Wealth Creation without Pollution

Designing for Industry, Ecobusiness Parks & Industrial Estates

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Content

- What can we learn from history?
- Effluents, accidents and incidents
- Diffuse pollution & industry
- Minimising adverse impacts
- How to shape our future for business & environment?
- Conclusions
- References

WHAT CAN WE LEARN FROM HISTORY?

Why sharing experiences is essential

- There is *a real risk*, especially as the world is entering a dangerous period of trade wars and 'me first' nationalistic politics, that the *lowest level of environmental protection will become the business standard*.

- Many business leaders have *no peronal experience or insight into environmental issues* and how they are associated with **business inefficiency**

The classic pollution horror stories

Example	Problem	Pollutants	Cost to business
Bhopal, India *Union Carbide*	Leak & explosion >3,800 deaths	pesticides	$470M
Hinkley, California *Pacific Gas & Electric Co.*	Storing toxic liquid in **unsealed tank** for years over groundwater supply of local people	Chromium chronic exposure in water supply	>$333M [the Erin Brokovich story, but US Geolog. Verification & ref.]
Minamata & Niigata, Japan *Chisso Corporation*	Effluent discharge over decades 100s of deaths, congenital impacts	Methyl mercury bioaccumulation in food chain	$86M in compensation by 2004
Sweizerhalle, Switzerland *Sandoz*	Fire at pesticides factory R Rhine polluted through 4 countries	Mercury & other chemicals	Led to EU legislation.
Tianjin, China *Ruihai Logistics*	Fire & explosion at factory 173 deaths, Fish mortalities	Cyanide, [40 different hazardous substances]	$360,669 paid to families of firefighters killed (95 deaths)

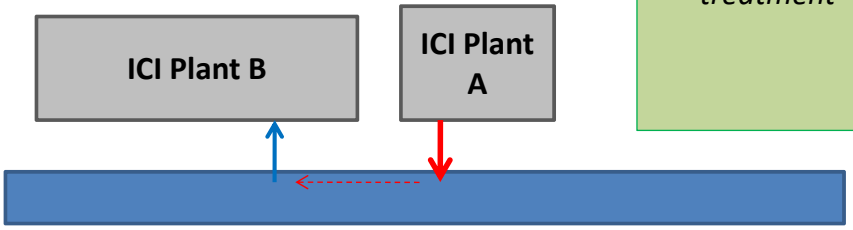
Pollution = is bad business practice

ICI: lesson in poor business practices

- "We don't need to bund" [ICI 1970s]
- The largest chemicals company in Britain & one of the worst polluters
- Effluent from one plant was **often pH 1-12** !
- One of their discharges (A) corroded and destroyed the water intake for another of their plants (B) downstream on the same canal
- **ICI eventually collapsed** in economic failure

Effluent treatment now = **resource recovery**

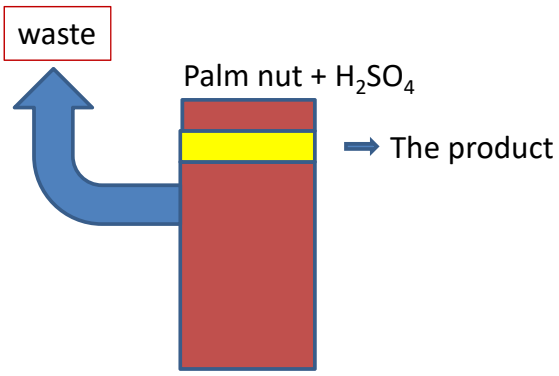
- Distillers in UK: solids from process → *animal feed*; soluble organic effluent→*biofuel*; main product = whisky & other spirits
- Potato logistics company, UK: *off-spec. potato* → *ethanol* for distribution fleet, solids →*animal feed*
- In Thailand *6 companies* on *one eco-business park* making products similarly to above based on sugar cane crop
- *Waste minimisation and resource recovery is replacing effluent treatment*



Canal: effluent from A tracked along edge to intake of B

Shocking waste of resources, loss of resource for others, & public incurs costs for restoration

- Peerless Refinery, Bootle, Liverpool (1970s-80s) UK
- ***Single product manufacture*** from oil nuts
- The oil fraction required was extracted in a process using H_2SO_4
- **All** non-product material dumped to public sewer, which collapsed (dissolved concrete, into **local stream → pH1**)
- Company has gone (***uneconomic***)



Environment & business culture

European

- Rhine incident, Switzerland,
- A major fire in a pesticide store, polluted the River Rhine through France/Germany and Netherlands.
- Company sent a Director to Britain for example for a seminar with representatives of Fire Services and UK Environment agencies to share and LEARN FROM THE EXPERIENCE

USA

- **Denial**
- Multi-million dollar legal costs
- Multi-million dollar compensation payments after years of adverse impacts
- Examples: Hinkley, Bhopal
- Litigation culture is expensive and counter to learning from experience of avoidable problems

3 Types of Industry Impacts on the Water Environment

1. **Process effluents**
2. **Accidents & incidents** (can happen on a class A river as they can on a polluted one)
3. **Diffuse pollution** – 2 impacts of industrial activity:

   (a) contamination at centres of production (on the premises, around industrial estates)

   (b) contamination by products in use (widespread, even global, e.g. plastic, PCBs, DDT, anti-fouling paints, etc).

