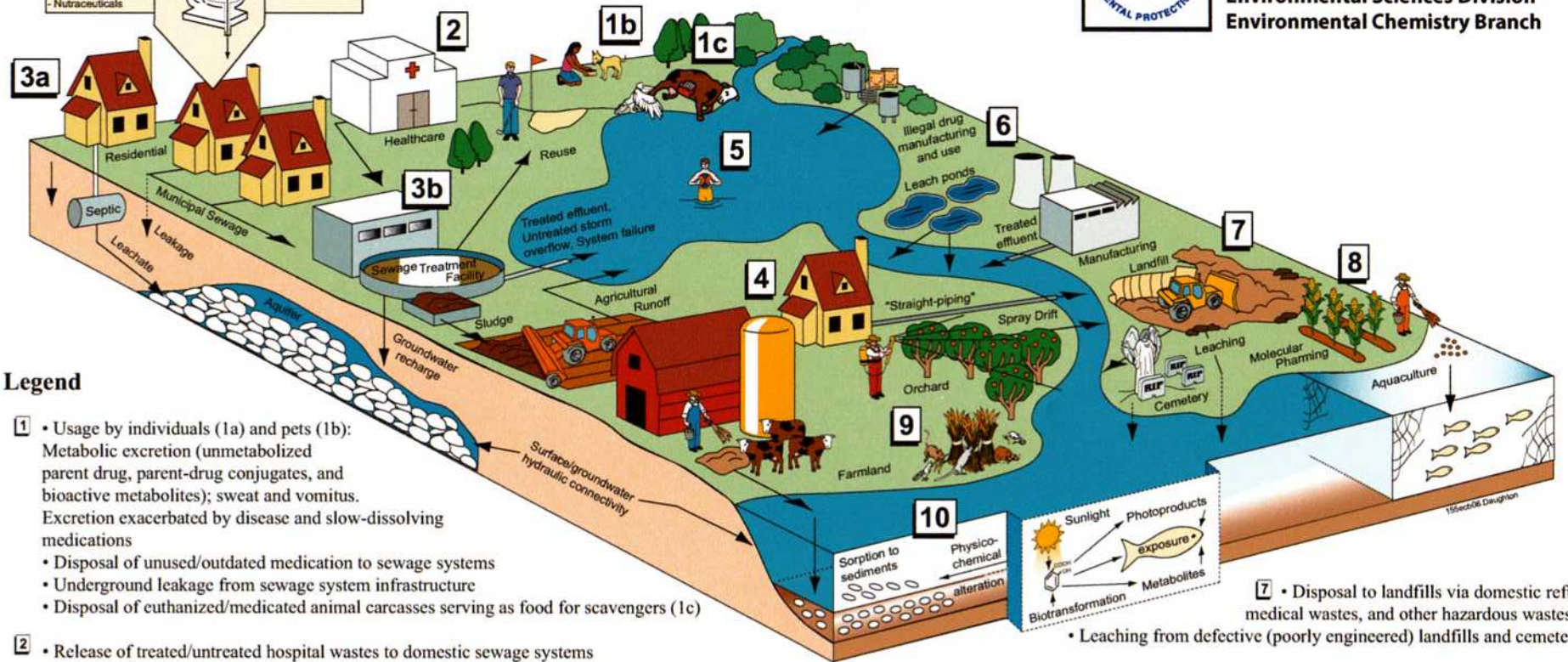


# Origins and Fate of PPCPs<sup>†</sup> in the Environment

<sup>†</sup>Pharmaceuticals and Personal Care Products



U.S. Environmental Protection Agency  
Office of Research and Development  
National Exposure Research Laboratory  
Environmental Sciences Division  
Environmental Chemistry Branch



