Odors from mycelium sludge waste and bone meal manufacturing

Date: Oct. 13, 2004

This is a reply to request of information about gases from
1. Landfill where mycelium sludge is dumped (from penicillin production)
2. Bone meal production process.

This also includes information about the potential health effects of the gases causing the bad odors in both cases.

Odorous substances that have not being identified as toxic to humans may evoke violent or alarming physical symptoms in a substantial fraction of an exposed population whenever odor intensity is high and exposure more than fleeting.

It is likely that the nuisances caused by the "fetid" or "stinking" odors include a mixture of gases, some of them could have identified toxic effects in humans, but they produce violent and alarming symptoms in the exposed population. Any of these physiologic reactions to foul odors result from the direct action of the odorous substance on receptors that affect the autonomic nervous system. All these reactions clearly represent a matter for public health concern and attention under the Word Health Organization's (WHO) definition (1958) of health --"a state of complete physical, mental, and social well being and not merely the absence of disease and infirmity" even though the chemical components individually or collectively responsible for the foul odors have not been specifically identified as toxic substances by the usual criteria.
http://www.who.int/about/definition/en/

Whenever the withdrawal of the foul odor results in prompt, complete, and permanent remission of all the physiologic symptoms, this might be accepted as a criterion for the absence of toxicity as classically defined. Therefore the nuisance caused by the odors is enough argument to file a petition to the authorities, not only based on "the character of the odor, but also on the duration of the exposure, time of day, day of week, intensity and frequency of exposure". National Academy of Sciences (1979) "Odors from Stationary and Mobile Sources".

I. PHARMACEUTICAL COMPANY - MYCELIUM SLUDGE WASTES

Methyl mercaptan and hydrogen sulfide are two possible gases that match the description of the odor you mention from the pharmaceutical company. I also included a general description of the industrial production of penicillin.

According to your message, a pharmaceutical company is dumping mycelium sludge in an open landfill and covered with coir and mud. It is very likely that the odor comes from the decomposition of the organic matter in the sludge.

The odours from the mycelium sludge could be a mixture of several odor compounds produced by complex simultaneous chemical reactions that occur during putrefaction. Indole (also called 2,3-benzopyrrole, 1-benzazole, benzopyrrole), is a subtance with characteristic fecal odor.

Industrial biosynthesis of penicillin commonly involve the use of corn steep medium used for the growth of the fungus Penicillium chrysogenum during the fermentation process to obtain penillicin(the production process also involves lactose, amino acids, mineral salts and other substances).

Corn kernels on an intact plant accumulate indole-3-acetic acid (IAA) at the rate of 190 ng g-1 fresh weight h-1. This substance is produced by metabolic reactions that involve tryptophan.

The mycelial sludge not only is composed by pure fungal biomass but it also contains other compounds formed during the production process. After the mixture of substances called "mycelial sludge" is dumped in the open space, it is subject to the action of groups of bacterias and other microorganisms.

The microbiological breakdown of the fungal biomass (enriched with the wastes of the corn medium) in the open dumpsite can produce indoles (indole, 3-methylindole and other indole derivatives), as well as other malodorous substances which include hydrogen sulfide, and others.

Information on the human health effects from exposure to indole is limited.
http://avogadro.chem.iastate.edu/CHEM211L/MSDS/Indole.htm

Even if the “fetid” or “stinking” odors does not have identified toxic effects in humans, they produce violent and alarming symptoms in the exposed population. Any of these physiologic reactions to foul odors (which are documented) clearly represent a matter for public health concern and attention under the WHO definition of health.

Sources:
http://www.zauberpilz.com/indol_extract_analysis.htm
http://leda.lycaeum.org/?ID=10410
http://web.ukonline.co.uk/webwise/spinneret/edexcel/penicl.htm

The odors may alsocome from the decay of organic matter. This degradation produces "methyl mercaptan" which smell like feces, and “hydrogen sulfide”, which are produced during the bacterial degradation of organic matter in the sludge.

1. METHYL MERCAPTAN

If methyl mercaptan is released to soil, it probably then goes into the air or is carried through the soil by rain or any other water that contacts it. Sunlight can break them down in the air to other substances.

Methyl mercaptan can be smelled and recognized in air at a level of about 1.6 ppb (1.6 parts of methyl mercaptan per billion parts of air). It can be smelled when it is present in water at a level far lower than 1 ppb.

a. Health Effects

Methyl mercaptan is always present in the body, urine and feces in small amounts. According to the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) very little is known about the health effects of methyl mercaptan. A single case of death resulting from occupational exposure to methyl mercaptan has been located. A 53-year-old Black male laborer worked for about 1 week emptying tanks containing methyl mercaptan. No details of exposure level were available; however, it is assumed that both inhalation and dermal exposure were probably involved. The man was hospitalized in a coma, developed hemolytic anemia and methemoglobinemia, and died 28 days after admission (Shults et al. 1970). The immediate cause of death was determined to be a massive embolus that occluded both main pulmonary arteries. It is not known whether long-term exposure to low levels of methyl mercaptan can result in harmful health effects.

