

Quality Scientific Approach for Remediation and Analysing Clandestine Laboratory Residues

¹*Abdullah, Ahmad Fahmi Lim (PhD), ²Miskelly, Gordon M. (PhD),
³Yew, Chong Hooi (PhD)

¹ Forensic Science Programme, School of Health Sciences, Universiti Sains Malaysia, Kelantan, Malaysia

² Forensic Science Programme, Department of Chemistry, The University of Auckland, Auckland, New Zealand

³ Royal Malaysian Police Forensic Laboratory, Royal Malaysian Police, Malaysia

Abstract : The growing concern over the chemical hazards posed by clandestine laboratory has resulted in many clandestine laboratory remediation guidelines being individually developed, particularly by the overseas governmental agencies. These guidelines have commonly included recommendations and procedures for remediation of the clandestine laboratory structures, adapted from a variety of sources and experience. This article reviews the scientific literature and the established guidelines on remediation and residue analysis at clandestine laboratory scenes. The areas included are scientific approach of clandestine laboratory cleanup, contaminant sampling, on-site testing, analytical methods for common clandestine laboratory contaminants, discussion and a reference to complete guidelines readily available for adaptation if such development is justified.

Key words: Clandestine laboratory, Remediation, Contaminants, Residue, Sampling

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Introduction

In response to the growing concern over clandestine laboratories (clan labs), overseas agencies, particularly in the US, have established guidelines for clandestine laboratory contamination reduction and sampling procedures [1-3], and many similar guidelines are under development [e.g. 4, 5]. The most up-to-date information is necessary in order to determine the type of contaminants present, their health risks, whether or not the property needs cleanup, and to establish that the property is fit for re-occupancy after cleanup.

Contamination of a property used for a clan lab depends on the method of manufacture of the drugs. This article focuses only on methamphetamine, as it is one of the most common seized drugs in Malaysia in recent years [6-8]. Since most of the chemicals used in methamphetamine production present a certain degree of hazard particularly in the residential setting where sensitive subgroups (infants, children and elderly) may be exposed, it is important to establish quality scientific methods for analysing the chemical residues [9].

Remediation of a Clandestine Laboratory

Remediation of a clandestine laboratory generally begins with preliminary assessment, followed by the actual remediation, and finally post-clean-up evaluation. This section provides an

overview of the steps in the decontamination process [1, 3-5, 10-15].

Preliminary Assessment

Preliminary assessment is conducted prior to sampling and cleanup of a clan lab [3]. It aims to identify the method/methods used to manufacture the drug, determine the scope of testing or remediation needed at the site, evaluate whether or not the structures are fit for use, and investigate the presence of specific toxic chemicals such as mercury or lead [5].

Cleanup of Residual Contaminants

Many of the contaminants present in a former clandestine laboratory are harmful if people are exposed to them. They may cause symptoms including breathing problems, respiratory irritation, skin and eye irritation, headache, dizziness, nausea and vomiting. High exposures to some of the chemicals, even for a short duration, can result in severe lung damage, skin burns or even death. Health effects from long-term exposure after a clandestine laboratory has been remediated have not been studied extensively. There is also uncertainty about the human health effects on long-term exposure to low levels of methamphetamine and its precursors. Therefore, the most practicable option is to ensure the area is cleaned up using the most effective cleaning practice. This sub-section discusses a number of

methods which have been recommended for the remediation of a former clandestine laboratory cleanup.

i) Ventilation

Atmospheric contamination by volatile solvents, acids, or other volatile compounds can result from emissions during manufacture or from volatilisation from spills. Therefore, ventilation is normally performed during laboratory processing or gross chemical cleanup for the safety of onsite personnel. It can serve as a means to reduce the atmospheric concentration of volatile solvents or acids, which can be important when methanol or other solvents are used to clean surfaces [5]. The Minnesota Department of Health guidelines note ventilation should not be considered to be a cleanup method since it will not remove residues although they do recommend that ventilation should occur throughout the cleanup [5]. It is important that ventilation must be performed in such a way that the vented contaminants are exhausted to the outdoors and not to the air intakes of adjacent structures [3, 11]. A final ventilation for 3–5 days after cleanup has been recommended [1, 3, 10, 11].

