The Changing Needs for Source Control

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Overview

- The changing nature and sources of contaminants
- What happens between source and final products
- Why control at source has increasing importance
- The changing needs for managing contaminants

Contaminants

Group	Nutrients	Organics	Pathogens	Heavy Metals	Cations, Anions	Trace Elements	Physical Properties
Element	Nitrogen (TKN) Phosphorus (TP) Sulphur (S)	Phenolics Polycyclic Aromatic Hydrocarbons (PAH), Organo-phosphorus Pesticides, Organochlorine Pesticides, Emerging Organics; EDCs, flame retardants, pharmaceutical products, cosmetics, cleaning products	E. coli, Faecal coliforms, Enteric viruses, Helminth ova, Salmonella sp., Campylobacter	Arsenic (As) Cadmium (Cd) Chromium (Cr) Copper (Cu) Iron (Fe) Lead (Pb) Mercury (Hg) Nickel (Ni) Selenium (Se) Tin (Sn) Zinc (Zn)	Boron (B) Chloride (Cl) Fluoride (F) Sodium (Na) Total dissolved solids (TDS)	Antimony (Sb) Cobalt (Co) Molybdenum (Mo)	Colour pH Electrical conductivity
Risk	Toxicity to plants, aquatic systems	Toxicity to plants, Treatment, aquatic systems	Animals and humans	Toxicity to plants, treatment, animals, humans	Salinity, sodicity of soil, plant health	Plant health	Aesthetics of effluent, impact on soil and plant health

A Bit of History

- We started out protecting human health; Public health Engineers
- We now focus more on environmental health e.g. soil microbiology, algae; Environmental Engineers, Scientists
- plus, We focus on risk reduction and mass discharged, not just reducing concentrations
- There is often a conflict between protecting people Vs protecting the environment
- Everything is much more sensitive and more complex than it used to be…..and this trend is increasing!

Our Tilted Playing Field

- We don't have a level playing field!
  - People accept historical practices, even if we can't show they make today's criteria
  - New products are scrutinised much more thoroughly than historical uses
  - Legal/policy definitions contradict science; at odds with rules of nature where we need some and excess is toxic
  - Law says any amount is a contaminant – creates public fear of 'any'
  - The Poo factor; not sexy
  - Marketing and biased education fool the public
- We just have to accept it! Work with it and move on!
- We need a simple campaign to present elements of a complex subject

Our Production Industries

Sewage

WWTP

Effluent

Trade Discharges

Sludge

Biosolids

Organic Solids/Sludge

Sludge Processing

Community Trends

- Large industries often control their discharges well but when they get it wrong it can be a big booboo.
- Sources are often no-longer dominated by industrial discharges:
  - Domestic; water supply, eating habits, cleaning products, body care products, medicines

Potentially toxic element concentration	Zn	Cu	Ni	Cd	Pb	Cr	Hg
	$\mu g.l^{-1}$						
" 1960s residential"	74.3	219.4	5.2	0.71	9.02	5.65	0.114
" 1990s residential"	147.0	458.3	7.56	0.34	90.61	3.3	0.088

  - Trade/commerce; small manufacturing
  - Service industries; restaurants, laundries, dentists
  - Contaminated stormwater and groundwater

- These trends point to a need for increased source control, particularly of metals
- If we don't police and measure how do we know the status quo or make good decisions for improvement?

Trends cont^{d}

- Cities in Sweden have reported reductions of 88% in the mass load of metals arriving at the WWTP through adoption of stricter trade waste controls.
- USA and Australia have reported domestic discharges accounting for approx 33% of Cu and Zn.
- Despite the above, most studies to find where heavy metals derive from cannot account for 20-50% of them.
- Many studies are old and peoples behaviour and available products have changed markedly over the last 10 years.
- More current studies are needed…publically

WWTP & Sludge Processing

Biosolid: a sewage sludge (or sewage sludges mixed with other materials such as green waste) that has been treated and/or stabilised to the extent that it is able to be safety and beneficially applied to land. The term does not therefore include untreated raw sewage sludges or sludges solely from industrial processes (NZWWA, 2003).

Trends:

- Lower sludge production = lower biosolids production
- Increased energy production
- Increased removal of nutrients for separate re-use
- These trends will reduce pathogens and organics concentrations and increase metals concentrations
- Possible increase in odour potential too

