Disposal of chemical wastes

If your school is subject to regulations for disposal of liquid wastes (to sewer) or solid wastes (to garbage), you should follow these regulations rather than the recommendations from RiskAssess. All wastes that cannot be legally disposed of to the sewer or garbage should be retained for collection by a waste collection service.

In the absence of specific regulations, the advice from RiskAssess is designed to minimise harm to the environment and to offer a responsible approach for student learning.

Liquid wastes

Liquid wastes in school laboratories are mostly aqueous, and contain dissolved salts.
They may be strongly acidic or basic, and may contain suspended particles.
Depending on the nature of the salts, the suspended particles and the pH, it may or may not be acceptable to pour the waste down the drain. Usually, inland sewage systems that discharge into rivers regulate waste inputs more than coastal sewage systems. A particular concern of sewage treatment plants is the contamination of sewage sludge by heavy metals or persistent organic compounds, since the sludge cannot then be sold and must, instead, be sent to a controlled landfill, at great expense.

Some wastes, such as short-chain alcohols (e.g. “methylated spirits”), are non-aqueous and miscible with water. If the waste is able to be readily consumed by bacteria and contains no persistent toxins, it may be acceptable to dilute the waste with water (say, 20 times) and pour it down the drain.

Small amounts of water-immiscible wastes are generated in school laboratories, such as hydrocarbons and specific chemicals used mostly for organic chemistry. These wastes should NOT be poured down the drain, since they will float on top of the water in the sewer and may cause an explosive air/vapour mixture in the sewer pipe. They may also be hazardous to aquatic life.

The good news is that sewage systems provide dilution of liquid wastes, are able to buffer significant amounts of acid and base, and contain microorganisms that can consume simple organic compounds.

Aqueous wastes

pH

The pH of a chemical waste should be within the range found in natural waters (pH 6.5 to 8.5), or close to it, if the waste is to be discharged from a school into the sewer system. At a school, chemical wastes from science laboratories will be mixed with water from other school activities before discharge to the sewer. If a hundredfold dilution of chemical waste water occurs within the school, an acceptable range of pH for disposal of a liquid waste down the laboratory drain is pH 4.5 to 10.5. Dilute acid or alkali (e.g. sodium carbonate) can be used for pH adjustment, or acidic and alkaline wastes can be carefully mixed, taking into account any possible interactions.

Dissolved salts

The cations and anions in dissolved salts can be considered separately for the purposes of estimating their environmental effects.

Some cations, such as Na^+, are abundant in natural waters and should not pose a problem in moderate amounts. Others, such as Cu^{2+} are highly toxic to aquatic organisms and should be discharged in only tiny amounts, while others, like Pb^{2+}, bioaccumulate and should not be allowed to enter the sewer system at all. Anions similarly have a range of aquatic toxicities.

For discharge to sewer, the interactions with other sewage constituents must be considered. Tables D1 and D2 provide estimates of the quantity of each cation and anion that can be permitted during each laboratory class (in grams per class per day) without being likely to cause environmental damage in the natural waters into which sewage is discharged. The cations are estimated as the mass of chloride salts, while the anions are estimated as the mass of sodium salt. The allowable quantity for a simple salt is obtained by choosing the smaller of the two quantities for the cation and anion.

If the quantity of a chemical waste exceeds that in Tables D1 and D2, the waste should be placed in a dedicated waste container, that is, a container for ONLY that particular waste and clearly marked according to GHS (using Custom Labelling in RiskAssess).
Do NOT mix together different metal wastes, since this makes recycling difficult, or impossible, and will result in higher costs to the school for waste removal by a contractor.

A good trick is to precipitate the toxic constituent of each waste, so that it sediments to the bottom of a waste container. The supernatant liquid, provided it contains nothing else that is toxic to aquatic life, can be periodically poured down the drain. In this way, waste volumes can be dramatically reduced and so can the expense of their removal by a waste contractor. Table D3 provides recommendations for the precipitating liquid that can be placed in half-filled waste containers for each type of waste.

It is recommended that much less than the maximum quantity of each waste be poured down the drain. It is possible to incorporate collection of waste into virtually every experiment. If that is done, students will better understand the importance of recycling and the minimisation of environmental harm.

Table D1 Maximum quantities of common cations (as chloride salt equivalent) recommended for pouring down the drain by a class in one day.