PROCESS EFFLUENTS, ACCIDENTS & INCIDENTS

PROCESS EFFLUENTS

Calculating cost of effluent **treatment**…

e.g. BOD removal **$X/kg .** [**BOD kg load**] → **cost** of treatment
= Waste of resources!

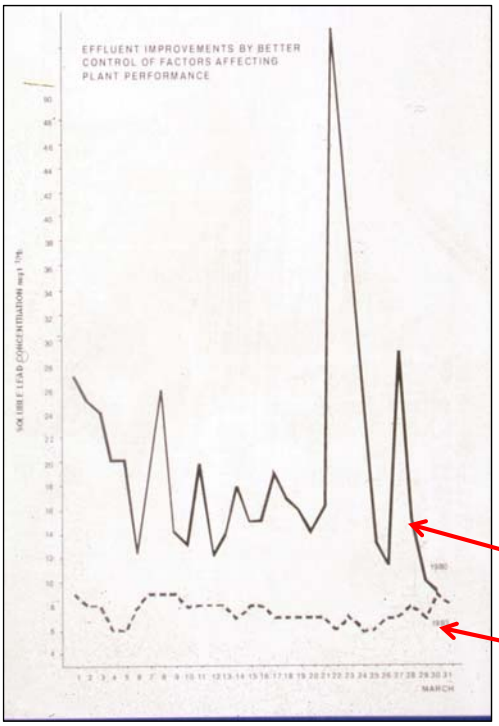
Distilleries in Scotland in 1980s were mono-product focused - disposed of everything else to rivers.

- **Now** highly profitable exemplars of sustainable industry
- by-products → animal feed, bio-energy,
- Supply-chain impacts too
- Eco-industry and waste minimisation have changed the approach to waste and resources

Refs.: D'Arcy et al 2018, Kim and Maniquiz-Redillas 2018, in D'Arcy, Kim and Maniquiz-Redillas (eds.) (2018) *Wealth Creation without Pollution – Designing for Industry, Ecobusiness Parks and Industrial Estates*.

Effluent & pollution prevention

Pb Conc^{n}.



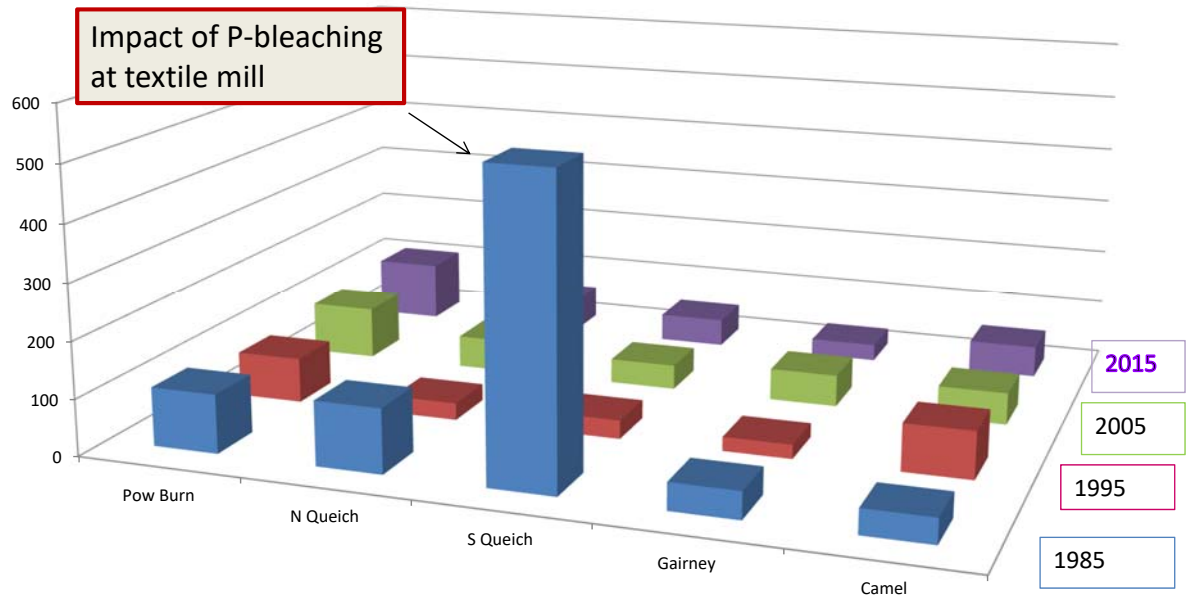
Company analysed process activities
Identified *cause of each peak concentration*:
•Leaking valve on product tank
•Cracked reactor vessel
•Leaking transfer pump
•damaged containment walls
Net result after corrective actions was elimination of peaks
AND reduced baseline concentration to within discharge limit

