Geo-environmental classification of the residuals and wastes of gas manufacturing

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Abstract: From 1805 to nearly the end of the 20th century the entire developed world and its major world port and trading cities were lit with gas manufactured from a variety of organic feedstocks. Each of the three primary processes (coal-gas, carburetted water gas, and oil gas) and their many variants generated a wide variety of physically and chemically variant, toxic residuals and wastes. These contaminants were subjected to a variety of handling and management practices, but substantial volumes of these compounds and chemical "mixtures" then and now represent non-degradable toxic contaminants capable of profoundly negative impacts on human health and on the environment.

Never has there been a broadly useful classification of these gas-house wastes, either in the times of manufactured gas, nor in the environmental era. This paper takes the measure of classification forward to arrange these toxics by two greater groups: 1) physical and chemical features, and 2) their association with the various process components of gas manufacture and of its treatment for removal of impurities (clarification and purification) prior to distribution to the consumer. All together this classification proposes 13 varieties of the first group (form and character) to include seven types of solid wastes and six types of fluid wastes. For the second group (affinity with gas plant component equipment), the wastes number 24 in type and do not particularly reference form or character.

With this classification in mind, it is then strictly possible to employ competence and quality in the site and waste characterization effort, without which it is highly likely that some or much of the toxics will remain at even the remediated sites. Most of these contaminants have geologic lives and will seek geologic pathways to the environment, whereby they will be encountered by human receptors over decades and centuries to come.

Résumé: 1805 presque à la fin du 20ème siècle le monde développé entire, les ports principal et villes marchandes ont été allumés avec le gaz construit d'une variété de matières de base organiques, par trois processus primaries: charbon-gaz, gaz d'eau carburetted, et gaz de pétrole et leurs beaucoup de variantes. Dans chacun des processus une grande variété les résiduels physiquement et chimiquement different et des pertes ont été produites et étaient sujettes à une variété des procédures de manipulation et de gestion. Presque tous ces composés et produit chimique "mélanges" étaient (puis) et (maintenant) restent les contaminants toxiques qui sont capables des impacts profondément négatifs sur la santé humaine et sur l'environnement.

Jamais il n'y a eu une classification largement utile pour les pertes de gaz-maison, ni dans les temps du gaz manufacturé, ni dans l'ère environnementale. Cet article prend la mesure de la classification de s'charger ces du toxics par deux plus grands groupes : 1) dispositifs physiques et chimiques, et 2) leur association avec les divers composants de processus de la fabrication de gaz, et de son traitement pour le déplacement des impuretés (clarification et purification) avant la distribution au consommateur. Tout ensemble cette classification propose 13 variétés du premier groupe (forme et caractère) ; pour inclure sept types de déchets solides, et six types de pertes liquides. Pour le deuxième groupe (l'affinité avec le gaz plantent l'équipement composant), ces 24 pertes et ces ne mettent pas en référence en particulier la forme ou le caractère.

Avec cette classification à l'esprit il est alors strictement possible d'utiliser la compétence et la qualité dans l'effort de caractérisation d'emplacement et de perte, sans lequel il est fortement probable qu'une partie ou une grande partie du toxics reste au égal remediated des emplacements et que ces contaminants chercheront des voies géologiques à l'environnement, par lequel ils soient produits par les récepteurs humains.

Keywords: Contaminated land, engineering geology, environmental geology, environmental protection geoenvironmental engineering, pollution

INTRODUCTION

Manufactured gas residuals and wastes are herewith classified for first time, and done so with respect to their origin at the various components of the former town gas plants and other factories producing gas for industrial fuel gas and at the many industrial plants that also processed residuals into more and further by-products. A second means of classification comes with consideration of the general physical-chemical associations of five groups of residuals and wastes, namely VOCs, SVOCs and purification wastes, the latter of which are found in several varieties and which may harbour dangerous concentrations of polycyclical aromatic hydrocarbons (PAHs), cyanogens, mineral salts, and combinations of heavy metals, most notably arsenic.

A need to classify gas-house wastes for site characterization

Manufactured gas industrial operations took place on dedicated plant sites and were continuous, night-and-day operations making intensive use of generally large quantities of organic feedstock, both solid and liquid. In the various gas manufacturing processes, the feedstocks were altered to commercial gases made not only for illumination, but for heating, cooking, and as fuels. Almost all of the residuals were harmful, in some way, to human and other forms of life, and much of the waste was in a liquid form.

Geo-environmental nature of gas-house wastes

Just as the commercial product, normally the gas, was created, treated for quality, and then distributed, so were the impurities separated from the gas and gathered up at the gas works. Incidental to their characteristics and properties, most of these wastes are toxic to human and other life, proportional to their concentrations, and are essentially non-degradable in the natural environment for geologic time.

