the removal efficiency of H_2S decreases .

Ammonia Removal

- This is a limited application in the water industry, but is more commonly used in wastewater treatment.
- One of the processes utilized in the wastewater industry is the aerated suspended growth process, which utilizes nitrifying bacteria and aeration to convert ammonia to nitrites and nitrates.

Oxygenation of Water

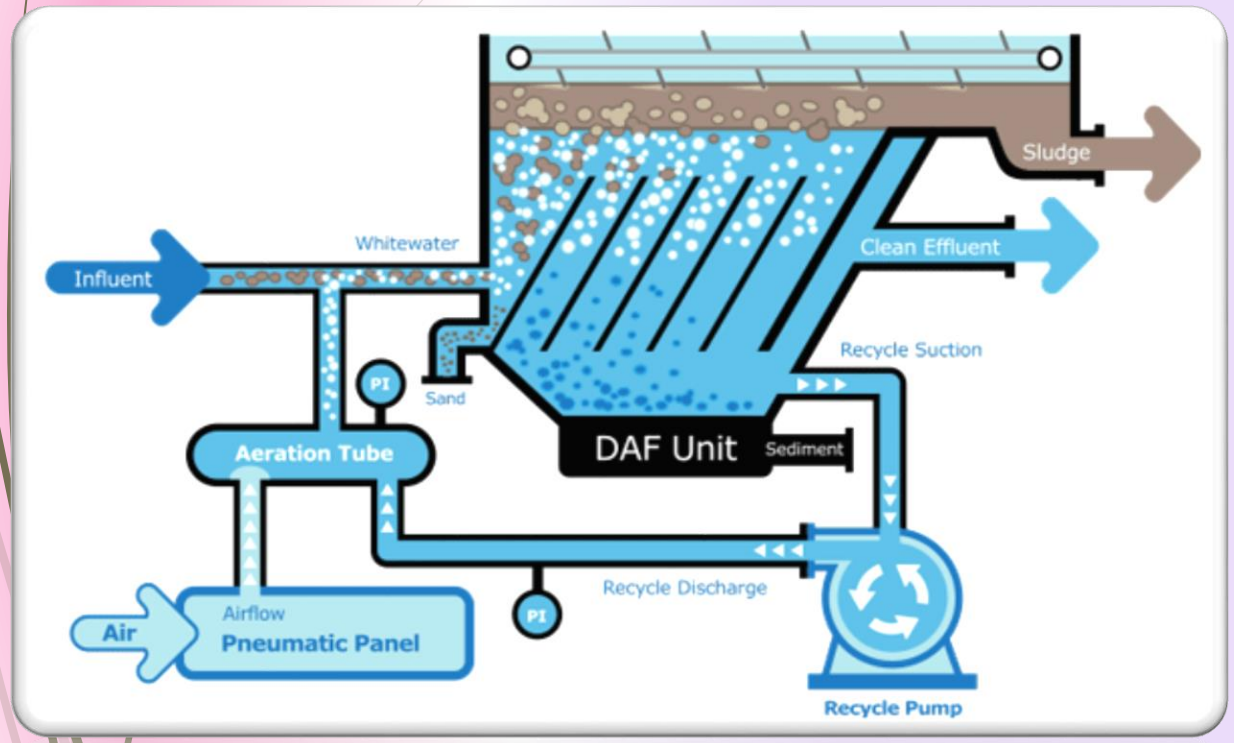
- In small reservoirs and ponds that have trouble maintaining dissolved oxygen levels in water near the bottom of the reservoir.
- aeration can accomplish the following: it mixes the water, reduces stratification, and increases the dissolved oxygen level in the water.
- This is accomplished by placing diffusers on the reservoir floor and bubbling air into the water or by using floating aerators.
- In some cases, this has proved Aeration restores oxygen to water, making the water taste better but it also increases corrosiveness, by increasing the CO2 in the water (resulting from the oxidation of organic matter to CO2). Therefore, there is often a trade off bet ween benefit and detriment.

