Pollution Control and Suggested Disposal Guidelines for Clinical Chemistry Laboratories

Pollutants generated by clinical chemistry laboratories of two cities (Buffalo, N. Y. and Rochester, N. Y.) are described. A stepwise procedure is suggested on how to deal with the toxic liquid wastes from such laboratories. A brief guideline of chemical procedures for the decontamination of selected toxic elements and compounds is included.

There is a long-standing question of whether or not clinical chemistry laboratories discharge harmful pollutants in considerable amounts, and, if so, whether or not this pollution can be decreased. Lack of specific data and scarcity of publications characterize this problem. In view of the lack of data, we felt that there was a need for a properly managed bench-level "survey" of the pollutants discharged by a group of clinical chemistry laboratories in a city. The results of such a survey should contribute to the development of a balanced view on this subject.

In 1972, such an assessment was made in the Buffalo metropolitan area hospitals (Table 1) with the help of a questionnaire worked out by the Buffalo Sewer Authority in close cooperation with an engineering firm and local clinical chemists. It contained 20 questions: four referred to solid waste, 10 to different types of frequently occurring liquid wastes, and six to other pertinent information concerning the waste discharge (temperature, color, etc.). These questionnaires were sent out by the Buffalo Sewer Authority to all local hospitals, and were collected after six months.

The data thus acquired can be presented in several ways. Because the quantity of waste is related to the size of the hospital, one possible approach is to relate the total waste of all laboratories to the total number of hospital beds. From this relationship, a 1000-bed "theoretical hospital unit" can be created as an aid to comparative data handling and display; Table 2 presents such a comparison of data from clinical laboratories in Buffalo and Rochester. Some preliminary evidence regarding these discharges in effluent sewer lines was already available. In 1973, the Buffalo Sewer Authority set up monitoring devices at the sewer outlets of local industrial plants and a limited number of local hospitals. Preliminary results showed that in the hospital sewer effluents, phenolic compounds exceeded by about 1000-fold the value permitted by the Buffalo Sewer Authority.

On the basis of the information obtained, I propose certain steps by which every clinical laboratory can begin to assess and to deal with its pollution problems.

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1 This report, a modified and abbreviated version of a report published by International Scientific Communications, Inc. in the December 1974 issue of American Laboratory (pp 9–23), is reprinted with their permission.

2 H. Sine, Rochester, N. Y., personal communication.
Regulations are already in effect concerning the safe handling and the disposal of radioactive materials in different types of laboratories (7). Also, regulations of local sewer authorities and a number of other publications give instructions about waste discharge in general, about thermal pollution, and about solid wastes. The present paper deals with some aspects of safety and with specific instructions regarding liquid wastes and discharges related to clinical chemistry laboratories.

To begin pollution control in clinical laboratories, a stepwise procedure consisting of three phases, is suggested: (a) data collection, (b) short-range remedial procedure, and (c) long-range remedial program.

Data Collection

In this phase, four initial steps are recommended.

1. A complete inventory should be made of all liquid wastes of the laboratory, and the harmful agents in them quantitatively assessed.

2. An updated list of "permissible levels" of all harmful pollutants in the streams of the respective state should be obtained, and this list should be used as a temporary guideline. Tables 3 and 4 present such lists from the Public Health Law of New York State and from California. The water-purity standards published by the Federal Water Quality Control Agency in 1968 are presented in Table 5. The latter list was to be updated in 1974. It would be easier to observe a list of limiting concentrations of harmful pollutants in effluents. Such a guideline of tolerance levels and list of effluent standards is in preparation by the Environmental Protection Agency for the whole country, and it is already available for certain geographical areas and states. A representative list for New York State is included in Table 6.

3. Once these documents are collected, the inventory of pollutants must be "cross-matched" with the permissible values (or effluent standards) to determine the toxic agents and their quantities; then efforts must be concentrated on the disposal of the most harmful agents.