ii) Chemical spills and residue evaluation

It has been recommended that all powders and liquids throughout the structure should be tested for their corrosivity, toxicity and flammability [1, 5]. In general, acids are neutralised with sodium bicarbonate, while bases are reacted with a weak acid such as acetic acid. The aim is to reduce risks of chemical burns from corrosives, but neutralization needs to be used along with other cleanup methods (such as detergent washing) since there may be other chemicals (which are not corrosives or able to be neutralised) at the same location. The neutralised surface is then tested with pH paper [1, 5]. Solids can be scooped up, packaged and sent to an appropriate waste disposal facility, while liquids should be adsorbed into non-reactive material (e.g. clay), packaged and also sent to an appropriate waste disposal facility [1].

iii) Removal

It is unlikely that all of the chemicals used or generated in a clandestine laboratory could be easily identified. Any contaminated materials (visibly stained, discoloured or etched) should be removed and properly disposed of. However, there may be practical limits of this method in certain situations if the parts of a structure cannot be removed or it is too expensive to do so. Other methods that can be used to reduce contamination must be used, as discussed in later sections.

Removal is recommended for visibly contaminated sinks, bathtubs, and toilets [3, 12],

since people may come in frequent contact with these areas. Absorbent materials such as carpeting, suspended ceiling panels, and wall paper can absorb vapours and collect dust and powder and hence are recommended to be removed and replaced, as should exposed furniture and clothing [1, 3, 12] since they can lead to skin contact. Non-porous and semi-porous surface with visible contamination and stains which cannot be physically removed should be intensively cleaned [12]. Compulsory disposal of appliances that were in the room which cooking was conducted has been suggested given that there would be a high risk of contamination of food during preparation or storage [12]. However, this may or may not be necessary depending on the situation, degree of contamination, and whether or not it is practical and cost-effective to remove an item than cleaning it.

iv) Surface Washing

Surface washing includes pressure washing, detergent – water washing, solvent (alcohol) washing, steam cleaning, and others [12]. The efficiency of several cleaning methods was studied by Bay West [13]. The study results showed that:

- Methanol washing reduced methamphetamine concentrations by an average of 89%.
- A standard household glass cleaner reduced methamphetamine concentration on window glass by 88%
- Combination vacuuming/shampooing of low pile carpet reduced methamphetamine concentrations by 88%
- The highest reduction in methamphetamine concentration (97%) was achieved on a vinyl floor after two washings with methanol

The study noted that if the starting concentration approached or exceeded 100 $\mu\text{g}/\text{ft}^2$, a single or even double detergent/methanol-washing may not achieve the required clean-up standard of < 1 $\mu\text{g}/\text{ft}^2$ [13] as set by the Minnesota Department of Health [5]. The Minnesota Department of Health recommends that internal surfaces are scrubbed (twice) using a standard detergent solution (such as trisodium phosphate, TSP), and then rinsed with clean water [5]. Some guidelines suggest that surface washing be performed three times, with a standard detergent solution, with thorough rinsing each time [14]. Methanol cleaning of surfaces such as countertops and stoves has been reported to be more effective than water-detergent washing [5]. The use of methanol and isopropyl alcohol should only be used in a well-ventilated area, and with appropriate personal protective equipment (PPE) [3, 12]. They can only be used on surfaces which are inert to such solvents. For washable porous materials that are not

discarded and with no visible contamination, recommended cleaning consists of HEPA vacuuming followed by hot water detergent scrubbing and extraction [5].

Surface washing protocols, ideally, must be able to clean the contaminated surfaces as much as possible, preferably down to non-detect level. Unfortunately, there is a lack of study and information on the best procedure for surface washing. Existing surface washing protocols are based on the procedures that are believed to work best and deemed to be practical by industrial hygienists. As each clandestine laboratory is different, it is impossible to set a rigid cleaning protocol. Therefore, the best procedures should always be based on professional judgement, together with a comprehensive guideline.