1980 effluent samples

1983 effluent samples

Source: D'Arcy BJ, Todd RB and Wither AW (1999) Industrial effluent control and waste minimisation : case studies by UK regulators. *Water Science & Technology*, 39 (10), 281-287

Average total phosphorus (TP) concentrations in the main inflows, 1985-2015*



*CEH data, from the four 10-yearly intensive P surveys of inputs to Loch Leven (Linda May 2018) [NB **concentrations here**, *not loads*]

The textile mill, Kinross: effluent to trib. stream

2018


Cashmere products, 2018


The mill & Loch Leven, 2018

Pollution control at the textile mill, Kinross

Phosporus (best practice* standard)

- **The largest** input of P (**1985)**
- Discharge in breach of consent limit; FRPB enforcement action taken (1987).
- **Consent reviewed**; P limit lowered from **10mg/L to 2mg/L**,
- **Process changes** made, prohibiting P in processes on site

*EU Workshop on P control, Perugia, Italy

Excellent record since 1987.

Toxic chemicals (EQS approach)

The **Consent review** also set limits on concentration of **moth-proofing chemicals** – in effect precluding use at the mill.

- *Company saved money, environment improved.*

Further improvements since then:

- biodegradable dyes (no toxic metals)
- ban on toxic agents (previously) used in China on raw wool

The mill has increased it's market share and is still the biggest employer in Kinross (August 2018)

Refs. D'Arcy (1991); Almeida, K (2018)

The basis of UK oil storage regulations

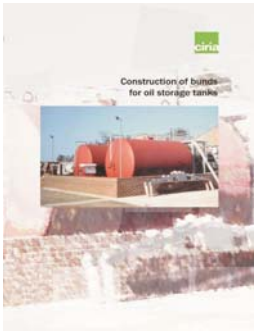
5 year dataset, 1986-1980, records of incidents by source

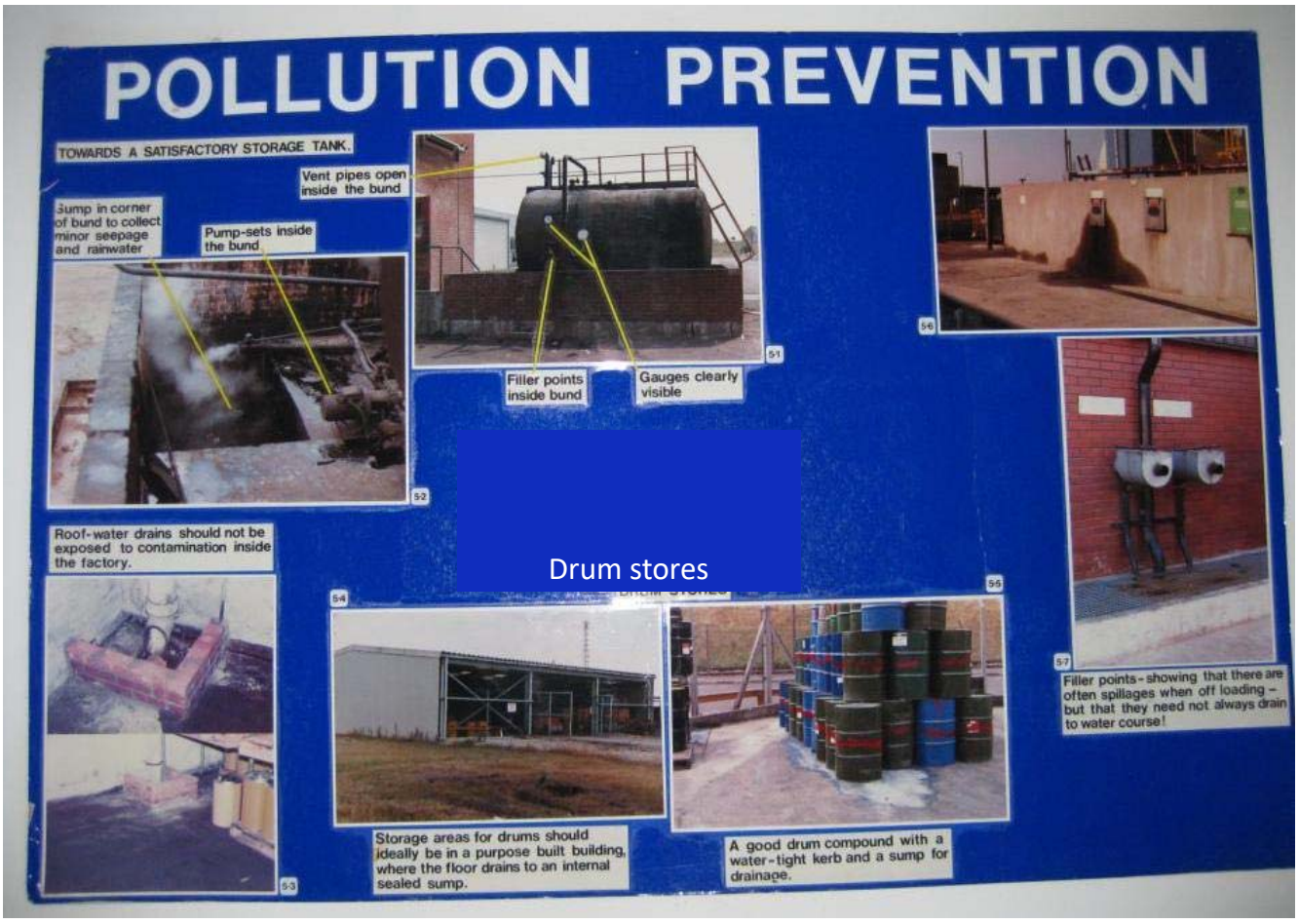
Source of reported oil pollution	% of all reported incidents	Comments
Storage installations	53%	Failed & over-filled tanks, pump-sets, fill-points, open valves
Factory pipelines	25%	e.g. filter valves left off when pumping resumed
Total containable in a bund	**78%**	*If filter on feed-line is located within the bund*
Boiler-house, factory unit	4%	Corrosion, contact & breakage, feed-line filters
Oil Drums	4%	Full and 'empty'
Road traffic accidents onsite	4%	Leaking vehicle tanks or loads
Other incidents	13%	Miscellaneous causes