4. Finally, it is important to find out the details about the laboratory sewer line, i.e., whether or not the waste enters an underground "buffer tank" before it is released to the city sewer line or if the laboratory sewer line joins the hospital sewer line. Also the total volume of waste water discharged by the hospital and by the laboratory must be determined. On this basis, the "dilution factor" for some harmful agents in the laboratory waste can be calculated. For example, a large Buffalo hospital releases about 420 000 000 liters of waste water annually, while the
chemistry laboratory of the same hospital discharges about 500,000–700,000 liters of waste water in a year—the average ratio of the two is 1:700.

After these data are collected, the next phase is the short-range remedial procedure.

**Short-range Remedial Procedure**

In the framework of this short-range program, the first steps are:

1. Collect the waste. For organic solvents one must use safety cans. Use seamless containers because seams easily corrode and result in leaks. (Protectosel Corp. and General Laboratory Supply Co.)

2. Dispose of the wastes, either by using the proper chemical method for detoxification or by shipping them to a testing laboratory (2). It is advisable to check whether or not the testing laboratory performs according to the respective state regulations!

Since one has to consider “ecology vs. economy,” the appropriate expenses involved are as shown in Table 7. Inflation might change this picture somewhat, but not dramatically, especially if one compares these expenses with the total supply budget of the hospital laboratory. (In three different-sized Buffalo hospital chemistry laboratories, it was found that the annual expenses for waste treatment constituted 0.5–2% of the total annual supply budget of the respective laboratories.)


4. For every harmful material, a short, concise index card should be prepared describing the characteristics of the material and safe methods for its handling and disposal. These cards should always be available to the laboratory personnel. It is advisable to label all dangerous and flammable chemicals with the nationally accepted hazard code of the National Fire Protection Association (3).

A safety book containing guidelines for handling and storing dangerous and toxic chemicals should also be at hand.
Because pollution is a continuous problem, the efforts to combat it should also be continuous and persistent. Waste treatment in laboratories is in its infancy, but one might add that in most cases laboratory safety is a neglected area. Data and evidence are slowly accumulating that show that clinical laboratories handle or discharge sometimes unexpectedly hazardous wastes originating from various laboratory procedures. For example, recent literature describes cases of hepatitis outbreaks and their consequences. Potentially harmful virus aerosol can be generated in the laboratory during handling of specimens infected with hepatitis B. It is also claimed (4) that the virus resists all treatment in sewer plants and reaches the streams with practically unimpaired infective capability. The literature mentions potential sources of hepatitis B infection from control sera (5) as well. Other reports describe azide explosions, mercury-vapor inhalation, the potential hazard involved in mixing incompatible chemicals, and improper care practiced in handling carcinogenic materials. All these show that one must remain alert concerning laboratory safety and waste decontamination and that for this reason a long-range decontamination program is also needed. The problem with decontamination will be increasingly important if we consider the fact that 40% of United States communities do not have adequate sewer facilities and that by 1990 all available fresh-water sources in the U. S. will be fully utilized. After 1990 sewage and waste water will probably be recycled in the whole country (as already is done in a few U. S. communities).

**Long-range Remedial Program**

1. A continuous effort should be made to work out or to use methods that generate no or less pollutants. Examples: the creatinine micromethod uses approximately 1/30th of the amount of picrate used in macro-methods; mercury can be avoided in chloride determination by using the Cotlove method, in which AgCl is generated, which is easier to dispose of.

2. One has to introduce new guidelines regarding the building of new hospitals (underground buffer tanks should be a routine in the future), regarding the construction of new instruments (separate waste lines), or regarding safety in laboratories.

3. The effort to introduce "ecology consciousness" and "safety consciousness" in the education of clinical chemists, physicians, medical technologists, etc., should be a continuous one.

4. A persistent effort should be made to offer and accept the cooperation of other laboratories (in the hospital) or of other organizations that are or should be active in similar areas of waste disposal (e.g., American Chemical Society, College of American Pathologists, American Society of Medical Technologists, sewer authorities, public health authorities, environmental protection agencies).