v) *Encapsulation*

Some guidelines recommend that porous or semi-porous surfaces (such as walls, wood flooring, panels, ceiling and concrete) which have high levels of contamination should be encapsulated with an oil-based paint, epoxy or similar sealant [3, 12], after the surface has been cleaned. The sealant is applied after surface washing has been completed [5, 12], and more than one coat may be required for a complete containment of residue [2, 3]. The limitation of this method is that it does not remove the chemicals; rather, it only provides a barrier for the contaminants from being exposed. Problems can arise if the sealant delaminates from the underlying surface or the containment is otherwise mobilized from the coated substrates.

vi) *Plumbing*

The plumbing systems of buildings can give off fumes or odour if wastes generated during methamphetamine manufacturing are disposed of down sinks, drains, or toilets. Etching and staining are common indicators that the plumbing system needs to be decontaminated. If appropriate, the drains can be flushed with water to reduce the concentration of the contaminants [3, 5]. In more severe cases, it may be necessary to expose the plumbing system and treat the materials as contaminated waste.

vii) *Ventilation System*

Ventilation systems tend to collect the contaminants and redistribute them throughout a structure. This can be especially problematic in cases where the ventilation system serves more than one unit such as in motels and hotels. Non-porous materials of the ventilation system such as sheet metal (and plastic ductwork if it is not able to be removed or replaced) can be HEPA-vacuumed, then washed down to arms length with an appropriate detergent, repeating two additional times [5, 14]. All

filters need to be replaced regularly and properly disposed of as contaminated waste. For a ventilation system which is connected to multiple rooms, it is suggested that samples from adjacent rooms to be taken (working outward from the contaminated site), until areas with low or no contamination can be identified [5, 14]. All contaminated areas are then treated in the manner described above.

viii) *Remediation of outdoor contamination*

Outdoor contamination by chemicals used in the manufacturing of methamphetamine should be dealt with the most appropriate measures including waste removal, site control such as fencing, drainage control, monitoring, and removal or treatment of contaminated soil or water [16]. When mercury and lead are used, soil remediation and groundwater cleanup should be performed and achieve their acceptable remediation objective and cleanup standard. Colorado Department of Public Health and Environment has set soil remediation objectives of 400mg/kg and 1.1mg/kg for lead and elemental mercury, respectively [16]. As for groundwater cleanup, the department has set a target of 0.1mg/L for lead, and 0.01mg/L for elemental mercury contamination [16].

Sampling

The aim of sampling is to determine the degree of contamination at a clandestine laboratory site, and whether residues of chemicals are still present after cleanup. Sampling strategies are developed based on [15]

- Information from pre-cleanup site assessment
- Methamphetamine manufacturing methods and chemicals used
- Visual evaluation of the extent and severity of contamination, and
- The best judgment of the person conducting the sampling

In general, areas with obvious visual contamination or areas which are believed to have been directly involved with the manufacturing activities may not be necessarily to be sampled prior to cleanup, but should always be sampled after cleanup [15]. Pre-cleanup sampling may be performed to determine the presence of contaminants in areas with no obvious contamination [15]. Also, pre-cleanup sampling may be conducted to prove to the court or insurance companies that methamphetamine was being manufactured in the property [14]. Post cleanup sampling may not be necessary in areas believed or shown to have low levels of contamination during initial assessment [15].

There are several guidelines specifically focused on sampling and testing of chemical residues at a clandestine methamphetamine laboratory. Examples are the guidelines established by the states of Arizona and Washington [4, 17].

The Drug Laboratory Site Remediation Best Standards and Practices established by the state of Arizona specifically states that photographs should be taken at all sample locations and be included in the final report [17]. Also, all sample locations should be shown on a floor plan of the residually contaminated portion of the real property, and included in the final report [17]. Samples should be taken from “areas representative of the materials or surfaces being tested” [17]. Sample preservation and handling should follow “industry standards for the types of samples and analytical testing to be conducted” and be maintained under the chain-of-custody [17]. To avoid contamination of samples, a new pair of gloves is worn while collecting each sample, and all reusable sampling equipment should be properly cleaned prior to and between sampling [17]. Prior to sample analysis, it is important that all testing equipment be properly set up and calibrated [17].

Methamphetamine sampling

Methamphetamine has been used as the principal indicator for contamination in former clandestine laboratories. Methamphetamine residues are used to indicate the effectiveness of decontamination after the completion of removal and cleaning, and to determine whether the property is considered adequately clean and safe for subsequent reoccupancy. It is also generally assumed that the cleanup procedures necessary to decrease the levels of methamphetamine to a ‘safe-level’ should also be adequate to reduce the concentration of many other chemicals used in methamphetamine synthesis to acceptable levels [15].

