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The Code of Ethics for Chemists between Universal Moral Values and Local Reality

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Abstract: In an increasingly globalized world, threatened by resource depletion, global warming and pollution, scientists in general and the chemists in particular are obliged to rapidly integrate ethical values into their work. This article shows that the codes of ethics are a valuable aid in this process. Two real life examples are highlighted. The first one concerns a misbehaviour situation from an academic, while the second one presents the entangled political, economic and legal implications brought about by the pollution by polychlorobiphenyls (PCBs) of the landfill La Pila, in the canton of Fribourg. Ultimately, the article underscores the collective responsibility of scientists, policy makers and economical players to uphold ethical excellence, for the benefit of the whole society and of everyone.

Keywords: Chemists · Code of ethics · Ethical behaviour · Local consequences · PCBs pollution · Responsibility

Motto: «La connaissance n'a pas de nuance morale, seuls les gens peuvent être immoraux, mais pas la physique ou la chimie, et à fortiori les mathematiques.» (Ludmila Oulitskaïa)

Olimpia Mamula Steiner: During her career in academia (Universities of Fribourg: PhD; Basel: post-doc, UNIL and EPFL: independent research group leader; HEIA Fribourg: full professor) and industry (R&D Swatch Group), she had a major and constant interest in the synthesis of organic/inorganic molecules (chiral ligands, diastereoselective metallosupramolecular assemblies) as well as functional (nano)materials with industrial applications. Presently, she is teaching organic chemistry and catalysis at HEIA and the chemistry of d and f metals at the University of Fribourg. She also represents the Swiss Chemical Society in the Working Party on Ethics in Chemistry of the European Chemical Society. Recently, she was nominated to represent the Universities of Applied Sciences in the Federal Commission for scholarships for foreign students.

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1. Science and Ethics

The impetuous development of science and technology, including chemistry, has brought many improvements and changed our way of life. But too often this development has sidestepped ethical questions and become a danger for our planet, thus a danger for humans too. "Science without conscience is but the ruin of the soul" says the *adagio*, and these days, without ethical questioning, without the proper measures to prevent irresponsible, harmful applications and aggressive short-term economic interests, science runs the risk of losing the trust of society, giving free rein to conspiracy theories and to far-fetched beliefs. In this context, the chemists together with all the scientists should have the capacity "to reflect on the values, develop and analyse moral and political arguments, build moral judgements and perform responsible actions, all of which belong to domain of ethics".[1a] Until recently, the academic curriculum for chemists was purely chemical. The very basic principles of ethics like: *impartiality* ('all people should be equally considered'), *non-malevolence and benevolence* ('do good, avoid harm and maximize the happiness of all people'), *justice and human dignity* were taken for granted. Fortunately, the humanities penetrated the science tower and among others, the ethics courses became mandatory in universities, following a clear necessity and the recommendation of the UNESCO's World Commission on the *Ethics of Scientific Knowledge and Technology*.[2] The ethical principles applied specifically to each profession are embodied in the codes of ethics. The physicians were the first to have it, the *Hippocratic Oath*, 3-5 centuries BC, but the first formal code of medical ethics dates back to the 18th / 19th century. *J. Kovacs* considers that a code of ethics "formalizes the informal bargains that professionals make with themselves and with society and can be used as a guide in ethical decision making".[1b]

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2. Chemist's Codes of Ethics – A Necessary Guidance

Formally, the first code of ethics for chemists was adopted in 1965 by the American Chemical Society (ACS) and was entitled 'The Chemist's Creed'. Following societal concerns and professional developments this code was expanded in 1994 and renamed as 'The chemist code of conduct'. This document contains for the first-time provisions about environment urging the chemists "to avoid pollution and to protect the environment". Other aspects are reformulated and given greater prominence: "chemists have a professional responsibility to serve the public interest of welfare", "understand the limitations of their knowledge". It also defines the scientific misconduct as "fabrication, falsification, and plagiarism". They must treat with respect their associates, employees, and students who should not be 'exploited'. The loyalty towards their employers is not a total one anymore but must "promote and protect the legitimate interests of their employers". As Kovacs underlines,[1b] the meaning of 'legitimate' is left to the everybody's appreciation and nothing is mentioned about the protection of the possible 'whistle blowers' who could be driven by higher standards than the company's profit.

