DEVELOPING TEACHING MATERIAL IN ETHICS FOR CHEMISTRY AND CHEMISTRY ENGINEERING STUDENTS

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Background

HYLE
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- Problem:
  - Lack of teaching material in ethics of chemistry
  - Narrow understanding of Ethics of chemistry = misconduct
- Solution:
  - Publish a special issue of a scientific journal
  - Aim: to publish a textbook to be used for university teaching.
  - Try it at a PhD course, summer 2019.

Ethics an intrinsic part of chemistry?

- Chemistry help solve global problems
- Solutions are never simple
- Conflicts of values and interests -> Ethics

- RRI and CSR agendas require ethics.

ETHICAL CASES STUDIES OF CHEMISTRY

edited by Tom Børsen & Joachim Schummer

OVERVIEW: http://www.hyle.org/journal/issues/special/ethical-cases.html
PART I: http://www.hyle.org/journal/issues/22-1/index.html
PART II: http://www.hyle.org/journal/issues/23-1/index.html

Introductory Material

- Call for Papers [PDF]
- Editorial 1 [PDF] by Tom Børsen & Joachim Schummer
- Editorial 2 [PDF] by Tom Børsen & Joachim Schummer

1. Intentional Misuse and Misconduct

1.1 Scientific Misconduct

- "The Case of the Finicky Reactions: A Case Study of Trust, Accountability, and Misconduct" [PDF] by Janet D. Stemwedel (Sa University, USA)

1.2 Weapons Research

- "Ethical Responsibilities in Military-Related Work: The Case of Napalm" [PDF] by Stephen M. Contakes and Taylor Jashinsky (USA)
- "Ethics of Chemical Weapons Research: Poison Gas in WW I" (forthcoming), by Joachim Schummer

1.3 Addictive Drugs Production

- Methamphetamine ("Crystal Meth") in WWII (in preparation)

2. Unforeseen Local Consequences

2.1 Industrial Desasters

- "Corporate and Governmental Responsibilities for Preventing Chemical Disasters: Lessons from Bhopal" (forthcomin
  (Stockholm, Sweden) & Tom Børsen (Aalborg University, Copenhagen, Denmark)

2.2 Adverse Effects of Pharmaceuticals

- "About the Futile Dream of an Entirely Riskless and Fully Effective Remedy: Thalidomide" [PDF] by Klaus Ruthenber
  Sciences, Germany)

2.3 Chemical Waste Deposal

- "When Laypeople are Right and Experts are Wrong: Lessons from Love Canal" [PDF] by Ragnar Fjelland (University

3. Global and Long-Term Influences and Challenges

3.1 Global Environmental Pollution

- X • "Applying Utilitarianism and Deontology in Managing Bisphenol-A Risks in the United States" [PDF] by Abi
  Rosen (University of California at Berkeley, USA)
- X • "Applying an Ethical Judgment Model to the case of DDT" [PDF] by Tom Børsen & Søren Nors Nielsen (Aa

3.2 Green Chemistry

- X • "Undoing Chemical Industry Lock-ins: Polyvinyl Chloride and Green Chemistry" [PDF] by Alastair Iles, Abig
  (UC Berkeley, USA)
- X • "Chemists' Responsibility for the Health Impacts of Chemicals: Green Chemistry and its Relation to Toxicol
  Paris, France)

3.3 Chemical Climate Prediction and Engineering

- "Ethics of Climate Engineering" (forthcoming) by Dane Scott (University of Montana, USA)
- Predicting the Ozone Hole: A Model Case of Scientific Responsibility (in preparation)

3.4 Intergenerational Justice (Sustainability/Recycling)

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3.5 Global Justice (Impact on Developing Countries)

- "Responsibilities in the Global Trade of Hazardous Chemicals" (in preparation)

4. Challenging Human Culture

4.1 Human Enhancement

- "The Ethical Judgment: Chemical Psychotropics" [PDF] by Klavs Birkholm (Tænketanken TechnoEthics, [

4.2 Creating Artificial Life

- "'Are You Playing God?': Synthetic Biology and the Chemical Ambition to Create Artificial Life" [PDF] by J