As a preliminary brief guideline, specific methods are given in the next section for disposal of the most frequently occurring harmful wastes discharged in clinical chemistry laboratories. Most of these methods were extracted from available literature (6). The methods were tested in our laboratory and additional observations have been added where necessary.

**Brief Guideline for Waste Disposal in Clinical Chemistry Laboratories**

- **Ag:** Ag is used mostly in the Cotlove chloridometer. Ag-containing waste should be collected in a bottle and acidified with HNO3 and HCl. The supernate occasionally should be decanted, neutralized, and flushed with copious amounts of water. The sediment containing the AgCl should be collected, dried, and sent to a jeweler or silversmith.

- **As:** This originates mainly from PBI and thyroxine methods. Acidified (HNO3) arsenious compounds should be saturated and precipitated with H2S gas or (NH4)2S under a well-ventilated hood. The sediment should be dried, collected, packed, and sent to a chemical plant for re-use. A better choice of action would be to change to a method that produces fewer pollutants, such as the competitive binding method.

- **CN:** CN is generated mostly in uric acid and hemoglobin determinations. Make the waste solution mildly alkaline (up to pH 8) with NaOH, add an excess amount of FeSO4, stir, and let stand for a few hours. Then bring the pH to 8 and flush with excess water.

- **Cr** (hexavalent): Chromates and dichromates are generated mostly from cleaning solutions. Under a hood, slowly add excess reducing agent (e.g., NaHSO3 or FeSO4) to the acidic dichromate solution (do not use a stronger reducing agent or sulfur). Stir well, let stand, and stir occasionally until a complete color change takes place (to a greenish color). Then dilute, neutralize, and flush with copious amounts of water.

- **Cu:** Cu is generated by several laboratory procedures, among others, in biuret, in the Folin–Wu sugar method, and in the cholesterol methods. Smaller amounts of copper salts should be well diluted and flushed with excess water. Larger amounts of solutions of more concentrated cuprous or cupric salts are better disposed of by diluting the solution and adding excess Na2CO3; if the Cu is mixed with other salts, add Na2CO3 + Ca(OH)2. Stir, let stand until settled, decant, neutralize with HCl, and flush with excess water. The sediment sludge should be dried and packed for landfill.

- **Fe:** Fe is used in several laboratory reagents: Stoke's solution, glucose, cholesterol determinations, etc. The procedure for Fe salts is the same as for Cu salts.

- **Hg:** Metallic mercury from gasometers, manome-

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3 Sodium azide is used mainly as an antifungal agent to preserve enzyme substrate preparations (e.g., serum glutamic pyruvic transaminase substrate), but most importantly to wash the Coulter counter instrument in hematology laboratories. It was in these laboratories where the explosive nature of azide was reported. This danger can be prevented by avoiding traps and piping made of lead, copper, or brass.
ters, Miller–Abbott tubes, dental filling amalgam, mercury compounds from chloride determinations, or in Nessler's reagents, as preservative in glucose standards, in Zenker's solution, etc. Spilled metallic mercury should be carefully collected in a bottle and tightly stoppered. Mercury found in inaccessible cracks should be covered with sulfur powder. Inorganic mercury salts can be precipitated as sulfide (H₂S, Na₂S, or other sulfides in acidified medium, under a hood). However, an easier procedure is as follows (J. Dallas, W. Mitchell, and D. A. Pragay): Add 10 g of Na₂CO₃ and 10 g of Zn powder (metallic) to 1 liter of waste with acidity adjusted to about pH 6. Stir and let stand overnight. The next day 99% of the original Hg will be in the sediment. Decant the supernate and flush with copious amounts of water. If the original Hg concentration was >100 mg/liter, it is advisable to repeat the whole procedure with the supernatant fluid and then dispose of it. The sediment (a Zn amalgam) should be collected in a tightly stoppered container. When sufficient quantity is at hand, it should be sent to an amalgamation plant for reclamation of the metallic mercury. Inorganic mercury can also be precipitated by simply adding NaOH or KOH to the solution, but this precipitation procedure is far from quantitative.