In 2007 this code was again updated and renamed, 'The Chemical Professional's Code of Conduct'. Since, this code was periodically updated (last time in 2019) with matters like sustainable development as well as bias based on gender, race, disability, *etc*.[3] Moreover, ACS provides an even more detailed document on the ethical guidelines to publication of chemical research[4] as well as other documents, which contain ethical recommendations for the professional employment, the education in the academic institutions and the use of scientific information by the political authorities.[5]

Similar documents have been issued by various other national chemical societies. In an effort to integrate all of them in one code, accepted worldwide, in 2016, another document entitled 'Global Chemist's Code of Ethics'[6] was issued by chemists representing 18 countries. It prompts the chemists to strive to become "role models, mentors, and advocates of the safe and secure applications of chemistry to benefit humankind and preserve the environment for future generations". Since 2015, another international code, *The Hague Ethical Guidelines*, made under the patronage of the organisation for the prohibition of chemical weapons, references measures and recommendations to prevent the misuse of chemicals as weapons.[7]

Chemists, therefore, have a multitude of codes of ethics at their disposal, which can provide moral guidance in their work. But they need to know these codes, have the will to follow them, and be able to apply them in the real world, as it is today. This is not an easy task, and we will illustrate it with two examples.

3. Applying the Code of Ethics: Zero Tolerance for Misbehaviour

As chemists, our primary focus may not be on behaviour, psychology, or evolution. However, as scientists, we possess the insight to understand the broader implications of our research and the necessity for fostering a healthy, inclusive future.

Just as we strive for excellence in scientific content, we must also serve as role models for ethical conduct. This involves recognizing and combating unconscious biases and appropriately informing the public to positively influence our surroundings. Those of us who are teaching and/or conducting research have a moral duty to champion the right causes whenever we have the opportunity, the strength and resources to do so.

Misbehaviour has many facets and means of expression. Handling this issue is not simple because boundaries are often ambiguous, and situations vary from case to case. Nevertheless, it is crucial to act appropriately, to take these matters seriously, and discuss them openly and honestly. In the scholar/academic system it is important to remember the huge responsibility given by society to the educators/professors: the education of the young generation.

3.1 *A Personal Experience*

In this section, one of the authors considers her own experiences.

During my PhD, a colleague persistently refused to call me by my name, using 'chick' instead. Despite my objections and attempts to explain how demeaning, uncomfortable and even insulting it felt to me, he persisted. My other colleagues dismissed my concerns, suggesting that I should find it humorous. Their attitude made me feel isolated and even rejected, especially as I was one of the few women in the group. As this dynamic bothered me, I went to tell my professor. He agreed that the behaviour of my colleague was not nice. The result was that I was moved to another office. My professor understood the situation but asked me not to make a big deal out of this – for the group.

This unpleasant experience left me questioning myself, feeling like a burden to my group. Only now, years later, I have realized how inappropriate and unacceptable the behaviour of my colleague's was and also how much it affected me emotionally. I understand now that laughing it off was not at all the right response, and I recognize that also my professor should have handled the situation better. Don't ask the victim to accept, ask the aggressor to stop.

Some readers might wonder why does this story matters if 'nothing significant happened'. The truth is that tolerating such minor issues sets the stage for more severe transgressions. As a scientific community, we must address these so called 'minor' situations with care and consideration. It is essential to engage in open and honest discussions with the involved parties, to take adequate actions (instead of sweeping the dirt under the carpet) ensuring that everyone feels comfortable and respected.

3.2 *Ethical Implications*

From an ethical point of view the above example might be seen somehow as 'simplistic'. In the '*Professional Practice and Code of Conduct*' of the Royal Society of Chemistry (RSC) from the UK,[8] the professional behaviour is articulated around three main principles: 1) inclusivity-respect; 2) leadership-responsibility; 3) integrity-rigor. In the specific case presented above, it is clear that the first principle was not respected neither by the colleagues in the group nor by the colleague who showed poor manners and total lack of courtesy towards his female colleague. The second principle was not respected by the professor, who did not take action against the insulter, but punished the victim again by moving her to another office.

In more complex situations, involving not only one professional group but also other categories (entrepreneurs, public authorities, mass media, *etc*.) with completely divergent interests, a moral assessment based on the code of ethics is far more complicated. The case of the landfill La Pila in the canton of Fribourg is a good example.

4. The Challenge of the PCBs Decontamination: The (Un)Ethical Example of the Landfill La Pila (Fribourg)

4.1 *PCBs Pollution, A Planetary Persistent Problem*

Polychlorobiphenyls (PCBs) are organic compounds in which a variable number of hydrogens (from one to ten) of the biphenyl have been replaced with chlorine atoms (Fig. 1). The number and the position of these chloro-substituents give rise to 209 types of molecules, named PCB congeners. Among them 12 are 'dioxin-like' because of their similarity with the dioxin toxicity profile. This class of compounds is particularly stable chemically, non-flammable and has outstanding insulating properties.