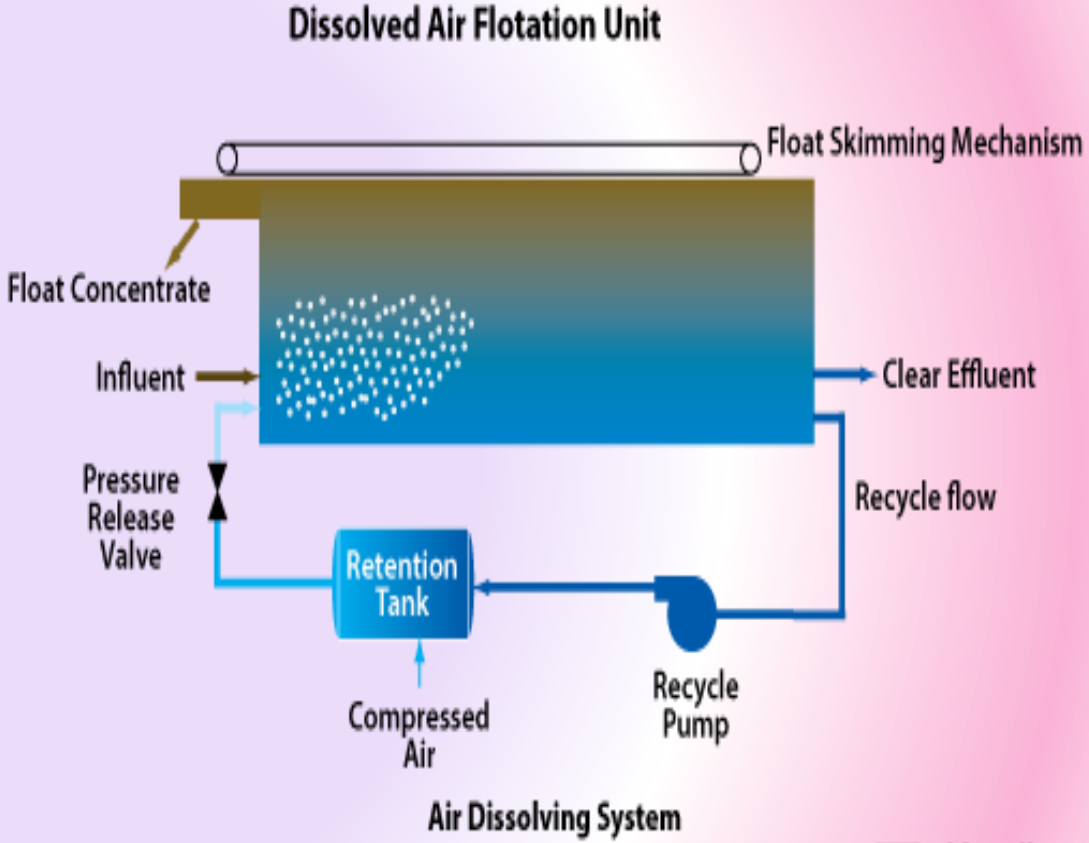
Dissolved Air Flotation for Flocculation/Flotation DAF

- Aeration has been used rarely for air flotation for flocculation.
- The purpose of this application is to increase flocculation size by inducing particle-to-particle contact.
- However, air bubbles attached to the flocculation particles often cause them to float rather than to settle.
- A newer, promising approach is flotation, which injects oxygen- saturated water at the bottom of shallow basins, resulting in flocculation forming A scum layer at the water surface, which is then removed .

Trihalomethanes Removal

- The aeration process is rated as good to excellent for the removal of trihalomethanes (THM) because they are fairly volatile.
- This is an increasing application because THMs are not effectively removed by other processes such as granular activated carbon (GAC), although GAC is suitable for organic precursors that react with chlorine to form trihalomethanes .
- Aeration is a poor choice for THM precursors removal but suitable for removing trihalomethanes.





Komline-Sanderson

Volatile Organics Removal

- The US EPA has identified many types of organic compounds in our water supplies.
- Some of the organic compounds are volatile, and, as a result, aeration would be a good process selection for removing them from water.
- Some common volatiles include trihalomethanes, which have already been discussed: chlorobenzene, 1,1,1-trichloroethane, tetrachloroethylene, and trichloroethylene , Aeration can achieve up to 95% removal of these compounds.
- For compounds that are non-volatile, adsorption would be a better process selection than aeration for their removal from the water.
- Adsorption is an excellent removal method for non-volatiles such as styrenes, benzene, phthalates , and fluorine.

Hazardous Waste Cleanup

- An increasing amount of contamination results from landfills, leaking containers, and accidental spills.
- Many of the contaminants are volatile and amenable to aeration. A two fold approach can be used : either clean the water supply or clean the contamination source. When a highly concentrated contaminant is aerated through a packed tower , then air pollution from the aeration process becomes a concern.
- Air discharge from the packed tower must be collected and treated.