Therefore, it is essential to detect and delimit bodies of concentrated gas-house wastes and of residual concentrations of such waste as have been imparted to earth media during the passage of contaminated gas liquors emanating from these facilities.

As a result of his 18 years of practice in the field of remediating former manufactured gas plants (FMGP) and other coal tar sites, the author employs a classification scheme of 26 varieties of residuals and wastes to be expected at, and around, these sites (Table 1).

Parties to FMGP site remediation are and should be faced early-on with the serious question of "Why should we be concerned with gas works wastes?" These questions should be posed by citizens, the media and by regulators. Responsible parties, of course, will naturally prompt such discussions, often preferring to see that coal-tar sites be labeled NFRAP (No Further Remedial Action Planned), and left for future generations to rediscover their presence and again evaluate the environmental and human health damage that may have already been done.

SUMMARY

The fact that former coal-carbonization and other by-products sites are of high priority for site and waste characterization efforts, blends well with the methods and technologies of engineering geology. In fact, the entire effort of characterizing these sites and their wastes presents an appropriate challenge to practicing engineering geologists. The three main thrusts of this engineering geological work are to locate and define the nature and three-dimensional bounds of the earth media underlying each site and of the bodies of concentrated or diffuse toxic gas works residuals and wastes. The author hopes that the geo-environmental classification scheme for gas-house residuals and wastes, presented herein, will be of direct use in practice.

Table 1. Predicting FMGP waste types as the basis for site and waste characterization

Residual or Waste	Conditions By Which Defined as a Waste	Approximate Quantities per 10,000 cu ft Gas Produced
Coke	Always a candidate for fuel, for sale in the community or for use in plant furnaces; normally inert unless accidentally sorbed with PAHs	About 60 percent, by weight of the original quantity of feedstock coal; approximately 2000 lbs. of coal per 10,000 cu ft of coal gas produced yields of about 1200 lbs. coke.
Tar	Often salable under local and regional market conditions when produced or treated to have less than about 4.0 % water content All tars are diagnostically chromatographically different; greater differences are to be found between coal carbonization and other gas manufacturing processes.	When marketable and containing less than 4.0 % water, sold at the plant and via rail tank cars to the many tar distillers, in the range of $0.05 to $0.02 per gallon. Required an effort to capture and separate from liquors and its own unsaleable sludge. Calculate at 10 to 14 gallons per 10,000 cu ft gas, depending on the feed stock and operating conditions. Some coals provided up to 17 gal. of tar per ton. Specific viscosity and chemistry of each tar largely controls environmental fate within a give earth medium or body of water.
Tar-Water Emulsion	Commonly formed in CWG process, especially after 1910 and whenever soft coal was substituted for coke and when heavy or crude oil was used in carburetion in lieu of light petroleum oils or light tar oils.	Generally unsaleable whenever untreated to reduce the water content of tar water emulsions, which ran from in excess of 4 % market limit to as much as 92 %, as noted in the literature. Calculate at 4 to 6 gallons of additional gas liquor per 10,000 cu ft gas generated.
Naphthalene	Captured at plant and distribution-system sumps, as pumped from yard and street trips on a weekly basis.	Had to be captured and pumped or would crystallize solid naphtha and cause blockages of transmission and distribution pipes and clogging of gas lights and stove jet ports. Had recovery value as a gas enrichment oil and for use as a universal industrial solvent. Also commonly discharged to the ground as gas-house waste.