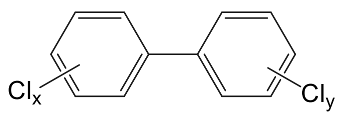

Fig. 1. General formula of PCBs.

They were used in 'closed systems' as dielectric fluids in capacitors and transformers to reduce the risk of explosion, and in 'open systems' as plasticisers and flame retardants (exterior paints, clothing pigments and dyes, construction sealants, caulking, coatings, lubricants, fluorescent bulbs, cable insulators, and roofing materials).[9]

Between 1930 and 1993, the chemical industry fabricated no less than 1.3 million tons of pure PCBs which, combined with other substrates, resulted in about 17 million tons of contaminated materials and waste, most of them already released in the environment.[10] Monsanto produced half of the total amount of PCBs and recognized their toxicity immediately after the implementation of large-scale production in the 1930's. Monsanto, however, found a justification by claiming that in closed systems (*i.e.* capacitors and transformers) the risk was minimal. But they did not sell these compounds only for such closed systems and did not consider the disposal of the aged electrical appliances. Thus, the business went on undisturbed until the 1970's when finally the danger of these already widespread environmental contaminants came into light. Afterwards, the production started to decline as a consequence of the restrictions introduced by western countries. PCBs were recognized as persistent organic pollutants (POPs) because they can enter into any ecosystem, are not biodegradable and, giving their hydrophobicity, accumulate in the adipose tissues of animals and thus pass into the food chain. The main sources of this pollution are the leaks from electrical capacitors and transformers dumped in nature and waste incineration.[11] Worst, the decomposition of PCBs by incineration for example can lead to even more toxic secondary products that can induce hormonal disequilibrium and affect the lungs activity and the reproductive system of humans.[12] For humans, the animal origin food (meat, milk) and inhalation are the main routes of exposure.[13]

Managing PCB contaminations worldwide is challenging technically (sampling, analysis, clean-up technologies),[14] logistically (incomplete inventories of polluted sites and of the current stocks), politically (application of international regulations) like the Stockholm convention on Persistent Organic Pollutants not ratified by all countries *i.e.* Italy and USA, (while one country, North Korea, is still producing PCBs) and of course, financially. The goal fixed by the Stockholm convention for the environmentally sound management of waste liquids and equipment contaminated with PCBs by 2028, is clearly illusory.[15] Adding to this the even more difficult management of newer POPs like chlorinated paraffines, irresponsibly chosen to replace the PCBs in the open applications[16] and banned since 2018 under the Stockholm convention, one can only agree how righteous sounds the first principle of green chemistry: '*Prevention: It is better to prevent waste than to treat or clean up waste after it has been created.*' [17]

4.2 *PCBs Legacy in Switzerland*

As a strongly industrialised country, Switzerland also has an important toxic legacy, consequences of the past errors. Much work has already been performed for the inventory of the contaminated sites and for their remediation, Switzerland being one of the pioneers in the environmental protection and conservation. However, there still is a lot to do, as highlighted in a press article[18] from 2021, which revealed that around 38'000 polluted sites covering a total surface almost 3 times the area of the city of Zurich, still need remediation. Most of them are in industrial areas (50%) and old landfills (40%).

Concerning the PCBs, many years after their ban from the use in open systems (1972) and complete ban for any form of use (1986), relevant environmental concentrations in air, water,[19] soil, food and feed[20] are still measured. The estimation of the future emissions of PCBs to air, as presented in a very interesting research article 'Import, use, and emissions of PCBs in Switzerland from 1930 to 2100'[21] shows that we will have to deal with this problem for few decades from now on.

The goal fixed by the Swiss Confederation is to finish the cleaning up of all polluted sites by 2040, giving priority to those that threaten water sources. Beside the technical challenges represented by this important task, there is also a financial burden estimated at more than 5 billion CHF. As the principle 'polluter pays' ('pollueur-payeur') is imposed by the Swiss law, one can figure out that those responsible for the pollution, often private companies, would pay the bill and that public authorities wouldn't have to worry about it. In reality, the situation is far more complex. Identifying and ascribing the liabilities takes time, effort and resources and in the meantime some of these companies have disappeared, became insolvent or have been transformed into other entities through merging, acquisitions, *etc.* A typical example is the La Pila landfill in the canton of Fribourg, which contaminated the groundwater and the La Sarine river.