Source: Allcock et al 1991, quoted in D'Arcy and Taylor 2018

Housekeeping measures

Good guidance readily available
But pollution risks still often discovered…





1984 poster

DIFFUSE POLLUTION

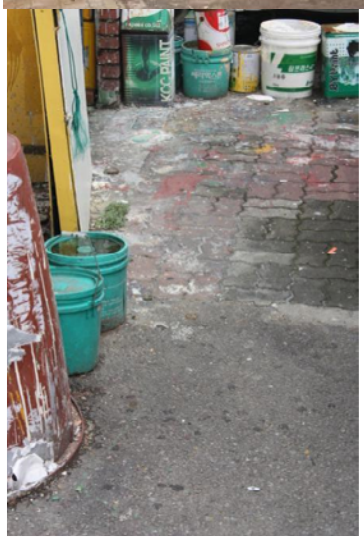
Diffuse pollution

Definition:

"diffuse pollution is landscape or atmospheric contamination transported into the water environment by weather conditions"

D'Arcy *et al* (2017), IWA Watershed & River Basin Management conference, Kruger National Park, S Africa

DIFFUSE POLLUTION ON THE PREMISES



Extensive areas of contamination preclude simple containment
SUDS needed

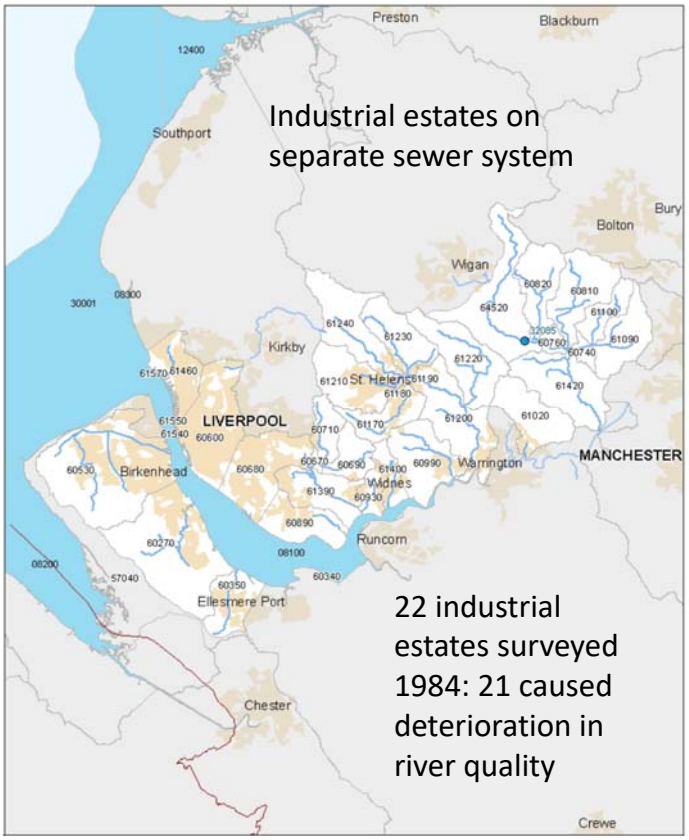
RIVER MERSEY ESTUARY

Pollution Problems 1970s

- Untreated sewage
- Industrial effluents
- Industrial estates (*contaminated surface drainage*)

Pollution Problems 2000s

- Industrial estates (*contaminated surface drainage*)
- Diffuse pollution



Types of pollutants identified in surveys of industrial estates in England & Scotland

Industry	Typical contaminants of surface runoff	Comments
Haulage fleets (a feature of several different industries)	Detergents, oil, PAHs, toxic metals	Contamination by deposition and wear exacerbated by *ad hoc* steam cleaning
Metal finishing	Toxic metals, cutting oil, lub. oil	Toxicity, high BOD
Packaging	Sediment, COD	Waste materials & vehicle fleets are main contamination sources
Food industries	BOD, COD, H/Cs, sediment	Spills: grain, sugar, beer, etc
Retail outlets/commercial	Sediment, H/Cs & metals	Car parks, vehicle unloading areas
Steam cleaning plant components in yard (many industries)	Detergents & oil, SS, BOD	Strictly= a trade effluent & needs a licence, but often *ad hoc*.
All, especially construction	Soil & suspended solids	everywhere