4.3 Intellectual Property Rights (Patenting DNA)

- Ethical and Legal Issues of Patenting DNA

4.4 Natural versus Chemical

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5. Codes and Regulations

5.1 Codes of Conduct

- "The American Chemical Society's Code of Conduct" (forthcoming) by Jeffrey Kovac (University of Tennes

5.2 Chemical Regulation

X • "Ethics and Chemical Regulation: The Case of REACH" [PDF] by Jean-Pierre Llored (University of Paris

DDT - Conclusion

- We recommend that the use of DDT must be heavily regulated to prevent overuse. The Stockholm Convention provides an ethically sound legal framework for the regulation of DDT.
- We do not identify persuasive ethical arguments for the use of DDT in agriculture as alternatives exist both in the form of target-specific pesticides and by means of holistic agricultural approaches. We suggest that it becomes more widely accepted to choose holistic alternatives, and that barriers for making this choice are lowered.
- We find that a modest use of DDT in the fight against malaria is ethically justified until better alternatives are available.
- It is suggested that early warning mechanisms are set up to spot unforeseen effects of the alternatives developed to replace DDT in both agriculture and in the domain of public health.
- An ethical dilemma is identified between the benefits provided by a modest use of DDT in combatting malaria and the effect on nature's integrity and the potential negative consequences related to the moderate use of DDT. The authors encourage students of chemistry and chemical engineering to discuss how to transcend that dilemma.

A Method for Proper and Quick Ethical Analysis

Table 2. Ethical issues and their adjacent short and long term effects

Ethical Issues	**Short term effects**	**Long term effects**
Elimination of pests in order to ensure and increase outcome of production in crops	Successful elimination of pest, Additional elimination and impact on non-target organisms, Acute toxic effects likely to be low in humans but not in nature	Accumulation in soils, Effect at non-targets of the whole ecosystem through bio-concentration and bio-magnification
Prevention of illness: removal of insect-borne vectors in malaria, typhoid control	General improvement of life conditions, Elimination of diseases	Induction of *e.g.* endocrine disruption, Re-appearance of disease vectors
Misuse/overuse	Non-exploited doses build up and left in crops and soils	Resistance of organism leading to no effect of use
Bio-concentration and magnification	Uptakes in tissues affecting farmers and local populations, Uptake in local as well as migrating animals, Binding in food and other organic pools	Residues found everywhere far from use even in pristine sub-arctic and arctic areas, Ever increasing concentration and accumulation until saturation or threshold levels are reached
Mono-cultural food production	Monoculture can produce more food in the shorter term, Gives less diversity in food, leading to nutritional bias and impact on health A more vulnerable economical system Farmers in the developing world are put in debt	Lessened biodiversity, less resilience and buffer capacity, Potential eradication of endangered (red-listed) and protected species, Local agricultural knowledge disappears, Induction of poverty through instable economics

DDT - values

Table 3. Main ethical issues of the use of DDT are linked to ethical values.

Issue	Linkage to ethical values
To increase food production by protection of crops against pests	In compliance with utility, food safety, justice – if the food is distributed fairly; In a long-term perspective, it violates social stability and stewardship of the earth
To prevent disease – by killing vectors	In compliance with utility, health safety, justice
Over- and misuse of DDT	Violation of humility, precaution
Bio-concentration and bio-magnification	Violation of stewardship for the earth, respect for nature, safety and security
Agriculture based on monocul-tures	Violation of autonomy, social stability, respect for nature

Poly-vinyl chloride PVC

- Conclusion – Green chemistry can create solutions to tackle PVC’s negative impacts or replace PVC altogether

Green Chemistry

- Designing molecules, reactions and products that are non-toxic and sustainable
- Diminish the exposure of human societies to harmful chemicals
- Founded on the Precautional Principle PP
- Green chemists have a moral responsibility to reshape safe chemicals

PP versus Cost-benefit analysis (Utility)

When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.