## Legend

- Usage by individuals (1a) and pets (1b): Metabolic excretion (unmetabolized parent drug, parent-drug conjugates, and bioactive metabolites); sweat and vomitus. Excretion exacerbated by disease and slow-dissolving medications
  - Disposal of unused/outdated medication to sewage systems
  - Underground leakage from sewage system infrastructure
  - Disposal of euthanized/medicated animal carcasses serving as food for scavengers (1c)
- Release of treated/untreated hospital wastes to domestic sewage systems (weighted toward acutely toxic drugs and diagnostic agents, as opposed to long-term medications); also disposal by pharmacies, physicians, humanitarian drug surplus
- Release to private septic/leach fields (3a)
  - Treated effluent from domestic sewage treatment plants discharged to surface waters, re-injected into aquifers (recharge), recycled/reused (irrigation or domestic uses) (3b)
  - Overflow of untreated sewage from storm events and system failures directly to surface waters (3b)
- Transfer of sewage solids ("biosolids") to land (e.g., soil amendment/fertilization)
  - "Straight-piping" from homes (untreated sewage discharged directly to surface waters)
  - Release from agriculture: spray drift from tree crops (e.g., antibiotics)
  - Dung from medicated domestic animals (e.g., feed) - CAFOs (confined animal feeding operations)
- Direct release to open waters via washing/bathing/swimming
- Discharge of regulated/controlled industrial manufacturing waste streams
  - Disposal/release from clandestine drug labs and illicit drug usage
- Disposal to landfills via domestic refuse, medical wastes, and other hazardous wastes
  - Leaching from defective (poorly engineered) landfills and cemeteries
- Release to open waters from aquaculture (medicated feed and resulting excreta)
  - Future potential for release from molecular pharming (production of therapeutics in crops)
- Release of drugs that serve double duty as pest control agents: examples: 4-aminopyridine, experimental multiple sclerosis drug → used as avicide; warfarin, anticoagulant → rat poison; azacholesterol, antilipidemics → avian/rodent reproductive inhibitors; certain antibiotics → used for orchard pathogens; acetaminophen, analgesic → brown tree snake control; caffeine, stimulant → *coqui* frog control
- Ultimate environmental transport/fate:
    - most PPCPs eventually transported from terrestrial domain to aqueous domain
    - phototransformation (both direct and indirect reactions via UV light)
    - physicochemical alteration, degradation, and ultimate mineralization
    - volatilization (mainly certain anesthetics, fragrances)
    - some uptake by plants
    - respirable particulates containing sorbed drugs (e.g., medicated-feed dusts)





# Proper Disposal of Prescription Drugs

Office of National Drug Control Policy February 2007

## Federal Guidelines:

- Take unused, unneeded, or expired prescription drugs out of their original containers and throw them in the trash.
- Mixing prescription drugs with an undesirable substance, such as used coffee grounds or kitty litter, and putting them in impermeable, non-descript containers, such as empty cans or sealable bags, will further ensure the drugs are not diverted.
- Flush prescription drugs down the toilet *only* if the label or accompanying patient information specifically instructs doing so (see box).
- Take advantage of community pharmaceutical take-back programs that allow the public to bring unused drugs to a central location for proper disposal. Some communities have pharmaceutical take-back programs or community solid-waste programs that allow the public to bring unused drugs to a central location for proper disposal. Where these exist, they are a good way to dispose of unused pharmaceuticals.

The FDA advises that the following drugs be flushed down the toilet instead of thrown in the trash:

**Actiq** (fentanyl citrate)

**Daytrana Transdermal Patch** (methylphenidate)

**Duragesic Transdermal System** (fentanyl)

**OxyContin Tablets** (oxycodone)

**Avinza Capsules** (morphine sulfate)

**Baraclude Tablets** (entecavir)

**Reyataz Capsules** (atazanavir sulfate)

**Tequin Tablets** (gatifloxacin)

**Zerit for Oral Solution** (stavudine)

**Meperidine HCl Tablets**

**Percocet** (Oxycodone and Acetaminophen)

**Xyrem** (Sodium Oxybate)

**Fentora** (fentanyl buccal tablet)

Note: Patients should always refer to printed material accompanying their medication for specific instructions.

Office of National Drug Control Policy  
ONDCP, Washington, D.C. 20503  
p (202) 395-6618 f (202) 395-6730