Trends in Biosolids Management

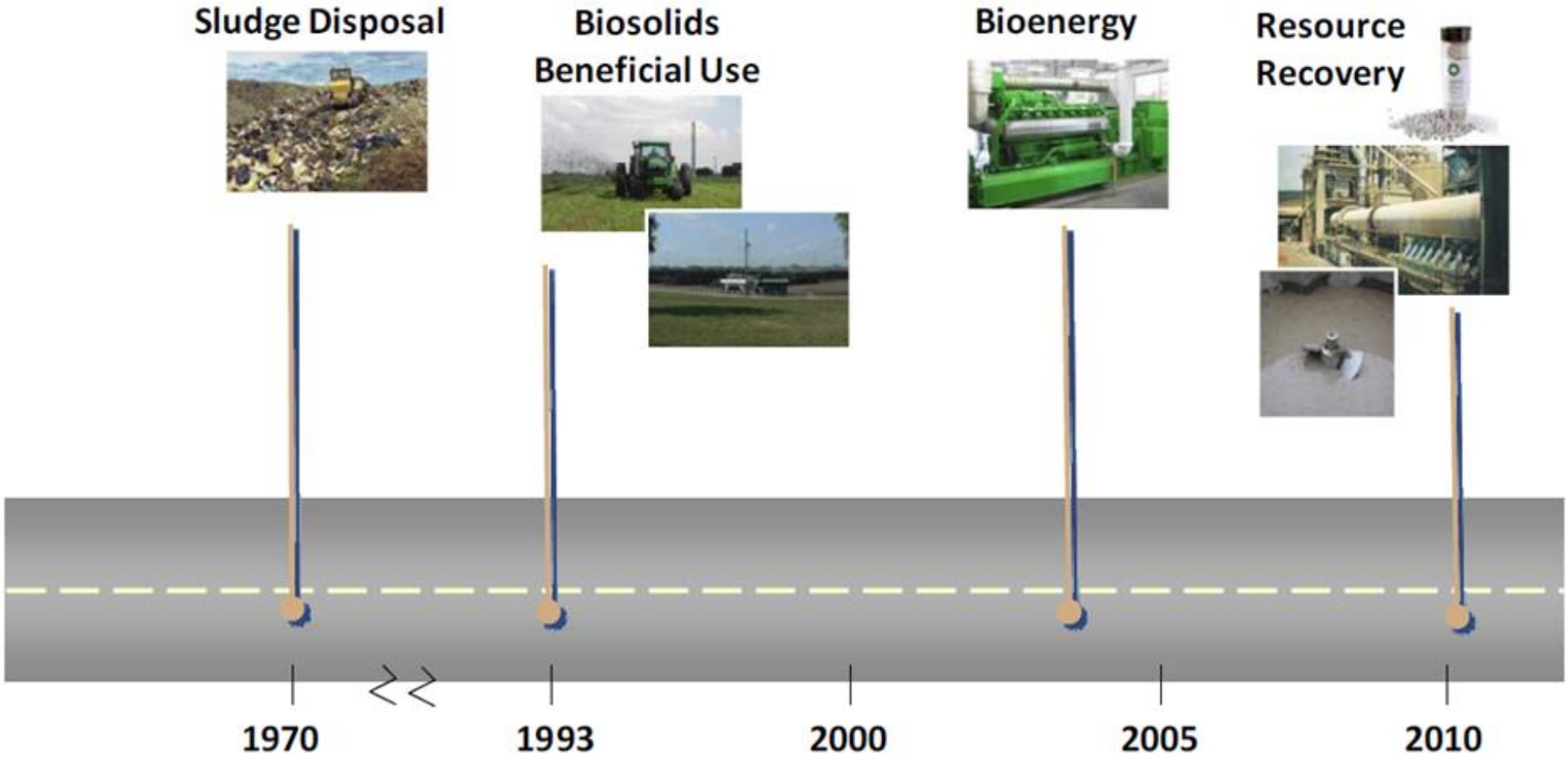


Figure ES-1: Our changing view of solids management

Resource Recovery Plant

Sewage

WWTP

Effluent

Trade Discharges

Sludge

Biosolids

Organic Solids/Sludge

Sludge Processing

Mixed Processing

FOG (fats, oils, grease)

Food Waste

Biogas

Organic materials contain heavy metals !

- and some organics and pathogens too

Metal content of some organic materials

Product	As	Cd	Cr	Cu	Ni	Pb	Zn
Greenwaste & foodwaste	*14*	*1.1*	*30*	*56*	*37*	*100*	*280*
Chicken manure	*26*	*0.06*	*23*	*43*	*6*	*6*	*295*
Pig manure	*1*	*0.06*	*2*	*49*	*2*	*2*	*580*
Horse manure	*3*	*0.02*	*6*	*13*	*3*	*8*	*87*
Sheep pellets	*3*	*0.10*	*9*	*22*	*4*	*17*	*140*
Mushroom compost	*36*	*0.08*	*8*	*94*	*6*	*10*	*270*
NZ Biosolids Guidelines (max)	*20*	*1.0*	*150*	*60*	*60*	*250*	*300*

Organics

- Historical problems:
  - Detergents (Linear Alkylate Sulphonate as Methylene blue active substances, MBAS)
  - Phenolic Compounds (as Phenol)
  - Polycyclic Aromatic Hydrocarbons (PAH)
  - Organophosphorus Pesticides
  - Organochlorine Pesticides
- Emerging problems - What do we know?