Cost-benefit analysis (CBA) is premised on the idea that government rules or industry decisions should proceed only if significant benefits (calculated in monetary terms) will result. For example, a company should only choose to remove a chemical if a large number of people will have their health protected without excessive cost or loss of profit. Policies that force industry to spend many millions of dollars per human life preserved or enhanced are economically ‘inefficient’.

- Precaution only works beyond a certain treshold of danger that varrant costly interventions.

<table>
<tr><th>Value Chain Stages</th><th colspan="4">Acetylene Route</th><th colspan="4">Ethylene Route (90% of global capacity)</th></tr>
<tr><td>Raw material extraction</td><td>Limestone ($CaCO_3$) is
↓
converted into lime (CaO or calcium oxide).</td><td>Coal is
↓
refined into coke (3C), a hard, high carbon fuel.</td><td rowspan="2">Natural gas
↓
Combusting methane + oxygen yields
↓
Hydrogen (H) + <u>Acetylene gas (C_2H_2)</u>
↓</td><td rowspan="2">Salt (NaCl)
↓
Electrolysis of brine creates alkali, chlorine gas (Cl_2), hydrogen (H_2).
↓
Hydrogen (H_2) + Chlorine(Cl_2)
↓
Hydrogen chloride <u>(HCl)</u>
↓</td><td>Oil
↓</td><td colspan="2">Natural gas (including shale gas)
↓</td><td>Biomass
↓</td></tr>
<tr><td>Raw material conversion to obtain Acetylene, Ethylene and Hydrogen Chloride</td><td colspan="2">Lime (CaO) + coke (3C) reacted at high heat yields
↓
Calcium carbide (CaC_2) + Carbon monoxide (CO).

Calcium carbide (CaC_2) + water (H_20) combined in special generators yield
↓
Hydrated lime + <u>Acetylene gas (C_2H_2)</u>
↓</td><td colspan="2">Ethylene obtained from thermal cracking</td><td colspan="2">Ethanol dehydration on acid catalysts leading to ethylene (in development)</td></tr>
<tr><td>Manufacturing VCM</td><td colspan="4">Acetylene (C_2H_2) + Hydrogen Chloride (HCl) via mercuric chloride catalyst
↓
VCM</td><td colspan="4">ethylene dichloride (EDC)
↓
VCM</td></tr>
<tr><td rowspan="2">Manufacturing PVC including polymerization, processing, and specialty products manufacturing</td><td colspan="8">Depending on the intended market, PVC plants formulate PVC with plasticizers (e.g. phthalates) and stabilizers (e.g. lead, organotins) to give PVC the flexibility and durability desired by their customers.</td></tr>
<tr><td colspan="4">Construction (over 50% of total market volume in 2013).</td><td>Electronic</td><td>Automotive</td><td>Packaging</td><td>Other, including</td></tr>
<tr><td>End uses</td><td colspan="8">End user segments include automotive, electronic, construction, packaging, medical and consumer goods like toys, bottles, and eyeglasses. There is little value added by consumers in this stage beyond how consumer use affects the ability of PVC materials to be absorbed by one of the below "end of life" processes.</td></tr>
<tr><td>End of life</td><td colspan="2">Disposal: Most PVC is disposed of in landfills.</td><td colspan="3">Reuse: PVC building material (pipes, sheets) is being reused in urban agriculture and gardens, among other uses.</td><td colspan="3">Recycling: PVC is difficult, namely due to the many additives that make PVC useful.</td></tr>
</table>

Elements Green Chemists can design alternatives to

- Acetylene route:
  - Cl_2 production – high energy use
  - Cl_2 and HCl are toxic
  - Uses Mercury (Hg) as catalyst
- Ethylene route:
  - Emits organochlorine by-products (e.g. dioxins)
- Polymerising VCM is toxic
- Additives e.g. pthalates has potentially endocrine disrupting effects
- Replace PVC with bio-plastics

Bisphenol-A

- Part of polymers (plastics) etc.
  - Baby bottles and food wrapping.
  - Migrate to the food when heated
  - Example of emergence of unforeseen potential risk – disagreement whether it disrupts the endocrine functions.
  - Traditional toxicology focussed on cacinogenic effects.
- Conclusion:
  - Discusses different moral agents’ possible actions informed by deontological (safety and precausion) and utilitarian (more good than bad) ethics.