Most studies of occupational exposure to methyl mercaptan in the pulp industry also involve exposure to other sulfur-containing compounds such as hydrogen sulfide, dimethyl sulfide, and sulfur dioxide as well as to methyl mercaptan (Kangas et al. 1984).
http://www.atsdr.cdc.gov/toxprofiles/tp139-c2.pdf

b. Regulations

The EPA requires that discharges, spills, or accidental releases of 100 pounds or more of methyl mercaptan must be reported to the EPA. The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit of 20 milligrams of methyl mercaptan per cubic meter of air (20 mg/m^3) for an 8-hour workday in a 40-hour workweek.

The American Conference of Governmental and Industrial Hygienists (ACGIH) and the National Institute for Occupational Safety and Health (NIOSH) recommend an occupational exposure limit of 1 mg/m^3 for methyl mercaptan.
http://www.atsdr.cdc.gov/tfacts139.html#bookmark03
http://www.atsdr.cdc.gov/toxprofiles/tp139.html

HYDROGEN SULFIDE
[See information about health effects and guidelines for hydrogen sulfide in our memo: "Interpretation of the Results of air samples from Cuddalore" Date: Aug 18, 2004]

Background information about the commercial production of penicillin. The name penicillin is applied to a variety of compounds produced by various species of Penicillium and also to many semi-synthetic penicillins, produced by converting one antibiotic, such as penicillin G, into another, such as ampicillin. Penicillin G, one of the most active and widely used forms, is manufactured commercially using Penicillium chrysogenum.

There could be several sources of air pollutants during the production of penicillin, and as you mentioned, the solid wastes from the production process could also be a source of odors.

The manufacturing process is carried out in stainless steel fermenters of l0 000 dm3 capacity. The fermenter is steam sterilized and loaded with sterilized growth medium (corn steep liquor) containing lactose, amino acids, mineral salts and other substances. (Phenylethanoic acid, a metabolic intermediate, is also added, to increase the yield).

An inoculum of strongly growing hyphae is added. Both glucose and nitrate are added periodically. The pH requires adjustment from time to time, to neutralize ammonia produced by the fungus. Temperature is set at first to give the maximum growth rate and then altered to favor penicillin synthesis. The fermenter is continuously stirred and sterile air blown in. An external cooling jacket is used for temperature control. After about 160-200 hours, the broth is filtered. Penicillin passes through in the filtrate, which is further processed to crystallize the product.

Penicillin is a secondary metabolite, produced in large quantities only towards the end of the growth period of the fungus. Therefore, it is essential for all of the mycelium to reach peak growth at the same time. This is why batch fermentation, rather than a continuous process, is appropriate for penicillin manufacture.

II. BONE MEAL PRODUCTION - ODORS

The bone meal production process you describe may include a " Batch Rendering Process" that causes vapor emissions from the cooker pass through a condenser where the water vapor is condensed and non condensibles are emitted as VOC emissions. Volatile organic compounds (VOCs) are the primary air pollutants emitted from rendering operations.

The major constituents that have been qualitatively identified as potential emissions include organic sulfides, disulfides, C-4 to C-7 aldehydes, trimethylamine, C-4 amines, quinoline, dimethyl pyrazine, other pyrazines, and C-3 to C-6 organic acids. In addition, lesser amounts of C-4 to C-7 alcohols, ketones, aliphatic hydrocarbons, and aromatic compounds are potentially emitted. No quantitative emission data were presented. Historically, the VOCs are considered an odor nuisance in residential areas in close proximity to rendering plants,

and emission controls are directed toward odor elimination. The odor detection threshold for many of these compounds is low; some as low as 1 part per billion (ppb). Of the specific constituents listed, only quinoline is classified as a hazardous air pollutant (HAP). http://www.epa.gov/ttn/chief/ap42/ch09/final/c9s05-3.pdf

Your message describes a gelatine/bonemeal manufacturing unit that processes beef bones using HCl acid. The odor varies between that of a "decomposing corpse" to "burning corpse."

Hydrogen chloride (HCl) is a very irritant gas. It tends to react easily with the substances it gets in contact with creating other substances. When inhaled, HCL causes irritation nose, throat, larynx; cough, choking; dermatitis; its solution causes: eye, skin burns; liquid: frostbite; in animals: laryngeal spasm; pulmonary edema. You can find complete information about the health effects of HCl at: http://www.atsdr.cdc.gov/tfacts173.html

We would need more information about the process in able to give you precise information of the health impacts of the emissions from the bone meal plant. Usually emissions from these plants include groups of substances with different toxicity. The fundamental question is that a sizeable fraction of the population exposed to foul odors cannot live with them in comfort and well-being. The effects of annoyance, inconvenience, and irritation include sensory perceptions that are reflected in physiological stresses that interfere with life quality and performance.