Example ecological impacts, Scotland

Dechmont Burn below (d/s) Deans Industrial estate	BMWP 14 ASPT 3.5	Brox Burn u/s Dechmont confluence BMWP 80 ASPT 6.3
Dedridge Burn d/s Brucefield Industrial estate,	BMWP 45 – 84 ASPT 5.00 – 5.25	Investigational samples
Red Burn d/s Cumbernauld (mean 2003-2010)	D/s industrial estates & u/s Dunnswood STW: BMWP 25-50 ASPT 4.42	> 20 years of intensive clean up efforts
Caw Burn d/s Houston Industrial estate	Spring 2010: BMWP 20 ASPT 2.86 Autumn 2010: BMWP 50 ASPT 3.85	Twice yearly samples. Best quality after summer low flow period

DIFFUSE POLLUTION AT POINT OF USE

- Impacts widespread
- Can be catchment and global scale

  e.g. Anti-fouling paints (TBT, organo-copper)

  e.g. Plastic, pesticides, toxic metals
- Bioaccumulation
- E.g. PCBs, micro- and nano plastic particles

MINIMISING DIFFUSE SOURCE IMPACTS

Minimising Impacts from diffuse sources

- Capture the pollutants
- Optimise capture features for in-situ degradation
- Product substitution (metals, plastic…)
- Contingency planning (design & operations)
- Synergies & multi-purpose features
- Partnerships, regulatory regimes & enforcement

Two super-classes of diffuse pollutants

Natural contaminants

- Soil /Sediment
- Nutrients (NPK, traces of Cu, etc)
- Natural organic matter
- PAHs derived from natural fires
- Cyanobacteria
- Faecal pathogens

Man-made materials

- Pesticides
- PCBs
- Fire-retardants
- Solvents
- Plastic
- Micro-plastic
- Nano-particles Including heavy metals, PAHs
- Toxic forms of metals in many materials
- Imposex substances (hormone surrogates)
- And many more…

Even if complete change away from anthropogenic persistent substances, SUDS/LID still needed

Problem pollutants in problem quantities

Persistent pollutants
Prevent losses
Reduce use
Re-use
Recycle
Recover

Product replacement*
e.g. Pb in petrol
Pb in wheel balancing weights
Cu in brake pads
Cl-H/C pesticides
TBT anti-fouling paints
Plastic…

For foreseeable future:
Runoff contamination will continue
Capture in drainage [LID] features

TAKES YEARS & SIGNIFICANT DAMAGE
Pre-requisite for action = widespread use
EVIDENCE of adverse impact needed
Then more evidence, in more places
Development of alternative chemicals

*Ellis & D'Arcy (2018) Product substitution – addressing the challenge of hazardous priority pollutants. In *Wealth Creation without Pollution*, IWAP, London.

How to achieve a multi-functional landscape for water management?

- The landscape is an important part of the land-use management challenge.
- Landscape determines pathways for pollution and pathways for flooding.
- Landscape also determines *public acceptability* of development proposals

Above: Raingarden in Cardiff, UK, 2018 – already discarded plastic & other litter

Left: grass is above the level of the road; built on assumption runoff -> road gully

Treatment trains & Constructed Wetlands for industrial estates (e.g. Lockerbie, Scotland)

- **Treatment trains**: grass swales -> sedimentation basin -> wetland
- **Contingency planning**: e.g. catch spills before

HOW TO SHAPE THE FUTURE?

Water wise cities & businesses: aspirations

'Water as a risk' issues

Flood risk
Lack of enough water
Diffuse pollution
Inability to insure property
Inability to sell property
Development /redevelopment constraints

'Water as an asset, a resource'

Rainwater harvesting
Groundwater recharge
Pre-treatment prior to water treatment plant & potable supply
Other ecosystem services

Passive stormwater management [LID]

Control of diffuse pollution
Management of flood risks
Natural flood management u/s
Creation of amenity habitats
Resilience planning
Resource capture & protection

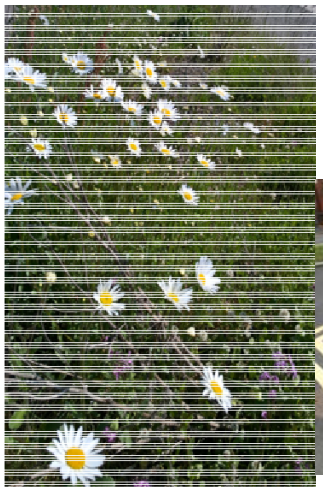
Water as part of place-making:

Amenity habitats & well-being
Informal recreation
Angling/fisheries
Property values
Freedom from drainage constraints -> redevelopment, improvements

20+ years of innovative thinking

- Novotny *et al* & Cities of the Future
- Blue-grey cities
- Sponge cities
- Water wise cities

