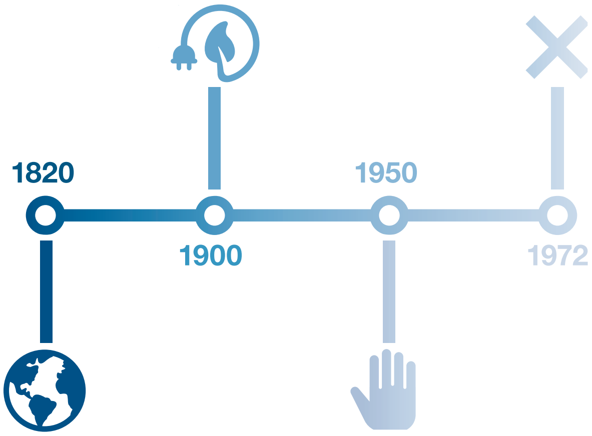
Lurking Environmental Dangers of Manufactured Gas Plants

Manufactured gas plants (MGPs) were pivotal fixtures in local power generations from the early 1800s to the mid-1900s.[1] As the name suggests, MGPs produced gas which could be stored, distributed and used for heating, cooking and lighting, similar to natural gas use today.

Although historically terminated, MGPs environmental impacts remain today. Regardless of the duration or when the operation ceased, these impacts of MGPs continue to generate long-term harm to the environment and have the potential to incur liability cost to property owners.

SECTION I

History of Manufactured Gas Plants



The first successful attempts to create a manufactured gas occurred in France and England around 1800. The first MGP utility was founded in England in the **1820s**, and soon followed by other MGPs across Europe and the United States.[2]

MGPs typically existed in towns with populations greater than 5,000 residents and were commonly referred to as "town gas."[3] More densely populated cities commonly had multiple MGPs. In the early **1900s**, many MGP locations began closing in favor of cheaper energy alternatives as oil resources and refining developed, and electric power networks grew nationwide. By the **1950s**, most (but not all) MGP operations had ceased. In New York, for example, the last MGP was not shuttered until **1972**.[4]

MGP Process

The gas manufacturing process varied based on the size and age of the MGP operation, but it generally involved heating a hydrocarbon-based feedstock, typically coal, in a sealed oven-like structure, where the anaerobic conditions prevented the feedstock from burning. This process, known as carbonization, produces volatile gasses, which can be collected, purified and stored for later use as fuel for heating, cooking and lighting. Oil and other feedstocks may also be used in place of coal.[5]

The gasses generated contained moisture and particulates. MGP gasses were typically sent through condensers where the moisture and particulates could settle out as a by-product. The moisture and coal particulates formed a black viscous substance more commonly referred to as coal tar.[6] Prior to entering the gas holding tank, other gaseous impurities like ammonia were removed by 'washing' the coal gas in water. It was common to have additional coal tar settle out during the washing and holding process.[7] MGP by-products like tar or specific refined gasses were commonly sold to other industries, but unsold by-products were waste commonly dumped on site. The solid portion of the coal remaining after carbonization was called "coke," which was highly valued by many industrial uses for being a very hot and clean burning fuel. Coke plants operated by a similar process as MGPs, but the primary product was coke, and gas was the by-product.[8]

In the 1870s, the manufacturing process evolved to incorporate steam and petroleum injections into the sealed oven chamber, called carbureted water gas (CWG), which produced a higher energy value gas end product. Some MGP plants never upgraded to CWG processes and continued with the carbonization processes.[9] The CWG process still produced a coal tar by-product but with less viscosity than carbonization process coal tars and a consistency like vegetable oil.

SECTION II

MGP Residual Contaminants

Former MGP operations have left residual contamination in two main forms.

- ***Coal Tar***
- ***Purifier Waste***

Coal Tar

As described above, coal tars were a primary waste by-product of an MGP's manufacturing process. The term coal tar is a broad classification of oily, non-aqueous phase liquid (NAPL) MGP residuals, which tended to be more of a flowable liquid than a true sticky, viscous "tar," although some MGP processes did create more viscous tar-like by-products.[10] Regardless, the term coal tar is widely used when referring to MGP contaminants and will be retained for congruity.