4.3 *La Pila: The Judicial Battle or How to Privatise Earnings and Socialize Losses*

Between 1952 and 1973, La Pila (Fig. 2), situated on the banks of the Sarine river, was used by the city of Fribourg as a landfill for household, construction and industrial waste. Since 2004 the authorities became aware of the very high PCB content on the site, and that the groundwater and the Sarine have also been contaminated. Such an important pollution can only be explained by an influx of industrial and artisanal waste in liquid form, containing PCBs. In 2009, the cantonal authorities launched an investigation which, on the basis of evidence found at the site and eyewitness accounts, concluded that the massive presence of PCBs at the site was due to industrial waste from a private company we will call B. B manufactured electrical capacitors and was the main consumer and importer of PCBs in Switzerland (in 1972, for example, the company imported 120 tons of pure PCBs). Eleven years later, in 2020, the Fribourg authorities decided on the shares of responsibility and therefore on the financial contributions to the remediation, which are estimated to cost between CHF 150-250 million depending on the technical variant chosen. The liabilities are divided between the city of Fribourg (45%), the canton of Fribourg (30%) and the company B (25%).

But company B as such no longer exists: in 1992 it merged with C, giving rise to D, which after a few years later was transformed into A. The authorities deemed A to be the successor of B and consequently asked A to pay the first millions. From that moment on, a merciless legal battle began (even the federal court got involved).

A denies responsibility and every conceivable argument is brought to the court. The company is even calling for the suspension of some members of the cantonal authorities and doesn't hesitate to put forward a 'promise' allegedly made by a member of the Fribourg Government Council to arrange the financial contribution in such a way in order to prevent company A going bankrupt.[22] As a scientist, reading these court decisions is an experience in itself and leaves a bitter, unethical taste.

But this game hides another which had already begun long before, in 2009, as soon as A was aware of its possible financial responsibility for cleaning up La Pila. In fact, A's management began a massive disinvestment which, according to the court, was intended to drain the company of its resources in favour of its shareholders. A sold its real estate in Fribourg and refused to provide the financial information required by the authorities. Four

Fig. 2: View of a small part of the La Pila landfill from the side of the river La Sarine (photo: personnal archive Steiner).

years later, the legal wrangling continues, but one thing is for sure: time is on A's side, and not on the side of the Fribourg taxpayer, who will certainly have to pay even more to cover the costs needed for the site cleaning.

4.4 *The Ethical Point of View*

Many questions arise when studying this case. For example, let's consider the moral duty of hazard foresight: "if your action has unintended adverse consequences, your action is morally wrong whatever your good intention might have been".[1c]. The duty of B would have been to take into account the most advanced scientific knowledge and put in place adapted precautionary measures, at the earliest stage possible, to avoid harm. In 1976, the USA adopted the *Toxic Substances Control Act*, a law whose purpose was, among others, to regulate chemicals that posed an 'unreasonable risk of injury to health or the environment'. And the PCBs were on their list. It seems then reasonable to presume that this knowledge existed. In these conditions, a minimal moral duty of B would have been to inform the authorities, even after the landfill La Pila has been taken out of service (1973), about the nature of the waste they previously dumped there. Did they make it? We will never know.

A's legal and economical actions are also questionable. But experience shows that the authorities should have expected that something like that would happen. The lack of reaction from the state professionals (chemists and others) in charge of the landfill and environmental services is also problematic. They should have known about the toxicity of these products and acted before the problem became chronic. The same question can also be raised at the political level. Why the cantonal government needed 11 years to reach a decision on liabilities?

However, this is only looking at the problem at the local level (on the shoulders of the local government, city, and the canton of Fribourg) while the root cause goes much deeper and broader. Monsanto was well aware of the toxicity of the PCBs but continued to sell the products all over the world – unacceptable and everything but ethical. The regulatory bodies (both international and national) were surely aware about the toxicity of the products. PCBs were not produced in Switzerland but imported to Switzerland. Aren't all of the above-mentioned organisations starting with Monsanto also responsible? Shouldn't they also be called upon to assume their responsibilities and share the price for cleaning? But there again we run into even more convoluted legal affairs as it goes global – a Monsanto was an American company, which doesn't exist anymore. Ethics and law are sometimes two worlds.

In the end, more leadership-responsibility and integrity-rigor at international and national level would have prevented a health and environmental threat and the local financial resources needed to remediate the problem could have been allocated for other beneficial goals like education and research.

5. Conclusion

Various leading organizations, including the Royal Society of Chemistry,[8] American Chemical Society,[5] American Institute of Chemical Engineers (AIChE),[23] International Union of Pure and Applied Chemistry (IUPAC),[24] and the Chemical Institute of Canada (CIC),[25] have developed comprehensive ethical guidelines to uphold the moral values. Despite these frameworks, real-world situations (*i.e.* environmental issues) are often very complex and require a harmonisation between the ethical standards and laws. By fostering a culture of responsibility, integrity and respect, the scientific community, here represented by chemists, can reinforce its credibility and positive impact to the world.

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