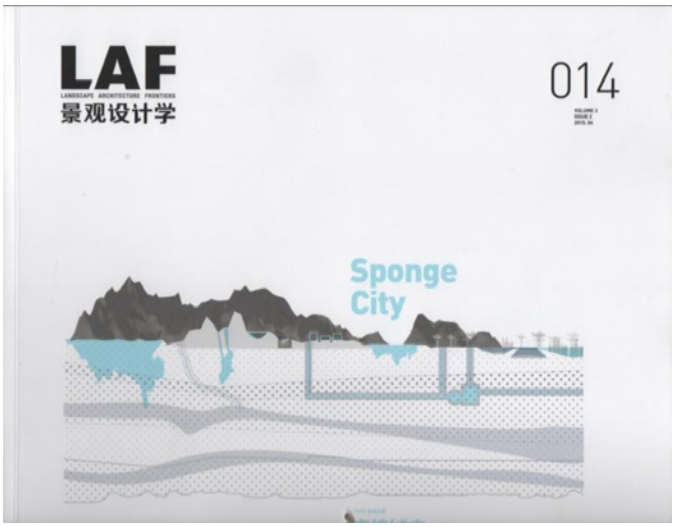
KEY IDEA = integration & multiple benefits



The sponge city

- Prof. Kongjian YU* says
- "The concept of Sponge City is… approaching water and other environmental issues at ***different scales***, including stormwater management, *flood control*, *water purification*, *supplementing groundwater*, *restoration of brownfields* and *urban habitats*, *improvement of green spaces* and *urban micro-climates*"

- *Yu K (2015) *LAF*, 014, vol.3, issue 2, 2015.04, Editorial.



The sponge city: made in China, but now being used all over the world…

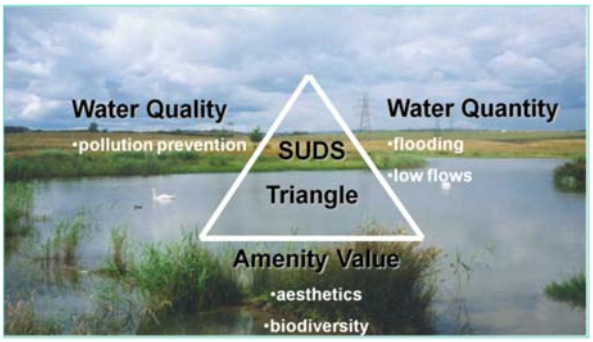
The sponge as a bioreactor too?

- Not enough to just capture diffuse pollutants in landscape features
- What happens to them there?
- Intermittently dry landscape features favour biodegradation in soil*.
- **Design the landscape features for optimal removal therein by *uv light* and in *aerobic soils**.**

*Napier *et al* (2009) Evidence of traffic-related pollutant control in soil-based Sustainable Urban Drainage Systems (SUDS) *Water Science & Technology* 60 (1) pp 221–230

Top: detention basin, Dunfermline.
Above: *Fiona* Napier field and lab. investigation of fate of pollutants in SUDS

Low Impact Development, LID

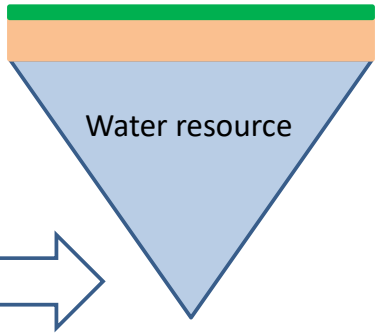


1998 sustainable drainage triangle sought to encourage multiple benefits features, integrated within landscape planning.

Now **an even broader mindset is needed**, as scale and severity of problems has increased

Problems increasing faster than solutions…

Land surface: the filter between pollutants and the water resource



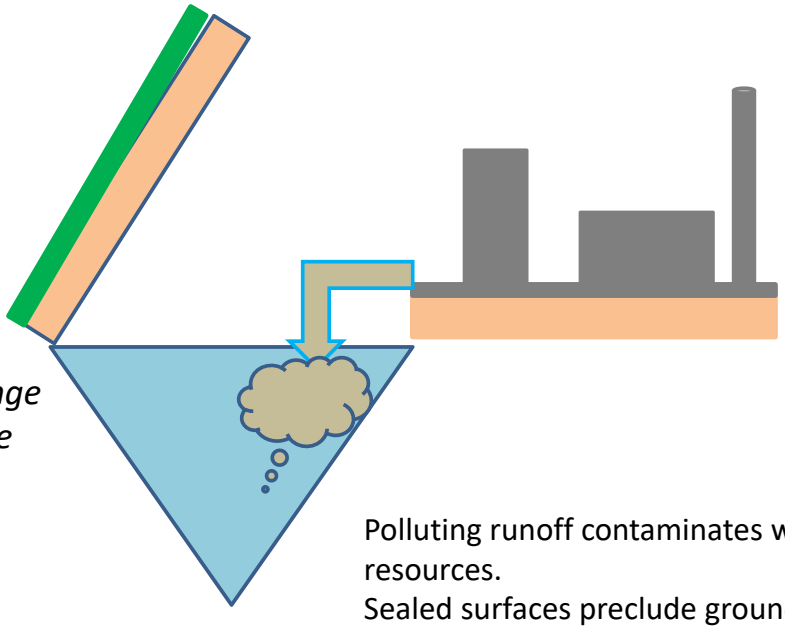
Landscape design for low impact is vital