A resin, Sraffion NMRR, is said to bind the noble metals and inorganic Hg firmly and selectively. Under proper circumstances it can decrease the Hg in an effluent 100-fold. The resin is not available in the United States, but can be imported directly from the present manufacturer, Ayalon Co., Ltd., Haifa, Israel.

Zn: Zn is mostly generated by protein-precipitating reagents in the Somogyi–Nelson glucose method and in PBI, VMA, D-xylene, and lactic acid methods. The procedure for Zn is similar to that used for Cu and Fe salts.

Acids (mixed group of acid reagents): Acids should be neutralized before disposal, diluted, and flushed with excess water. The final pH of the waste should be between 5.5 and 9.5. There are a few exceptions where special treatment is needed:

1. Perchloric acid or perchlorates (explosive when dry!) are used mostly in protein precipitation methods. The disposal of perchloric acid is not without danger because of its violent (often explosive) reaction with reductants. The recommended method is to dilute the acid very well, neutralize it and discharge it. Because of fumes, it is best to handle the concentrated acid under the hood.

2. Phosphoric acid is used in uric acid methods, in the VMA method, and in Folin's phenol reagent. Phosphoric acid should be neutralized with a mixture of Na₂CO₃ and Ca(OH)₂ (1:1 proportion), the resulting slurry sedimented, and the supernate flushed with excess water. The sediment should be dried, packed, and used for landfill.

Phenolic compounds: Phenols and nitrophenols or their derivatives are used in several laboratory methods as enzyme substrates, enzyme test reagents, and as disinfectants and indicators. Send the simple phenolic compounds to a testing laboratory that has a proper burner. Nitrophenols should be handled separately and first be destroyed chemically in the laboratory as follows: Under a hood, prepare a reagent of 1 part (weight) Na₂S·9H₂O and 6 parts (weight) water. Calculate the weight of the phenolic compound, and, while stirring, add 30-fold as much reagent by weight. Leave the reagent under the hood for a few hours with occasional stirring, and then dilute and flush it.

Pirate: Pirate is used in creatinine determinations and in Eabach's reagent. Because of their explosive nature and the substantial quantity discharged in every laboratory, picrates should be considered separately. They must be chemically destroyed in the laboratory as follows: Under a hood, prepare a reagent of 1 part (by weight) NaOH and 21 parts (by weight) Na₂S·9H₂O in 200 parts (by weight) water. While stirring, add this reagent to the picate in the following proportion: 25 parts (reagent) to 1 part (picrate) calculated by weight. Stir, and then bubble air through the solution for at least 3 h until the color changes to deep reddish brown. Then bring the solution to pH 8, dilute well, and flush. (Important: always avoid creating dry picrate dust and grinding dry picric acid crystals; they are explosive.)

Organic solvents: These are used mostly in tests for steroid hormones and triglycerides. Organic solvents should be collected in safety cans. Ether and chlorinated solvents should be collected in two separate containers. All other solvents may be collected in a single container. Store the safety cans inside metal cabinets, possibly in an explosion-proof cold room. (In the western New York area, pathology laboratories appear to discharge 5 to 10 times as much organic solvents as do clinical chemistry laboratories).

The disposal of these solvents should be left to properly equipped (with "afterburner") state-controlled testing laboratories, because evaporation is not acceptable and recycling is difficult in a routine laboratory. Chloroform and carbon tetrachloride should be returned to the supplier for recycling.

All these disposal procedures should be done under well-ventilated hoods by a technician wearing safety glasses.

The preceding list describes the disposal of a selected group of harmful pollutants in the clinical laboratory waste. Undoubtedly future development and research will add to this list.

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