Washington State Department of Health has (Jan 2004) revised the former Appendix C from Guideline for Contamination Reduction and Sampling at Illegal Drug Manufacturing Sites [4]. This guideline describes detailed procedures for the collection, handling and transportation of septic, soil, methamphetamine and caustic samples. Methamphetamine wipe sample procedures [4]. Whatman 40 ashless is preferred as methamphetamine sampling media by the State of Arizona as the manufacturer can confirm that it does not interfere with methamphetamine GC-MS analysis [14]. However, Whatman 41, 42, 43, 44, 540, 541, Ahlstrom 54, VMR 454 and S&S WH Medium are reported to have equivalent performance by the Washington State Department of Health [4]. Other guidelines do not specify the type of sampling media [5, 15]. A methanol-soaked gauze pad and a sample

area of one square foot are suggested by The Minnesota Department of Health [5]. At the time of writing, literature was lacking on the relative performance of different materials for methamphetamine sampling.

The size of sampling per area differs between guidelines. Washington State guideline uses a template to define a square area of 100cm²[4]. Arizona State Guideline does not specify the use of a template though the sampling area is specified to be 10cm x 10cm per area [17]. The Minnesota Department of Health, on the other hand, requires the sample to be collected from an area of one square foot [5]. Defining a specific area is important so that the amount of recovered methamphetamine per area can be reported, usually in weight/area. However, defining a 100cm²/1ft² may be practically difficult on certain surfaces (e.g. on a stove).

As a conclusion, there is a lack of specific procedures and/or consistency regarding the use of sampling media, template, number of locations per composite sample, and size of sampling area among different guidelines.

On-site VOC sampling and testing procedures

Indoor ambient air quality monitoring has been proposed by some agencies [3, 5]. For example, the Minnesota Department of Health recommends that indoor ambient air quality is evaluated with a photo ionization detector (PID) to detect the presence of volatile organic chemicals in every room and septic system drain after cleanup [5]. According to the Arizona State Guidelines, VOC sampling and testing procedures should be conducted [17]. Using a calibrated PID or FID, the background concentration of VOCs is collected from three exterior areas outside the limits of the residually contaminated portion of the property, areas with no known or suspected sources of VOCs, and all plumbing traps which are accessible [17]. The Environmental Management Department of County of Sacramento, however neither supports nor encourages such a practice, given that the concentration of the materials (that air monitoring would detect) would have decreased “to negligible if the property has reasonable ventilation” [12]. It should be noted that a photo or flame ionization detector instrument responds to a wide range of common clandestine laboratory organic solvents [18], thus this type of testing does not specifically detect what solvents are present at the clandestine laboratory site.

On-site pH testing procedures

A number of corrosive chemicals are used in the manufacture of methamphetamine. Surface contamination by these chemicals occurs through accidental spillage during handling and cooking, and

accumulation of these substances from their vapour, and from dispose.

Surface pH testing aims to ensure that corrosives are not present at levels that would pose a health hazard. Therefore, the acceptable range is set between pH 6 and pH 8. Since the actual surface corrosives are diluted more with the amount of deionised water, the actual pH value can be lower (if acids are present) or higher (if bases are present) on the surface than what is indicated from pH testing as outlined in the guidelines [4, 17]. The guidelines do not specify the amount of deionised water to be used for each sample area. Also, depending on the type of surface, different amounts of water may be needed, thus making the actual and observed pH reading different. As a result, pH testing must be carried out properly.

Target Analytes

Specific analytes for analysis should be selected based on the specific clandestine laboratory manufacturing process [12]. Target analytes for the Red Phosphorus Method include methamphetamine, its precursor (ephedrine/pseudoephedrine), hydrochloric acid (chloride), total phosphorus, and iodide. For the Anhydrous Ammonia Method of methamphetamine manufacturing, target analytes may include methamphetamine, precursor, hydrochloric acid (chloride), total lithium or total sodium, and total ammonia. If drug manufacture methods are suspected to have included the use of mercury (typically mercuric chloride) or lead (such as lead acetate), mercury and lead must be tested.