Lifting the Lid on LID…

Requirements of **landscape**:

Built-in filtration
Built-in pollutant capture
Built-in flow attenuation

This is the challenge for developing the LID concept



Polluting runoff contaminates water resources.
Sealed surfaces preclude groundwater recharge
Intensive rainstorms - > flooding

Green infrastructure to address diffuse pollution& manage stormwater

Needs to be on a city & catchment scale:

1. Passive systems
2. Capture contaminants
3. Degrade degradable ones within the infrastructure
4. Pollution management strategies require at source and successive physical measures (treatment trains)

- **The technology and planning policies which produced the problem will not supply the answers…**
- ~~"Build as usual" then add a raingarden or a pond…~~

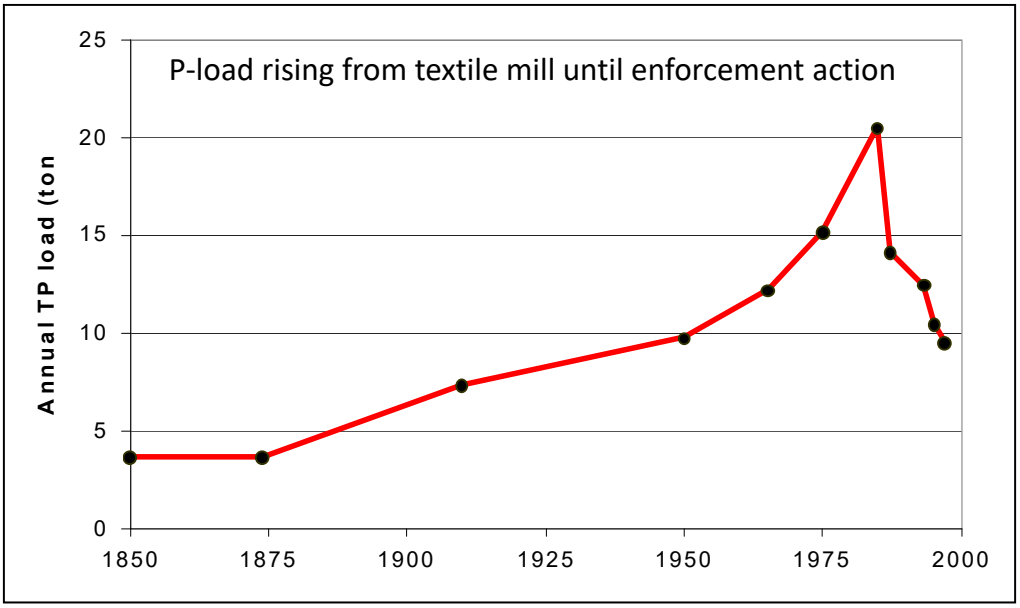
Accidents & fires

- Major accidents AND flooding risks:

  the risk of such incidents might be 1:30 or 1:50 years.

  But not simultaneously!
- Detention facilities should be designed as contingency features for major incidents
- the receiving point for contaminated fire-water (for safe disposal off-site as appropriate).

When it's got really bad…enforcement



Enforcement is simple, inexpensive and saves all parties money eventually and maintains essential water resources for all.

How to persuade people that a radical, approach is needed?

An international consensus supported by Strong, clear **evidence** of the problems is a pre-requisite for action

The application of structural BMPs/SUDS/LID needs to be **routine** for land-uses, as basic multi-purpose **landscape features**

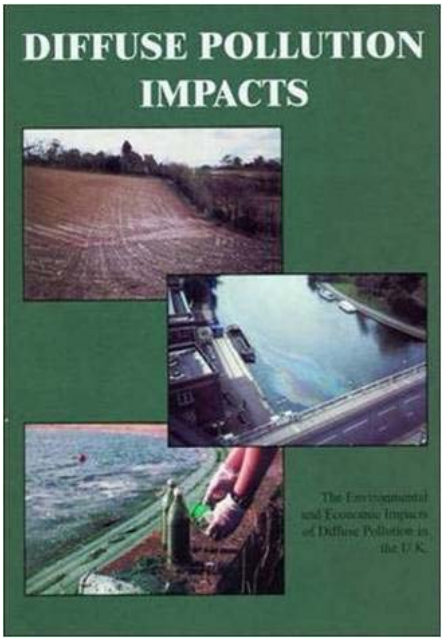
- *C.f.:*

[In the UK, the CIWEM report* on *Diffuse Pollution Impacts* **set up a decade of action** from 2000:

Implementation of measures

Monitoring & research

Policy & regulation]



*D'Arcy *et al* (2000). *Diffuse Pollution Impacts: The Environmental and Economic Impacts of Diffuse Pollution*. Chartered Institution of Water and Environmental Management, London