"There's Nowt so Queer as Folk"

Pathogens

- Why we measure what we do.
  - They are endemic in the environment and easily transmitted
  - We use indicators and reflect reported illnesses
  - Therefore a bit different in each country

- Not considered further here as we either accept them or know that WWTP and biosolids processing can destroy them; even if there is regrowth in subsequent biosolids or soils.

A Few Sources of Heavy Metals

- **Arsenic** - Water supply, household products, preservatives
- **Cadmium** - Excreted by humans, pipe fittings, industry, detergents
- **Chromium** - Cooking utensils, stainless steel fittings, dying
- **Copper** - Water fittings and pipes in houses
- **Lead** - Water fittings, pipes in houses, brake linings
- **Mercury** - Dentistry, anti-fouling paints
- **Molybdenum** - Cooking utensils, stainless steel fittings
- **Nickel** - Shampoo, pipe fittings, industry
- **Selenium** - Anti-dandruff shampoo
- **Zinc** - Water fittings, water proofing products, cosmetics

Water Supply - Effects

Ref. Up the Pipe: A literature review of the leaching of copper and zinc from household plumbing systems; Robina Ang, ESR 2012

- Leaching from household pipes and taps is the single biggest contributor of Cu to wastewater and also contributed around 5% Zn. This is also for 'all plastic' plumbing systems where the only possible source of Cu and Zn is brass taps
- Increased water velocity and turbulence enhance erosion corrosion.
- No single water stability index has demonstrated the ability to accurately quantify and predict aggressiveness or corrosivity of water
- Another source of Cu and Zn in wastewater is the largely unregulated home water filtration systems e.g. 'kinetic degradation fluxion' (KDF) filters, which contain small uninhibited brass granules that are purported to remove heavy metals i.e. Pb and Hg from water but release Zn or Cu ions in the process.

Water Supply – More Effects

- Hot water must be stored at 60°C to avoid Legionella outbreaks. Galvanised steel should not be used in contact with water >60°C.

- pH effects:
  - pH should ideally be maintained between pH 7-8 to minimise copper corrosion, meringue dezincification, and galvanised steel corrosion while not compromising chlorine disinfection
  - pH <7 leads to increased general corrosion of copper, brass and galvanised steel.
  - pH >8 can lead to type III copper pitting and meringue dezincification of brass.

