RESOURCE REVIEW

Remediation of manufactured methamphetamine in clandestine laboratories. A literature review

The purpose of the current literature review was to identify, collect, review, and organize all available information concerning clandestine laboratories used to produce methamphetamine through an analysis of routinely collected data sources. There were numerous peer reviewed journals, electronic databases, websites, and commercial vendors relevant to the remediation process of methamphetamine laboratories. Our intention in this review was to produce background information as well as a reference guide relating to the critical problem of methamphetamine production nationally and internationally in addition to generating future research projects associated with the topic. This literature review determined there has not been a national standardized analytical method recognized as a reference guideline for the remediation of clandestine laboratories for production of methamphetamine.

By Clyde V. Owens

INTRODUCTION

The clandestine production of methamphetamine is a growing concern nationally and globally. Until the early 1990s, methamphetamine for the US market was made mostly in laboratories run by drug traffickers in Mexico and California.[1] Since then, authorities have discovered increasing numbers of small-scale methamphetamine laboratories all over the United States, mostly in rural, suburban, or low-income areas.[2] Clandestine laboratories have been found in a variety of structures, including private dwellings, townhomes, apartments, motels, and vehicles. For example, Indiana state police found a record 1808 laboratories in 2013, although this number of laboratories may have been a result of increased police activity.[3] The sophistication of these laboratories varies widely, from individuals at home following online instruction to large elaborate set-ups. Illicit manufacturing of methamphetamine in clandestine laboratories poses numerous hazards to public health, the environment, and property, including hazards from fire and explosions as well as the production of dangerous chemical byproducts. Studies conducted by National Jewish Medical and Research Center (NJMRC) have shown that contamination by methamphetamine is a major hazard associated with clandestine laboratories. A single cook may result in residual methamphetamine surface contamination ranging from 0.1 μg/100 cm^2 to as high as 16,000 μg/100 cm^2.[4] With recent increases in property foreclosures, the question has been asked whether these former meth labs can be adequately remediated for reoccupation. Appropriate characterization, decontamination, and remediation of former meth labs are needed to restore these structures for reoccupation.

Currently, each state has listed research requirements to develop their own health-based procedures addressing characterization, decontamination, and remediation criteria issues. The U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD) and National Institute of Standards and Technology (NIST) have agreed to generate research products that will address science-related questions associated with meth lab remediation. The EPA has developed voluntary guidelines and established a program to support the voluntary guidelines. NIST is currently initiating a research program to develop new methamphetamine detection technologies and validating those procedures for detection testing.

The purpose of the literature evaluation was to identify, collect, review, and organize all available information concerning the remediation of clandestine laboratories used in the illicit production of methamphetamine. Several objectives exist to support the purpose of this literature review:

- Identify relevant sources of information by searching the scientific literature in online databases, as well as guidance documents relating to the remediation of former meth labs.
- Collect available information relating to the types and identities of chemical substances (1) used during the illicit production of methamphetamine; (2) generated as byproducts of methamphetamine production;

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1871-5532
http://dx.doi.org/10.1016/j.jchas.2017.01.004

Please cite this article in press as: Owens, C. V2., Remediation of manufactured methamphetamine in clandestine laboratories. A literature review. J. Chem. Health Safety (2017), http://dx.doi.org/10.1016/j.jchas.2017.01.004

(3) used during site decontamination and remediation, and (4) generated as byproducts of site decontamination and remediation.
- Collect available information relating to the methods used to sample, identify, and quantify chemicals in the indoor environment of a former meth lab.
- Collect available information relating to the gaseous, particulate, and residual concentrations of chemicals in former meth lab buildings.
- Collect available qualitative and quantitative information relating to the effectiveness of decontamination and remediation methods of buildings formerly used as meth labs and locations used to store methamphetamine related chemicals.
- Organize the information that is retrieved so it can be a useful resource to generate research products that address science-related questions associated with meth lab remediation.

Scope of the current literature review

Our review process started from summarizing the online databases TOXLINE, PubMed, NIOSHTIC-2, and Academic Search™ Premier to identify relevant sources of information related to "methamphetamine" (CAS #537-46-2). The initial search included over 8000 articles which were imported into reference managing software called EndNote®. A tiered process was used to identify, review, and manage potentially relevant articles. The first step was to produce a manageable list of citations to review using keyword filters to identify citations most relevant to the topics. Key terms included: *contamination*, *clandestine*, *decontamination*; *environmental monitoring*, *production*, *and remediation*. Search terms varied slightly depending on terminology used in individual databases relating to the remediation of former methamphetamine labs. The relevant articles included reports produced by international, federal, state, local health and environment, or law enforcement agencies, as well as additional information provided by nongovernmental organizations (NGOs) involved with the remediation of clandestine meth labs.

In addition, the websites of drug agencies such as the Drug Enforcement Agency (DEA), Alcohol Tobacco and Firearm (ATF), and National Jewish Medical and Research Center were searched for relevant reports. DEA explained that the agency does not remediate meth labs. However, their involvement includes removal of any controlled substances from the property and securing the site. The NJMRC was referred as the top research agency for clandestine meth lab remediation where Dr. John Martyny has provided a significant number of reports and publications in the field.[28] After identifying documents with relevant information, all pertinent information was collected and subjected to a thorough quality control (QC) review to ensure accurate reporting. The following QC review criteria included: information selected for inclusion was evaluated against project objectives; source data quality rankings were verified; included information was checked back to original sources. Much of the available information in this review is of limited scope and variable quality in terms of gold standard research. Many different viewpoints have been advanced on improvements in methamphetamine remediation; however, we identified no population-based studies or large trials which provided insight into the burden of methamphetamine remediation. While providing limited insight into some of the potential issues relating to remediation, only limited conclusions can be determined from this review.

Chemicals for methamphetamine production

From the literature review, there was not a single source identified that provided a comprehensive list of chemicals associated with methamphetamine manufacture. Some chemicals were cited by nearly every source, while others were only mentioned a few times across all documents. Methamphetamine manufacture has proven to be highly adaptive, as witnessed by the multiple shifts in production methods following regulations of specific precursor chemicals. The widely available book *The Secrets of Methamphetamine Manufacture*, currently in its eighth edition, may support this statement. The book cites the hurdles that federal regulations pose and then quickly clears those barriers by proposing new production methods to circumvent the most recent regulations.[5] Therefore, acknowledging the great number of chemical permutations possible, the following list does not claim to be a comprehensive account of every chemical that could be involved in methamphetamine manufacture.

Common chemicals used in the production of methamphetamine:

- 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
- Acetaldehyde
- Acetic acid
- Acetic anhydride
- Acetone (fingernail polish remover)
- Ally chloride
- Allylbenzene
- Aluminum
- Ammonia (farm fertilizer)
- Ammonium acetate
- Ammonium formate
- Ammonium hydroxide
- Hydrogen chloride
- Hydrogen iodide (gas)
- Hydrogen peroxide
- Hydrogen sulfide
- Hypophosphorous acid
- Iodine (flakes/crystals/prills)
- Iodine (tincture)
- Isopropyl alcohol (isopropanol, rubbing alcohol)
- Lead acetate
- Lithium (batteries)
- Lithium aluminum hydride
- Magnesium
- Perchloric acid
- Phenyl-2-propanone
- Phenylacetic acid
- Phenylpropanolamine
- Phosphine
- Phosphoric acid
- Phosphorus pentachloride
- Potassium chromate
- Potassium dichromate
- Potassium permanganate
- Propiophenone
- Pseudoephedrine (cold tablets)
- Pyridine

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