IWA Land-Use & Water Quality Task Group

- **Primary aim** greater interest in diffuse pollution globally, at a sufficiently high level to influence policies & actions by governments, environment agencies, and others.
- The group believes that will require publication of a high impact report [2020]

- Target readership needs: EVIDENCE
- Currently seeking sponsors to allow a contract to be let
- Contact: Dr BJ D'Arcy
- B.darcy@btinternet.com

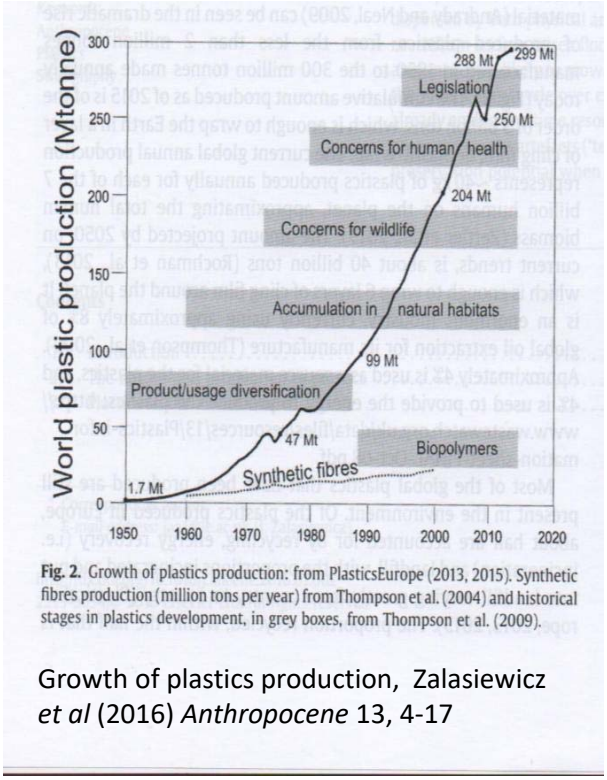


Fig. 2. Growth of plastics production: from PlasticsEurope (2013, 2015). Synthetic fibres production (million tons per year) from Thompson et al. (2004) and historical stages in plastics development, in grey boxes, from Thompson et al. (2009).

Growth of plastics production, Zalasiewicz *et al* (2016) *Anthropocene* 13, 4-17

Recommendations

- **Teaching** next generation of industrial chemists and engineers about the problems & risks – role for universities in mainstream higher education
- Holistic research? New products & environmental implications co-researched?
- Development of new, safe & sustainable products
- **Ecobusiness parks** – must be about water and environmental pollution risks too, not just nice architecture with a few trees and energy efficient walls or a green roof or recycled bits here and there… water environment often missing from eco-architect's agenda.
- **Market development** for cleaner environment (SUDS as routine)
- LID for new industrial, commercial and other land-use developments: ROUTINE techniques for all developments
- Research projects to look at benefits, barriers and feasibility for new and retrofit situations
- Make **Monitoring for performance evaluation & improvement**, **long term** as well as short-term, a research priority
- Review papers plus topical research on urban diffuse pollution impacts needed (e.g. for Novatech 2019, and DIPCON, Korea 2019)

Recommendations (2)

- Greater effort needs to be made to explain and note the significance of diffuse pollution events
- International efforts to provide and publish evidence of diffuse pollution impacts (2020) should help raise interest in the radical attenuation (pollutants and flows) role envisaged here for ***a developed and expanded LID role***.

- High impact case study review papers (land use & water quality) are needed in 2018-19:
  - High level state of the water environment - **national summary papers**
  - **Ecological impacts** case studies
  - **Resource impairment, economic impacts** case studies and examples
  - Impacts on **Water utilities**

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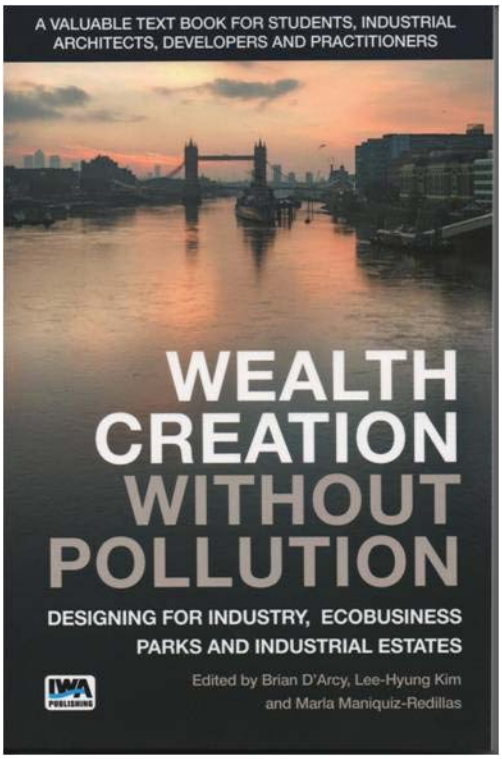
A Life's Work…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