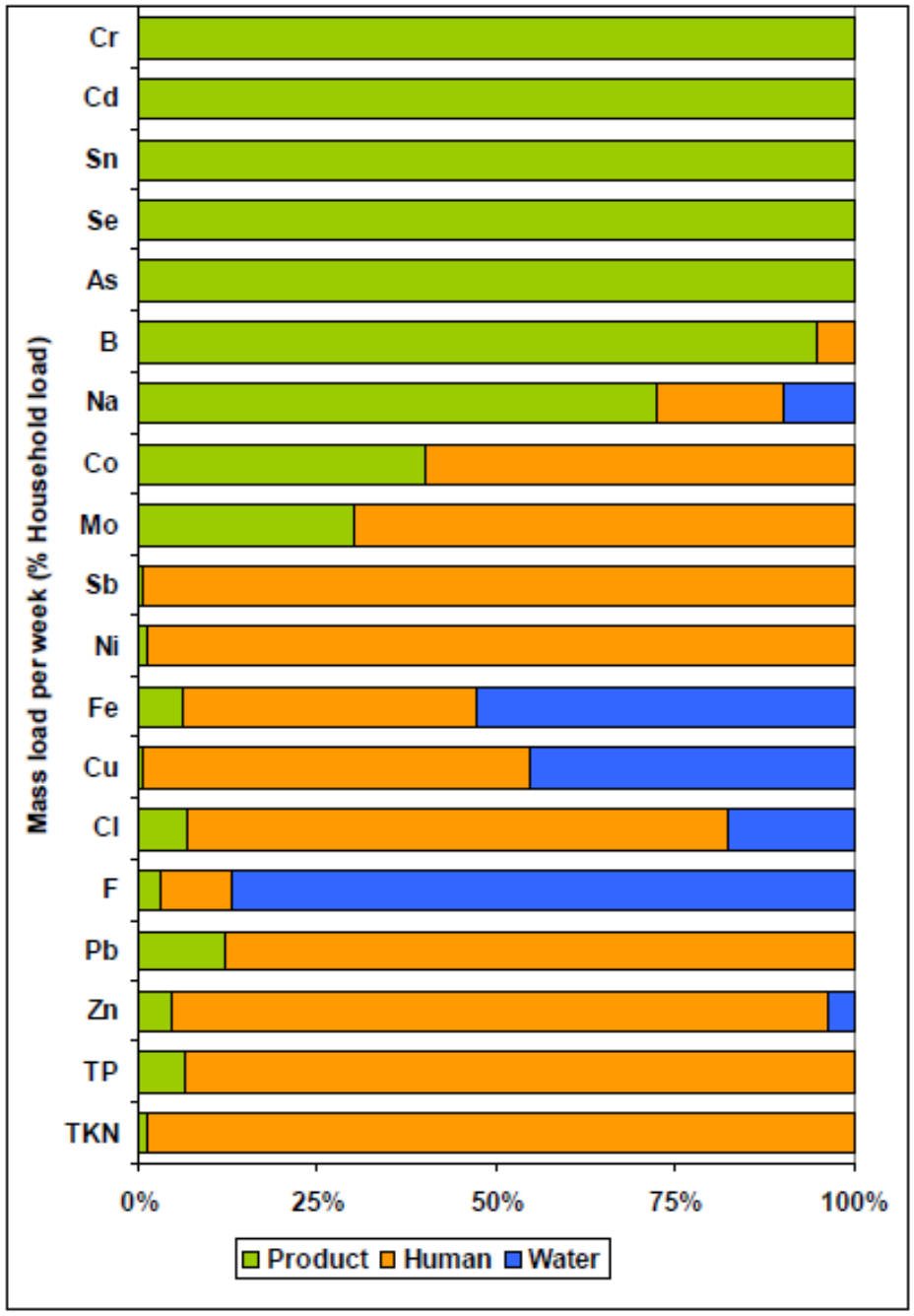
Effects of Greywater Recycling

cadmium:	faeces > bath water > laundry > tap water > kitchen
chromium:	laundry > kitchen > faeces > bath water > tap water
copper:	faeces > plumbing >tap water > laundry > kitchen
lead:	plumbing > bath water > tap water > laundry > faeces > kitchen
nickel:	faeces > bath water > laundry > tap water > kitchen
zinc:	faeces > plumbing > tap water > laundry > kitchen.

Cf. WRc 1994

Greywater recycling will have a variable effect on heavy metal discharge to sewer, depending on how aggressive the water supply is.

Contaminant Sources – Households (Smartfund)



Ref. G.Tjandraatmadja et al, CSIRO

Contaminant Sources – Households

Product type	Ag	As	Cd	Co	Cr	Cu	Hg	Ni	Pb	Se	Zn
Amalgam fillings and thermometers							√				
Cleaning products					√	√					
Cosmetics, shampoos			√			√	√	√	√	√	√
Disinfectants							√				
Fire extinguishers					√						
Fuels						√	√		√		√
Inks						√				√	
Lubricants					√				√		√
Medicines and Ointments		√		√		√	√				√
Health supplements				√	√	√				√	√
Food products		√		√		√			√		√
Oils and lubricants					√	√			√		√
Paints and pigments		√	√	√	√	√	√	√	√	√	√
Photographic (hobby)	√				√		√				
Polish	√					√					√
Pesticides and gardening products			√		√	√	√		√		
Washing powders			√						√		√
Wood-preservatives		√				√			√		
Other sources											
Faeces and Urine		√	√		√	√	√	√	√	√	√
Tap Water			√		√	√			√		√
Water treatment and heating systems			√			√		√	√		√