Radionuclides Removal

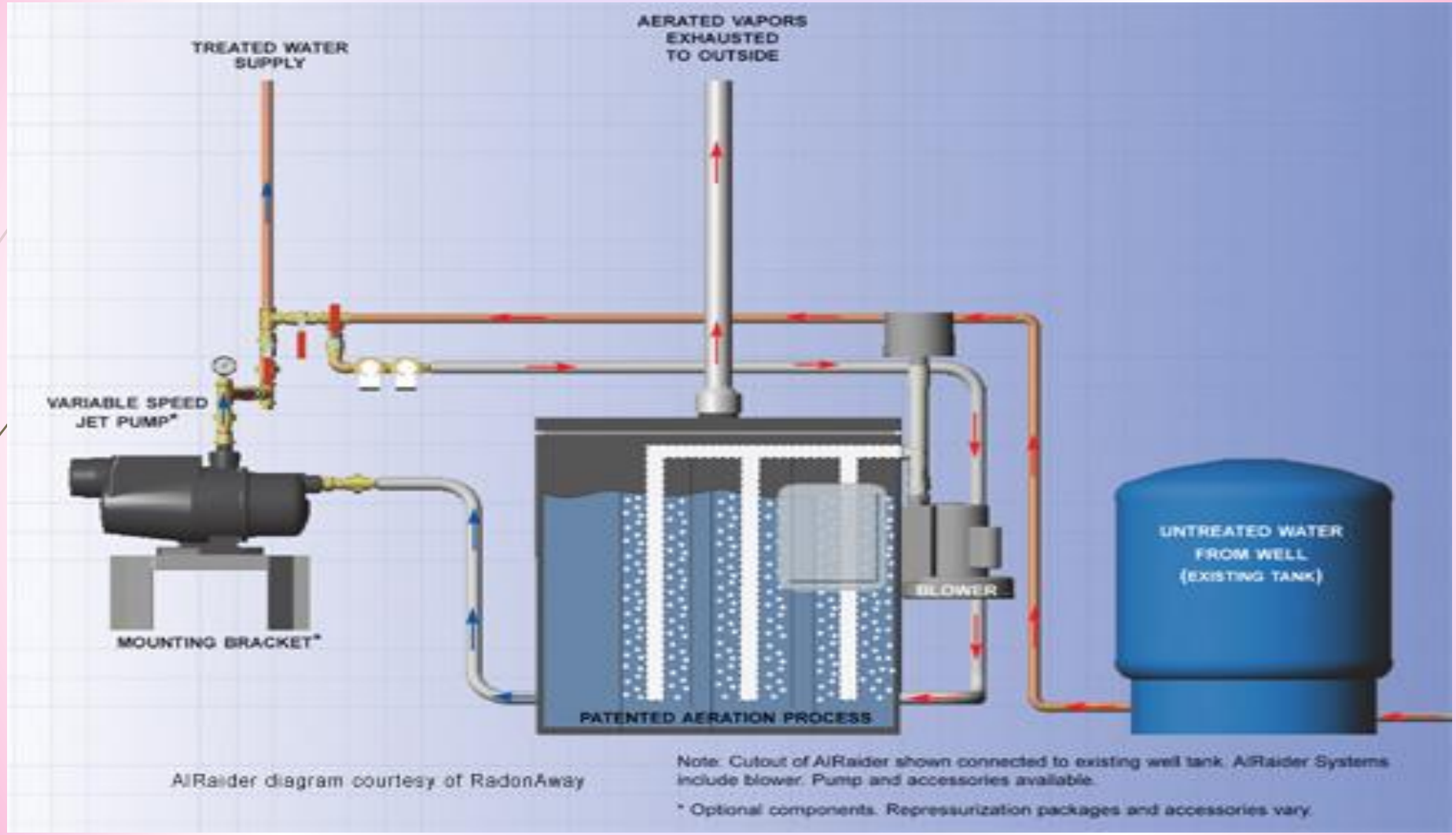
- The inhalation of a radioactive gas such as radon gas (Rn-222) were linked to lung carcinogenesis and also associated with development of acute myeloid, acute lymphoblastic leukemia, and other cancers.
- Regions with granite areas that have relatively high uranium content and are fractured have been found to have a high radon emanation rate.
- The unit Becquerel (Bq) is used to express radioactivity as disintegrations per second.
- US EPA surveys of well drinking water sources showed that 74% of the sources had
- radon concentrations below 100 Bq/L and only 5% had concentrations above 400 Bq/L.
- The high levels were linked to deep wells.
- A concentration of 400 Bq/L will increase the indoor air radon concentration by about 0.04 Bq/L.

Other sources of radon are:

- 1. Soil around buildings.
- 2. Cracks in floors and walls.
- 3. Construction joints.
- 4.Gaps in suspended floors and around pipes.
- 5. Cavities inside walls.

When the above sources are available, then the radon level in air could reach the US EPA action level of 150 Bq/m3 (0.15 Bq/L).

- Because radon is highly volatile, the radon levels in groundwater may be lowered by using an aeration process, such as a packed tower.
- aeration can achieve a removal efficiency ranging from 20% to 96% for radon (Rn), but is not used for radium (Ra) or uranium (U) removal.


TREATED WATER SUPPLY
AERATED VAPORS EXHAUSTED TO OUTSIDE
VARIABLE SPEED JET PUMP*
MOUNTING BRACKET*
BLOWER
UNTREATED WATER FROM WELL (EXISTING TANK)
PATENTED AERATION PROCESS
AIRaider diagram courtesy of RadonAway
Note: Cutout of AIRaider shown connected to existing well tank. AIRaider Systems include blower. Pump and accessories available.
* Optional components. Repressurization packages and accessories vary.

References

- Advanced Physicochemical Treatment Processes Edited by Lawrence K. Wang , Yung-Tse Hung,Nazih K. Shammas.

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Thank you