Methods of Analysis

Forensic analysis of methamphetamine has been performed using a variety of techniques. Gas Chromatography-Mass Spectrometry (GC-MS) is the most common method used in routine analysis of methamphetamine [e.g. 19, 20-26] and ephedrine/pseudoephedrine [27, 28]. Most of the literature reports extraction of drugs from biological materials such as urine [e.g. 20, 21, 29, 30], blood [e.g. 20] or hair [e.g. 31, 32] rather than extraction of drugs from surface wipes [33]. Other analytical methods such as Capillary Zone Electrophoresis [e.g. 34] and High Performance Liquid Chromatography (HPLC) [e.g. 21, 35] are also described in the literature. A standard method using GC-MS such as modified EPA Method 8270 has been recommended in cleanup guidelines [12]. EPA Method 8270 was originally developed to determine the concentration of semi volatile organic compounds in extracts prepared from solid waste matrices, soils, air sampling media, and water sample [36].

Phosphorus, which is used in conjunction with iodine to produce hydriodic acid, can be analysed using the NIOSH 7300 protocol [37]. NIOSH 7300 is

designed to sample air-borne phosphorus using a filter (0.8- μm , cellulose ester membrane, or 5.0- μm , polyvinyl chloride membrane) and a sampling pump. The sample is then analysed using Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) [38]. EPA Method 6010 for phosphorus analysis is recommended by the Environmental Management Department of the County of Sacramento [12]. Schieferecke et. al. [39] has developed a qualitative analysis method for the analysis of red phosphorus found in clandestine laboratories using a pyrolysis-GC-MS method in which the red allotropic form of phosphorus is converted into the white allotropic form of phosphorus using heat from a pyrolysis unit [39].

The study of iodine exposure of clandestine laboratory was conducted by Martyny et. al. [40-43]. Iodine can be analysed using the NIOSH Manual of Analytical Methods 6005 [37]. In this method, air-borne iodine is drawn through a solid sorbent tube (alkali-treated charcoal, 100mg/50mg) using an air pump [44]. The sample is then extracted and analysed in an ion chromatograph [44]. EPA Method 300, a method to analyse common anions, is recommended by the Environmental Management Department of the County of Sacramento [12]. Other methods using GC-MS [45-49] could potentially be applied in the analysis of iodine and this is worthy of further investigation [33].

Inorganic acids can be analysed using the method NIOSH 7903 [37], which can measure the total concentration of six air-borne anions. Air samples are collected in a sorbent tube using an air-sampling pump, and are then analysed using an ion chromatograph. The chloride originating from hydrochloric acid can also be analysed using EPA Method 300 [12].

Pre- and post-cleanup testing must be done in laboratories which may have used mercury or lead compounds, especially the methods using phenyl-2-propanone (P2P) precursor. To our knowledge, the P2P method has been used in a super methamphetamine laboratory dismantled in Kulim, 2006. OSHA ID-14, with a limit of quantitation of 0.004 mg/m³ for a 240-min (4.8 L) sample using a passive dosimeter or 0.0013 mg/m³ for a 75-min (15 L) sample using an active sampler, could be used for analysing low levels of mercury [50].

Additional chemicals of concern should be evaluated individually. However, as suggested by the surrogate approach [12], it may not be necessary to sample and analyse every analyte that might be present.

Conclusion

At the time of writing, there are no “universal guidelines” for the remediation of a clandestine laboratory, probably due to the difference in

regulations of a country/state, cleanup criteria, and the fact that each clandestine laboratory site and situation is different. Developing comprehensive written guidelines for clandestine laboratory remediation based on Malaysian setting is therefore necessary for regulatory purposes, as well as for effective decontamination of clandestine laboratory sites. These guidelines should be based on a practical and cost-effective approach, with procedures based on standard practice that contain logical and step-wise procedures for site evaluation, sampling, decontamination, post remediation sampling, and testing for contaminations. Since there is still a lack of information on clandestine laboratory sampling and validation of specific testing procedures, further investigation in these areas are warranted for prescribing quality assured scientific approach in clandestine laboratory residue analysis and remediation, thus will be continually investigated by our research group.

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