Ref. Lester 1987 and WRc 1994

Our Production Industries

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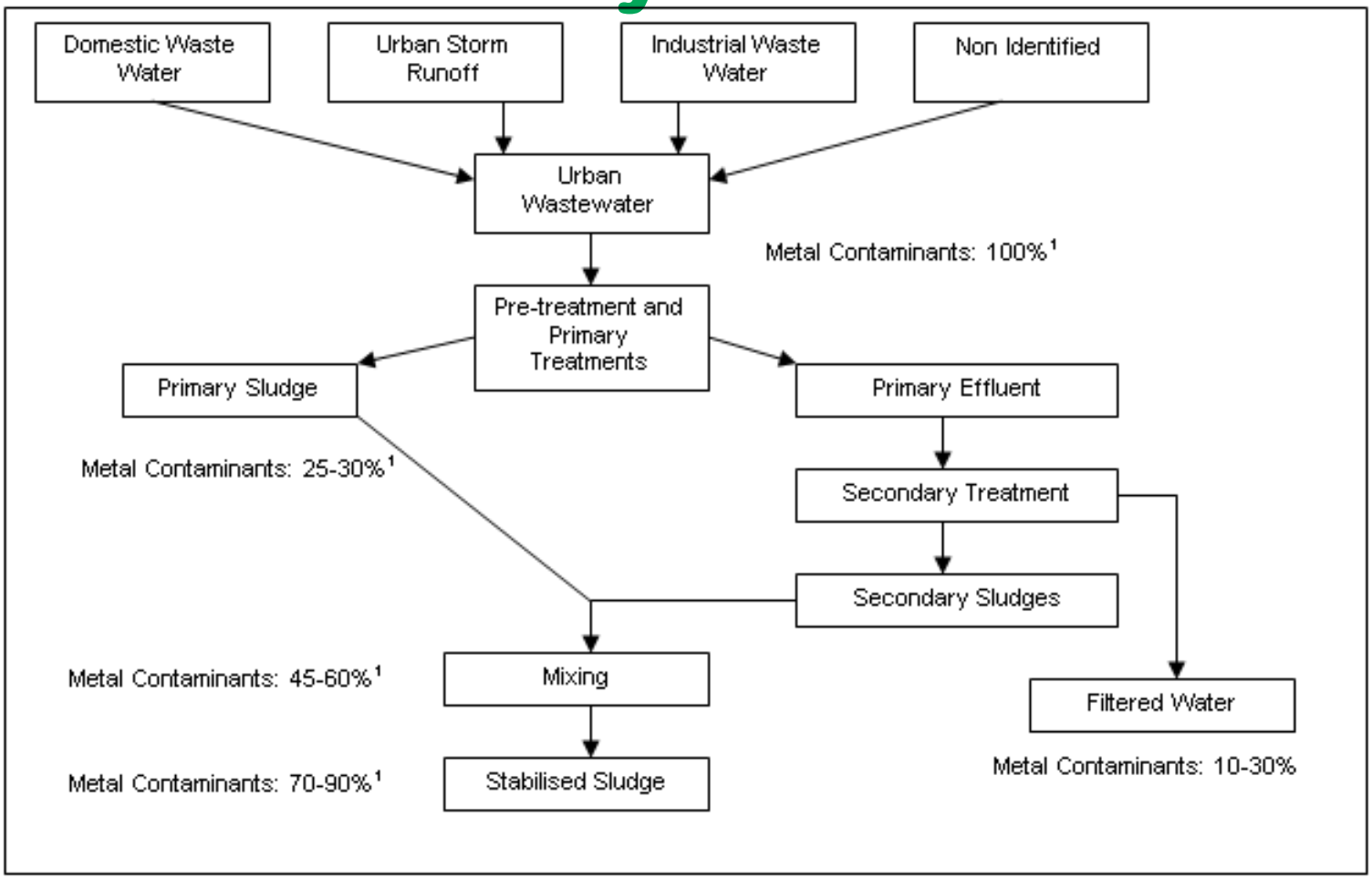
Heavy Metals



Percentage values relate to the proportion transferred during each phase of treatment e.g. this shows that 70 - 90% of the metals in the raw sewage end up in the stabilised sludge and 10 - 30% goes out in the effluent.

Heavy Metal Source Split

- Every catchment is different, and no mass balances actually balance, but ….
- Domestic inputs are the largest overall sources of Cu, Zn and Pb
- Non-domestic sources represent the major inputs of Hg and Cr
- Domestic and non-domestic discharges contribute comparable inputs of Cd to domestic sources

Examples of Contaminant Control

- Copper
- Mercury
- Motor Trades
- Textiles Processing
- Fat and Grease Controls
- Water Supply Changes

Copper (Cu)

- Cu piping dominates hot water systems. Metal finishing can result in chemical abrasion of the metal.
- Hard water (high pH) more aggressive to Cu and Zn. Can be reduced by pH adjustment
- Gardner WWTP study; corrosion control during water treatment and chemical addition at the water treatment plant would be necessary in order to comply with the NPDES permit.