While the bulk of coal tar was reused in roadway and roofing materials, significant volumes were lost through leakage in MGP holding tanks, unlined pits or ponds, process piping and direct discharge.[11] Even minor leakage could translate into major discharges over an MGP's operational lifespan of several decades, with some even operating for over a century.

> When released to the ground surface or subsurface, coal tar migration is primarily affected by gravity and will migrate downward through soils.

Most coal tars are denser than water (dense non-aqueous phase liquid; DNAPL), although some MGP processes generated coal tars that are lighter than water (light non-aqueous phase liquid; LNAPL). DNAPL coal tars will migrate down through groundwater until encountering an underlying low-permeability formation – i.e., a confining unit of silt, clay or bedrock. Lateral migration of DNAPL coal tar in the subsurface is dictated by the subsurface topography of the confining geologic layer and not necessarily by the natural groundwater flow direction or surficial features.[12]

DNAPL coal tars will migrate in the deeper substrate along the gradient of the confining layer and will accumulate in low-lying areas. LNAPL coal tars generally “float” along the groundwater table and migrate with groundwater flow. Depending on subsurface conditions and NAPL viscosity, coal tars can slowly migrate great distances beyond the area of direct discharge and even have been known to “daylight” in the surface waters or sediments of nearby water bodies, sewers and basements.[13]

Purifier Waste

Raw manufactured gas contained impurities such as cyanide and sulfur, which needed to be removed before final distribution otherwise those compounds would corrode piping and fixtures. The gas was filtered through beds of wood chips that had been treated with iron oxides to remove the unwanted cyanide and sulfur compounds.[14]

The purifier media (woodchips or lime) would frequently need to be replaced once the media had reached the end of its useful life or if it had become overly clogged with coal tar particulates. MGP operations often disposed of purifier wastes as fill in low-lying areas on the site or the surrounding properties.

Unlike coal tars, purifier waste does not migrate once placed in the subsurface. Purifier waste turns green or blue in color and will have solid tar material bound to the fibrous media.[15] Purifier waste impacts come as a result of leaching. Complex cyanide compounds will leach from the purifier waste and impact groundwater.[16] MGP cyanide contamination will move through the subsurface with the natural groundwater flow.

Leaching from purifier waste can also cause groundwater to become highly acidic. Depending on the characteristics of the surrounding area, highly acidic groundwater can erode subsurface structures and/or cause biologic harm for nearby surface waters.[17]

> MGP coal furnaces also generated coal ash waste, which was commonly also used as fill for nearby low-lying areas and may be buried with purifier wastes.

SECTION III

Characterizing MGP Residuals

Most MGP residuals have easily identifiable physical characteristics, such as color, odor and viscosity. They can often account for a significant percentage of the overall subsurface matrix. Coal tar oils and feedstock oils for the oil-gas MGP process are typically much more viscous than most fuel or lube oils, and the odor of coal tar oil is very distinct from petroleum oil. Additional characteristics include:[18,19]

Pollution Burden			Purifier Wastes		
Color	**Odor**	**Material**	**Color**	**Odor**	**Material**
Typically dark reddish to black	Distinct naphtha-lene-type odor (e.g. mothballs)	Plastic-to-solid materials	Blue to green	Acrid, sulfurous odor	Contain wood fibers
For the reasons above, visual assessment of the subsurface materials through test pit excavation and boring advance-ment can be an accurate and effective method for characterizing the presence of MGP residuals in the environment.					

Visual and olfactory assessment generates a large volume of information concerning the nature and extent of MGP residuals in a relatively short period of time and reduces the need for extensive laboratory analysis. Laboratory analysis helps to confirm field observations, provide quantitative values for risk assessment, confirm the limits of MGP residuals and distinguish MGP residuals from other anthropogenic materials in complex environmental matrices.