Bisphenol-A

Producers	Keep their production – alternatives might also have undesired effects	Product innovation. E.g. Nalgene produced BPS as an alternative
Retailors	Keep existing product line	Voluntary remove BPA and substitute it with alternatives if they exist
Regulators	Follow industry's experts in their risk assessment. Industry's self-regulation.	Follow advocacy groups and some university researchers in their risk assessment. Regulate.
Scientists		Design alternatives Provide input to regulators
Advocacy groups		Criticize regulators

Green Chemistry (GC)

- Conclusion – The moral imperative of GC has not internalized in the chemical community
- Values involved – safety, stewardship for the earth versus autonomy.
- Predictable negative effects – % Precaution, Humility.

DOCUMENT ANALYSIS OF ANASTAS ET AL. (MORAL IMPERATIVE OF GC)	INTERVIEWS WITH CHEMISTS IN US AND FRANCE (PERCEPTIONS OF CHEMICAL COMMUNITY)
Concerned with environmental health	Concerned with the image of chemistry: GC or better communication of the fruits of chemistry
Effects on health and the environment as an integrated element of chemistry.	
Effects on health and the environment considered at the stage of designing molecules (**Benign design**).	What is benign? What is green?
➔ Toxicology (and ecology?) is an intrinsic part of chemistry. Approach to assess dangerous effects of chemicals	Toxicology is not taught to chemistry students
Shared responsibility for negative effects between chemists, manufacturers, regulators, consumers	Scientists are responsible for producing knowledge. Should not refrain from generating new knowledge using a synthetic path that are not clean. Industry is responsible for use. Toxicologists and public regulators are responsible for assessing toxicity of chemicals.

REACH

- Conclusion – REACH is informed by the Precautionary principle (PP), but must be strengthened in three regards:
    1. Safer alternatives can have unexpected negative effects (how can these risks be spotted?)
    2. Companies can have vested interests in producing risk data (need for independent and transparent expertise to control reported data)
    3. It is not clear how public actors can comment on risk assessments
- Value involved – PP.
- Most chemicals have not been tested for their effects on the environment and human health. The effects are depended on the physical and chemical context (cf. Cocktail effects).

PP

- From curative and preventive regulation to anticipatory chemical regulation.
  - Curative regulation: Nature cannot cure itself. What has been poluted can be cleaned up. Polluter pays.
  - Preventive regulation: When damage is irreversible. Science can predict what needs to be prevented, and determine the level of damage so that compensation can be payed.
  - Anticipatory regulation: Deals with how to anticipate risks suggested by uncertainty, plausibility and propability. Serve to brake hasty action.
- Not identical to phronisis. (Not only ourselves, the polis but also the Earth and Humankind).

(1) The proportionality to the chosen level of protection;
(2) The non-discrimination of the procedure, in particular in regard to imported products;
(3) The consistency with similar measures previously taken for known risks, but taking account of scientific progress and change of concerns in the society;
(4) The choice of measures based on the consideration of the potential benefits and costs or various possible actions, including the no-action option; and
(5) The periodic review of measures in the light of new scientific results.
(6) The principle is implemented within a *sustainable development perspective* in line with the Brundtland Report (World Commission on Environment and Development 1987);[16]
(7) Public authorities are responsible for organizing risk assessment, which should be conducted *independently* and *transparently* on a *multidisciplinary basis*; and
(8) Civil society should be implicated and particular attention should be paid to *consulting all interested parties at the earliest possible stage*.

Conclusions

1. Ethics is not a central element in the chemical community. Education as an instrument of change.
2. Responsibility for unexpected effects shared in networks – chemists as designers, industrial managements, regulation authorities, consumers. Often locked in. Difficult to change the situation.
3. Precaution seems to be a central value / principle togehter with safety / security, utility (”more good than harm”), caring for the earth and inclusion.
4. Miss cases on justice (two cases are in the pipeline).
5. Overlap between Ethics of Environmental Health and Ethics of Chemistry. Ethics of Environmental Health and other fields of applied ethics.