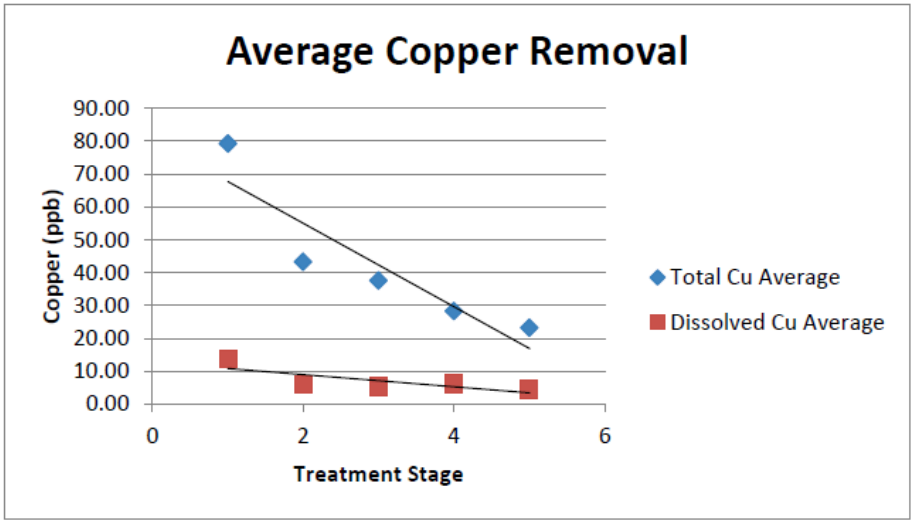
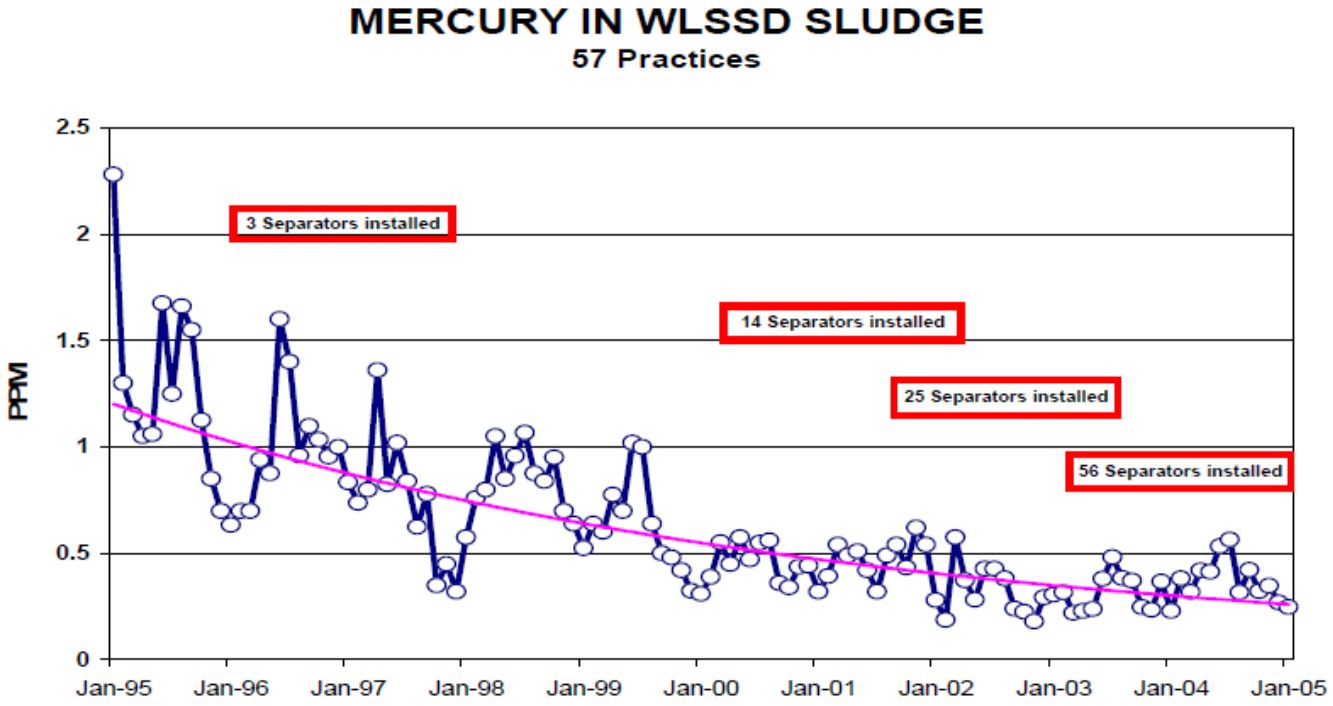


Figure 1: Average total & dissolved copper removal in the Gardner WWTF

Mercury

- Mercury; the 1st recognised workplace toxicant
  - Historical use as pigments, metallurgy, fungal control, dentistry, electrical conductance, marine antifouling paint, catalyst for manufacturing e.g polyurethane.
  - Sources; dentist amalgams, contaminants in chemicals (e.g. H_2SO_4)



Motor Trades

- Polluted wastes from:
  - Degreasing and washing of mechanical parts, vehicles
  - Washing of floors contaminated with hydrocarbons
  - Rub down and paint wastes
- Motor Industry:
  - Washing HGVs an important source of contaminants
  - Often fitted with combined oil separators and sludge traps
  - Swedish tests showed little benefit due to formation of emulsions
  - Italian car-repairers showed the careful segregation of spent baths induced a decrease of about one order of magnitude in the percentage of lead originating from car repair shops
- Typical Controls:
  - License discharge to sewer via oil/silt trap and pump to hazardous waste treatment facility
  - Isolate rainwater
  - Bund and screen spray areas
  - Operator mandatory training course and refresher