The following laboratory analyses are typically used to help characterize MGP residuals in soil, groundwater, surface water and sediment:

1. Polycyclic aromatic hydrocarbons (PAHs);
2. Cyanide, including total cyanide and physiologically available cyanide (PACN); and
3. Volatile organic compounds (VOCs), primarily consisting of benzene, toluene, ethylbenzene, xylene, and styrene;

Additional laboratory analyses sometimes used to help characterize MGP residuals include:

1. Metals;
2. Phenols (included in SVOCs); and
3. Petroleum hydrocarbons, including volatile petroleum hydrocarbons (VPH) and extractable petroleum hydrocarbons (EPH)

> Urban fill with coal, slag and ash will have similar detectable PAHs as MGP residuals. Where urban fill is present, visual and olfactory MGP indicators are useful in deciphering if analytical detections are attributable to fill or MGP residuals.[20]

SECTION IV

Remediation of MGP Contaminants

MGP remediation is determined based on multiple site factors including subsurface geology, depths of impacts, NAPL mobility and proximity to potential receptors. Typical remediation includes a combination of excavation with engineering and institutional controls. Excavation and disposal of shallow soils impacted by former MGP operations and backfilling with a clean fill cap removes the potential for direct exposure.

> Want to learn more about the importance of Clean Fill? More information on the examination of the impact of using contaminated fill can be found here.

With this type of remediation, it is common to see demarcation layers (i.e. geotextile fabrics or distinct backfill material) be installed at the bottom of excavation to serve as a visual indication and physical barrier separating impacted soils that remain in place. Engineering controls are often coupled with institutional controls, like land use restrictions or restrictive covenants, which prohibit certain future uses and outline the necessary oversight structure should certain ground disturbing activities need to occur within restricted areas. Vapor mitigation systems are also typical requirements of controls implemented at MGP sites.[21,22]

Groundwater extraction, treatment and DNAPL recovery can be another common aspect of remediation at MGP sites. However, the applicability and feasibility of this will ultimately be determined by the levels of groundwater contamination, the volume of recoverable DNAPL, the mobility/stability of the DNAPL as well as the consistent distribution of DNAPL in the subsurface. DNAPL is often found dispersed inconsistently, as it settles in low-lying pockets of the confining layer. Pumping may not be effective at mobilizing DNAPL, especially if the extraction points are not sited to target limited areas. For some sites, DNAPL recovery may be impractical.[23] Long-term groundwater monitoring and/or active groundwater remediation systems may be necessary to control migration of dissolved contamination in groundwater. Groundwater remediation by DNAPL recovery, groundwater extraction, treatment and/or reactive barriers will have high implementation and operational costs.

> Remediation at MGP sites can typically range from $500,000 to tens of millions of dollars, depending on the magnitude of impacts and complexity of the remediation required. MGP remediation can in some cases surpass costs of $100 million if remedial measures are needed to prevent migration into sensitive receptors. For instance, many historic MGPs were cited along waterways and remediation controls such as slurry cut-off walls can drive up the overall clean-up costs.

SECTION V

Additional Considerations

Odor

Although MGP operations ceased decades ago and residual contamination is buried in the subsurface, sometimes residual MGP odors can be detected in the air in the vicinity of the former MGP location, particularly on warmer days.

> MGP odors can be a nuisance and raise public awareness and concern of MGP sites, particularly during remediation activities. Excavations and other remediation activities at MGP sites often require odor mitigation/suppression measures and community outreach.

There are two broad categories of odors that may be present at a former MGP site including: 1) MGP-like Odors and 2) Petroleum-like Odors.

MGP-like odors are distinct and may be further distinguished by field personnel to any one of the following sub-categories:[24]

- Tar-like odor
- Naphthalene-like odor (mothballs)
- Styrene-like odor (sweet, fiberglass-like)
- Light-end odor (e.g. akin to gasoline)
- Acrid, caustic odor

Petroleum-like odors may be associated with MGP operations; however, petroleum odors can be more commonly attributed to a variety of other non-MGP related sources. Therefore, the locations of other sources of petroleum odors must be evaluated before attributing a petroleum-like odor to the former MGP activities.

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