Naphtha	Chemical term for crystallized naphthalene	AKA "moth balls" in commerce. Found as a common nuisance for most gas plants, in both yard piping and in the distribution system. Required careful operational controls over heat and duration of generation, as well as temperatures of gas treatment prior to distribution.
Light Tar Oils	Monocyclic and duocyclic PAHs	Historically these were sold as commercial solvents and fuels or used as carbureting oils at CWG plants.
Medium Tar Oils	Another term for medium tars of the general 3 to 4-benzene-ring tars.	Miscible and co-soluble with the tar mass; separable through distillation; seldom done on plant site.
Heavy Tar Oils	5,6,7- benzene-ring tars, includes anthracene and the "green oils" (tars).	Miscible and co-soluble with the tar mass; separable through distillation; seldom done on plant site.
Tar Pitch	Heavy ends of any residual tar of manufactured gas. Common to all processes.	Not encountered on site in absence of a still; the end reside from distillation; favored for use as waterproofing and roofing material
Tar Sludge	Made up of heavier tar oil fractions, along with refractory geologic debris minerals and lithologic fragments from the parent coal or residues from parent oil feedstock.	Tens to hundreds of gallons per day, depending on local design and operating conditions. Difficult to relate to quantities of liquor per 10,000 cu ft gas produced. Sludge was unsaleable, unusable, and nearly always dumped.
Lampblack	Uncommon to coal-gas Sometimes found in CWG Common to oil gas manufacture	Major amounts produced by Pacific Coast Oil Gas process; as produced, nearly pure, powered carbon; easily sorbs toxic PAHs in post-operational deposits or in gas works dump environments.
Liquor	Always a contaminant; was the process water used to extract tar from the tar fog of produced gas. *Ammoniacal Liquor* with coal gas and *Gas Liquor* with CWG and other processes	Highly dependent on plant design and mode of operation; generally in the range of high hundreds to tens of thousands of gallons per day. Plant-specific operational circumstances controlled the absolute quantities of liquor per 10,000 cu ft gas produced.
Ammonia	Released mainly from coal-gas production, stemming from feedstock coals	Typically wasted in both (pre-1875) and smaller coal-gas plants. Required special equipment to capture; after 1870 some large-city collection as a household and commercial cleaning agent. After 1890 sometimes a market as ammonium sulfate fertilizer.
Sulfur	Released from coal and oil feedstock's alike, and accumulated as a residual impurities from virtually all gas-manufacturing processes employing organic feedstocks.	Typically wasted in both (pre-1875) and smaller coal-gas plants. Required special equipment to capture; after 1870 some large-city collection as cleaning agent. After 1890 sometimes a market as converted to ammonium sulfate fertilizer.
Cyanogens	CN formed mainly in coal carbonization, from C and N released from feedstock coal. Cyanogens formed in complexes from other available impurities	Typically wasted in both (post-1875) and smaller coal-gas plants. Required special attention to recover; after 1890 some large-city collection for industrial chemicals and for flotation-recovery of gold values from milled ore.
Cyanide/ Prussian Blue	Cyanides formed from C and N released from coal Captured mainly at purification boxes and found as several compounds depending on plant conditions.	Most formed in coal carbonization Minor amounts to be expected with CWG and lesser amounts with oil gas Mainly in the presence of box-waste sulfur Can be released to environment in modern times under locally acidic conditions Sometimes water-soluble and capable of releasing poisonous gas under exposed ambient conditions

Sulphur	Captured in purification boxes	Could be gathered and sold under favorable market conditions, mainly to generate vitriol (sulfuric acid) in urban centers; generally not the case elsewhere.
Ash	Inert refractory mineral residue of coal as a gas-making feedstock or as a plant furnace or boiler fuel.	Not expected to contain contaminants above remedial action levels. Should be sampled and tested, however.
"Scurf"	Hard carbon deposits formed on interior surfaces of retorts and generators	Removed by manual chipping via iron rods. Not expected to contain contaminants above remedial action levels.
Clinker	Partially-fused ash	Not expected to contain contaminants above remedial action levels.
Slag	Mineral-fused ash	Forms from retort and boiler furnaces. Not expected to contain contaminants above remedial action levels.
Spent Lime ("Blue Billy")	Spent lime cleared from one-time use in purifying boxes; most common before 1875; calcined crushed limestone as well as pulverized sea shells from food suppliers	Generally a toxic waste containing cyanide and heavy metals, possibly sulfides. May be associated, as dumped, with other spent purification media.
Spent Wood Chips, Excelsior* or Coarse Sawdust	Sorbant wood waste brought to the plant for purification medium; Generally from 1870 to end of manufactured gas era.	Consider potentially toxic unless shown otherwise. May be associated with other spent purification media. May not display Prussian blue color until exposed to air.
Spent Iron Spirals Spent Iron Strips Spent Iron Oxide Spent Bog Iron (ore)	Sulfur-capturing media brought to the plant for use in purification Generally post-1875 to the end of manufactured gas	Considered toxic unless shown otherwise. Be concerned with sulfur-related pH conditions that can lead to release of cyanide to the environment.** May be associated with other spent purification media.
Retort & Bench *** Fragments	Retorts generally replaced at 24-month or lesser frequency	Approximately one ton per bench per year. Forms a void matrix for dump-sequestering of PAH toxic waste.
Replaced CWG Generator Shell Lining Brick	Average refractory liner replacement each six months	Approximately three tons of brick removed and replaced per generator set per year. Forms a void matrix for dump sequestering of PAH toxic waste.

*spiral-form wood shavings
** "sulfuric" spelling is consistent with historic usage.
*** "Bench" is the North American equivalent of the UK "Bed"

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