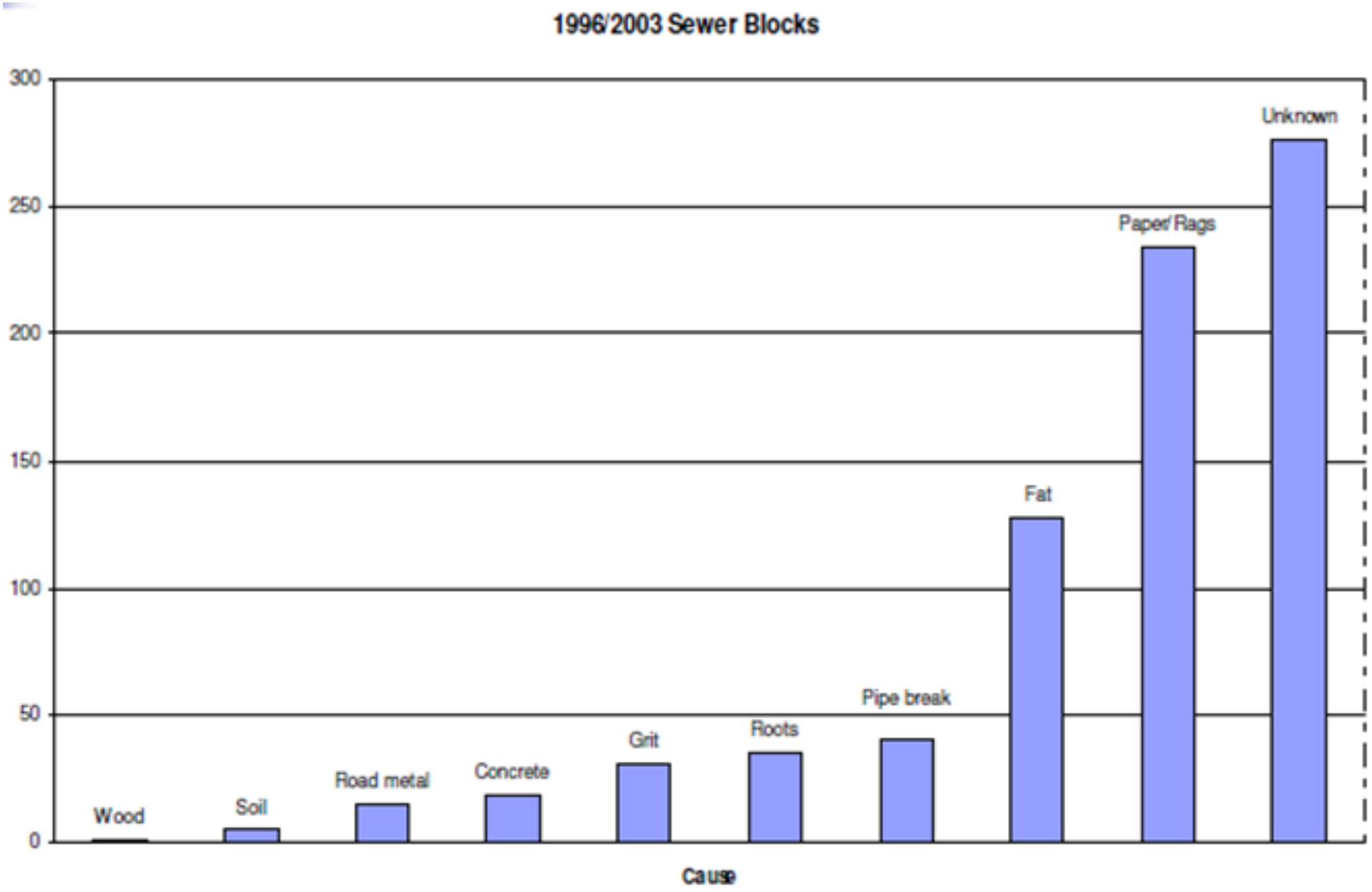
Textile Processing

- Toxic Elements Measured in Finland (Kalliala 2000)

	Wastewater analysis (µg l^{-1})	
	Company 2	Company 4
Lead	0.11	-
Chromium	0.03	60
Copper	0.4	80
Zinc	-	20

- High variations due to:
  - Cellulose Vs polyester and polyester blends Vs natural fibres
  - Types of dye used e.g. metal complex dyes Vs mordant (chrome) dyes Vs vegetable dyes etc

Fat and Grease



Fat and Grease

- Fast Food Joints:
  - Often pH 4.3 - 4.5
  - Should lift pH but often don't as due to VFAs – weak and don't dissociate readily, often well diluted in sewer
- Cooking fats and oils changing; variable heavy metals content and can be more water miscible
- Food Preparation Business e.g. restaurants, supermarkets:
  - Typically ≥ 60mins retention in approved trap
  - Clean out by full pump out method every 1-3 months
  - Collection and disposal docket(s) system registered
  - Used (spent) oil, grease and fat should be recycled and not discharged to sewer

Water Supply Proposals

Recommendations:

- Standards for tapware and home water filters should be included in the Building Code compliance documents
- All new buildings should be required to have only corrosion resistant plumbing components, including dezincification resistant taps
- The importance of choosing corrosion-resistant materials that comply with relevant standards should be communicated widely to suppliers, plumbers, and homeowners
- Older buildings should replace corrosion-prone plumbing components with corrosion resistant alternatives where possible/feasible.