Cation	**Quantity g/day**	**Explanation**
aluminium	100	Phytotoxic, but precipitated as the hydroxide in sewer; used in water purification to settle suspended particles
ammonium	100	Critical plant nutrient, present in fertilizers; causes eutrophication of natural waters
barium	10	Not reactive in sewer
cadmium	0*	Highly toxic; bioconcentrates up the food chain; critically contaminates sewage sludge
calcium	1000	Abundant in natural waters, especially in limestone regions and in concrete, including sewer pipes
chromium(III)	10	Toxic to aquatic life; precipitates as the hydrated oxide; contaminates sewage sludge
cobalt	1*	Highly toxic to aquatic life; contaminates sewage sludge
copper	1*	Highly toxic to aquatic life; contaminates sewage sludge
iron(II)+(III)	100	Precipitates as hydrated Fe(III) oxide in sewer
lead	0*	Highly toxic; bioconcentrates up the food chain; critically contaminates sewage sludge
lithium	100	Not reactive in sewer
magnesium	100	Not reactive in sewer; occurs in limestone; abundant in sea water
manganese	10	Toxic to aquatic life; contaminates sewage sludge
mercury	0*	Highly toxic; bioconcentrates up the food chain; critically contaminates sewage sludge
nickel	1*	Highly toxic to aquatic life; contaminates sewage sludge
potassium	100	Critical plant nutrient, present in fertilizers; causes eutrophication of natural waters
silver	1*	Toxic to aquatic life; forms AgCl in sewer; contaminates sewage sludge; valuable
sodium	1000	Occurs at high concentrations in natural waters; released domestically in large quantities (salt, washing powders)
strontium	100	Not reactive in sewer
tin(II)+(IV)	100	Toxic to aquatic organisms; oxidised to tin(IV) which precipitates in sewer; contaminates sewage sludge
zinc	10*	Highly toxic to aquatic life; contaminates sewage sludge

* Waste quantities in excess of the recommended quantity should be placed in a dedicated waste container, clearly marked according to GHS (use Custom Labelling in RiskAssess). See Table D3 for recommendations. Do NOT mix together different metal wastes, since this makes recycling difficult, or impossible, and will result in higher costs to the school for waste removal by a contractor.

Table D2 Maximum quantities of common anions (as sodium salt equivalent) recommended for pouring down the drain by a class in one day.

Cation	**Quantity g/day**	**Explanation**
acetate	1000	Consumed readily by microorganisms
bromide	10	Not reactive in sewer; greater problem for inland waters
carbonate	1000	Neutralised in waters to become hydrogen carbonate; released domestically in large quantities (washing powders)
chloride	1000	Occurs at high concentrations in coastal waters; released domestically in large quantities (salt); greater problem for inland waters
chromate + dichromate	10*	Highly toxic to aquatic life, but reacts in sewer with organic matter to form Cr(III)
fluoride	1*	Toxic; not reactive in sewer; greater problem for inland waters; added to tap water
hydrogen carbonate	1000	Natural buffer in surface waters
hydroxide	100	If soluble salt, increases pH; largely buffered in sewer; NaOH used as drain cleaner
iodide	10	Not reactive in sewer; greater problem for inland waters
nitrate	100	Critical plant nutrient, present in fertilizers; causes eutrophication of natural waters
nitrite	100	Critical plant nutrient; causes eutrophication of natural waters; preservative in foods
permanganate	10	Highly toxic to aquatic life, but reacts in sewer with organic matter to form Mn(II) and MnO_2
phosphate	100	Critical plant nutrient, present in fertilizers; causes eutrophication of natural waters
sulfate	1000	Occurs in natural waters; released domestically in large quantities (washing powders)

* Waste quantities in excess of the recommended quantity should be placed in a dedicated waste container, clearly marked according to GHS (use Custom Labelling in RiskAssess). See Table D3 for recommendations. Do NOT mix together different anionic wastes, since this makes recycling difficult, or impossible, and will result in higher costs to the school for waste removal by a contractor.

Table D3 Composition of collection liquid for each chemical species in a dedicated waste collection container. A container half-filled with collection liquid is recommended, e.g. bottle (Winchester, 2.25-2.5 L) with funnel in mouth or a large beaker (1-2 L).