Water Supply Proposals

Recommendations cont^{d}:

- Compulsory limits for key water chemistry parameters should be set, monitored for, and adhered to
- Monitoring and subsequent adjustment of the chemistry of reticulated water by suppliers should be promoted and supported
- Extended stagnation periods should be avoided and plumbing systems should be designed so flow rates do not exceed 1.2m/s
- Information resources on water chemistry guidelines and adjustment for people with un-registered water supplies should be developed and disseminated
- Standard tests to determine the corrosivity of water to plumbing systems should be developed with the water industry
- Long-term studies on innovative plumbing materials in realistic differential flow set-ups should be conducted to evaluate their impact on Cu and Zn leaching, and their suitability for plumbing systems as a whole

Pharmaceuticals

- Education and good advice – VERY IMPORTANT
  - Communities often told to flush expired medicines down the drain
  - Yet WWTPS are mainly biological and not designed to remove them
  - Need community 'take-back' programmes to collect and destroy
  - Recent women's magazine articles promoted environmental benefits of insinkerators and everything can go down
  - Immediate priority is to stop this and explain why.

- An example of US advice from poison centres and environmental agencies:
  - Destroy patient identifiers
  - Mix contents with something nontoxic and unpalatable such as sawdust, kitty litter, charcoal or powdered spices (like, cayenne pepper)
  - Encase in bottle or water tight plastic
  - Drop into garbage
  - Not fool-proof to children, pets etc who can access rubbish bins, landfills.

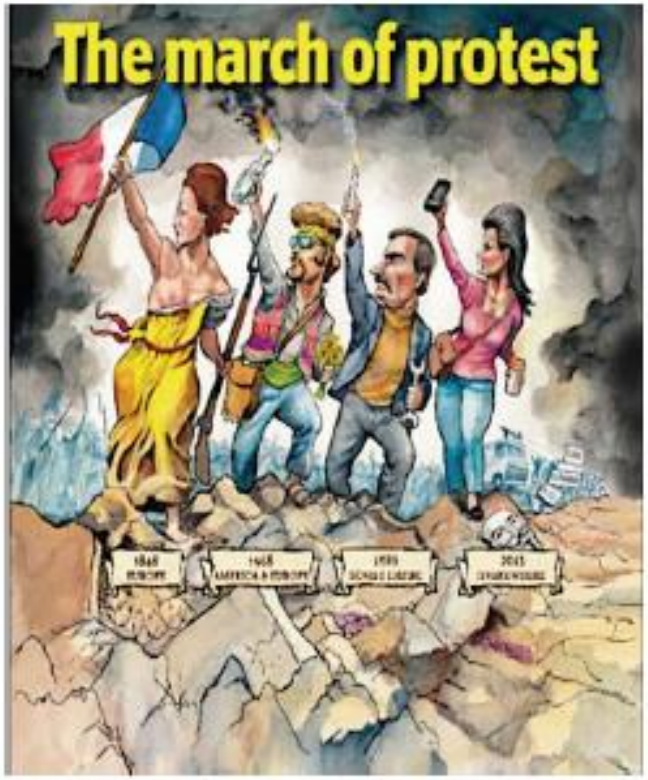
History of Controls on Discharge to Sewer

- Initially focused on industry discharges, excluding site stormwater
- Trade Waste Bylaws initially to limit effects of corrosion and odour in sewers and toxic effects on WWTP. Typically assumed minimum 10:1 dilution. Initially concentrations only
- Changed to mass controls and recognition of contaminated stormwater and effects on biosolids
- Current political trend assumes industries under control and less need for trade waste officer
- Little recognition that controls and education needed across an increased spectrum; industry, trades, commerce, domestic community
- Periodically this causes major WWTP upset but can't find out why and smaller utilities don't prioritise biosolids quality

What Should We Change?

A new world...

- ...a new democracy:
  - People-led...*not* politician-led
  - Locally-driven...*not* centrally controlled
  - Interactive...*not* authoritarian
  - Creative...*not* restrictive
  - Networked...*not* hierarchical
  - Learning...*not* stagnating



- **These shifts are fast changing consumer power with companies too**

Should We?

- Avoid ‘trade’ and say ‘non-domestic’?
- Decide that the trade waste officer is one of the most important folk in the team?
- Employ marketers and educationalists to simplify and deliver the message?
- Define future targets and work towards them rather than police todays requirements?
- Publicly recognise good practice and improvement within local dischargers?

Integrated Contaminant Controls

- Policy and economic controls
- Trade Waste Controls; industry, small manufacturing, service industries
- Stormwater control; I/I reduction and quality controls
- Bylaws/systems to reduce organic wastes to sewer e.g. no insinkerators, user friendly collections
- Policy re content and labelling
- Education programs:
  - Central government
  - Community level; schools, workplace, community groups
- Transparent and common KPIs e.g. Kgs contaminant/1000 dwellings/year
- Training and career paths; trade waste officers, system operators, asset managers. Too little understanding of how they work together
- Regular team meetings between different groups in a utility

They will work on their own but are better in combination!

Conclusions

- If we want to provide beneficial use of biosolids, business as usual (BAU) management is not enough
- We need to expand what we do and have a more integrated approach
- More specific training and career development
- More specific policy and community education
- More integrated management, particularly within smaller utilities
- Start public and common KPI reporting of levels of contaminants to sewer

Q & A Time

- Prove you are awake;
  - make a comment,
  - agree,
  - disagree,
  - ask a question.