Species	**Collection liquid**	**Precipitate**	**Notes**
cadmium	Na_2CO_3 110 g/L	$CdCO_3$	[1]
cobalt	Na_2CO_3 110 g/L	$CoCO_3$	[1]
copper	Na_2CO_3 110 g/L	$CuCO_3$	[1]
lead	Na_2CO_3 110 g/L	$PbCO_3$	[1]
mercury	Na_2CO_3 110 g/L	HgO	[1] [3]
nickel	Na_2CO_3 110 g/L	$NiCO_3$	[1]
silver	NaCl 180 g/L	AgCl	[1] [2]
zinc	Na_2CO_3 110 g/L	$ZnCO_3$	[1]
chromate + dichromate	$FeSO_4$ 150 g/L	$Fe_2O_3.nH_2O$ Cr(III)	[4]
fluoride	$CaCl_2$ 350 g/L	CaF_2	[1]

[1] CO_2 evolved with acidic wastes; add acidic solutions slowly, in small quantities to a bottle. Alternatively, use a beaker half-filled with collection liquid, then transfer to a waste storage bottle. Waste bottles should be labelled according to GHS (use Custom Labelling in RiskAssess). Precipitate will settle slowly; pour off supernatant and add more collection liquid. Arrange for collection by a waste collection service when the bottle is filled with precipitate. Alternatively, transfer the solution (in portions) to a beaker and heat to boiling; this will cause agglomeration of particles and decomposition of the carbonate to the oxide, which will usually settle more fully.

[2] The silver chloride precipitate will gradually turn black as a result of light absorption and formation of metallic silver.

[3] Mercury carbonate is unstable and decomposes to red HgO.

[4] Cr(VI) species are reduced to Cr(III) with production of Fe(III) which precipitates as the hydrated oxide. Keep the bottle sealed to minimise access of air, which will slowly oxidise the Fe(II). This collection liquid is suitable for acidic or neutral Cr(VI) solutions. For alkaline solutions, use a solution of sodium sulfite (130 g/L); be aware that acidic wastes will release toxic SO_2 gas if added to this solution.

Sample calculations of recommended maximum daily wastes:

Sodium carbonate
sodium: 1000 g/day carbonate: 1000 g/day sodium carbonate: 1000 g/day

Copper sulfate
copper: 1 g/day sulfate: 1000 g/day copper sulfate: 1 g/day

Silver nitrate
silver: 1 g/day nitrate: 100 g/day silver nitrate: 1 g/day

Suspended particles
Small quantities of suspended particles can be permitted to enter the sewage system, provided the quantities given in Tables D1 and D2 are not exceeded. Suspended particles (typically oxides, hydroxides, carbonates) may dissolve in the sewage system. Waste solutions containing large quantities of suspended particles should be allowed to stand, so that particles can precipitate, then the precipitate should be treated as solid waste.

Non-aqueous wastes

Water-miscible liquids
The most common water-miscible wastes are
- short-chain alcohols, e.g. methanol, ethanol, "methylated spirits", 1-propanol, 2-propanol
- short-chain ketones, e.g. acetone, 2-butanone

Of these, "methylated spirits" and methanol are the most abundant in school laboratories. All of these substances are readily consumed by microorganisms in the sewer but are highly flammable, so they should be extensively diluted, at least 1 part waste to 20 parts water, before being poured down the drain.

Water-immiscible liquids – non halogenated
Hydrocarbon solvents, such as hexane, heptane, petroleum fractions, mineral turpentine and kerosene, are the most common wastes. They should be retained in a labelled waste container for collection by a waste service. Do NOT pour them down the drain, even in small quantities, since they are less dense than water, float on the top of water in the sewer, evaporate, and may form an explosive air/vapour mixture which can be detonated by an ignition source.

Water-immiscible liquids – halogenated
Halogenated compounds should be retained in a labelled waste container for collection by a waste service. Do NOT pour them down the drain, even in small quantities since many are flammable and many are highly toxic to aquatic life. Do NOT mix the halogenated and non-halogenated liquid wastes, since the halogenated wastes are more expensive to recycle and cannot be easily incinerated due to the formation of dioxins and other toxic chlorinated compounds during combustion. If a small quantity of a halogenated compound is added to a container of non-halogenated waste, the whole volume must be treated as halogenated, at much greater cost.

Solid wastes

Only "material of a domestic nature" is allowed to be disposed of in the garbage.
This term includes a wide range of materials.
Domestic garbage is not checked before collection and, consequently, householders often place in the garbage materials that are ecotoxic or could be recycled.

To assess which chemical wastes can be disposed of in the school garbage, we need to consider
• transport of the garbage from the school to the landfill, and then
• leaching of substances from the landfill.

Only a small number of chemical wastes from school laboratories are suitable for disposal in the garbage. These include:

Geologically-stable minerals, precipitated during reactions
e.g. barium sulfate (baryte) or metal oxides (haematite, etc)
These materials will not leach toxic chemicals when placed in a domestic landfill.

Empty chemical bottles
Empty chemical bottles should be rinsed with water and the rinsing treated as a liquid waste. The label on the bottle should be removed or rendered illegible, so that the bottle is not regarded legally (and logically) as a bottle containing a chemical. Follow your local rules for the recycling of glass or plastic.