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The chemical industry between regulation and self-responsibility

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The chemical industry seems to have the doubtful honor of being regarded by a considerable number of people, as *a,* if not *the,* major menace to human wellbeing. It threatens its surroundings and society at large by the catastrophe-proneness of its installations and processes and the unsafeness of its products, and it poisons the environment with its gaseous, liquid and solid wastes. Regrettably, there are real and very unfortunate cases that can be cited for exemplifying all three allegations. This bad image is the result - at least in part - of the psychological rules by which individuals and collectives intuitively view and assess the risks and benefits of a given situation or activity. From this psychological point of view chemistry or the chemical industry is in a particularly unfavorable position; its *hazards* - as illustrated and widely publicized by the incidents of past years - are perceived as uncanny, insidious, unavoidable, irreversible and unnatural - and to a certain extent not all of this can be contested. On the other hand its *benefits* under the trend towards romantic 'back to nature' ideas tend to be belittled, are argued away or not recognized at all. No wonder that an intuitive and emotional risk benefit assessment can easily come out against our industry! It is also evident that such a situation is a rewarding playground for a certain part of the media and of the political spectrum.

In my short talk I shall try to systematize the potential hazards posed by the chemical industry and its products, to put them into perspective and thus to point to what I consider to be the real areas of concern and problems to be solved or solved better.

I have to base my remarks on 2 simple axioms, one concerning the benefit, the other the risk side of the problem:

1. *The chemical industry is necessary*: it is indispensable for the maintenance of a standard of living in the industrial countries that evidently corresponds to the expectations of the vast majority of our societies; and it is necessary for assuring eventual coverage of the

basic needs and justified aspirations of the rapidly increasing populations of the developing part of the world. It is certainly superfluous to explain how essentially and unavoidably the products of the chemical industry permeate all parts of our daily life and what weight it has in our economic structures.

2. *There is no human and especially no technological activity with zero risk*: the handling and use of chemical substances and their interactions with the components of our environment are hazardous in a number of respects. Our knowledge of the properties of chemicals can never be complete. This is especially relevant for the vast number of chemical compounds in practical use that do not exist in nature, and for their behavior in biological systems. Consequently, the expectation that all possible hazards can be predicted through ever more elaborate testing, and that thereby all potential risks can be eliminated, is illusory.

These 2 premises together mean: discussions and actions in the toxicological and ecotoxicological fields must aim at optimizing the entire system society-chemical industry, that is minimizing risks, while maintaining or maximizing benefits.

For the purpose of our discussion we have to be aware of the great diversity, both technologically and economically, of the enterprises making up what is subsumed under '*chemical industry*', and of the indefiniteness of this term. Many industrial processes as far apart as metallurgy, food processing, and energy production of course depend on chemical processes, but for our purpose are not included, although some of their negative side-aspects are preferentially and popularly labelled and perceived as 'chemical'.

The term '*environment*' is equally blurred, and its meaning depends on who uses it. For our purpose it will primarily and simply mean atmosphere, water and soil. Physical and chemical behavior of chemical compounds in this environment (concentration, dispersion, chemical interaction, modification and degradation) will be distinguished from the secondary, biological effects of 'environmental chemicals' like toxicity to organisms, bioaccumulation, metabolic modification and biodegradation.

Let us now have a look at the field we want to discuss. Chemical production processes lead to products and, inevitably, to wastes, which can occur in a variety of forms: as exhaust gases, mother liquors, acid, alkaline or salt solutions, solvent mixtures, distillation residues and more or less well-defined side products. Products have a limited lifetime and become waste when this has elapsed. Part of this directly and indirectly produced waste can be reused by recycling it into the process in which it has arisen or by using it as raw material for another process. The reusable proportion of the waste as a rule is not great for a number of reasons; the rest has to be disposed of in some manner.

	Processes	Products ⇄	Wastes
Employees	XXX		
Users, consumers		XXX	
Environment	X	XX	XXX

In the other dimension of our chart we have the major interactions of the production cycle with human beings and the environment.

Processes affect mainly employees of the chemical industry. This interaction is the domain of occupational safety and health. Environmental effects of processes are considered to occur via wastes and material losses, or, rarely, as a consequence of larger scale accidents.

Products can affect users and consumers. This relationship is the concern of integrated quality assurance and especially assurance of product safety. Some classes of chemical products interact directly with the environment because of their use pattern. The most important cases in point are agrochemicals, fertilizers and pesticides, which are considered separately in the subsequent paper. Other classes are the solvents, e.g. in paints, or the detergents.

The most important category from our point of view are the wastes, directly or indirectly entering the environment from production processes or as discarded products and potentially representing toxicological hazards to organisms and man.

From this classification, the following problem areas emerge as subjects for discussion:

1. The toxocological situation at the workplace
2. Product safety
3. Process derived wastes, or industrial environmental protection
4. Product derived waste, or public environmental protection

It is a generally held misconception that due to the enormous growth of chemical production in the past 100 years and particularly since the end of World War II all environmental parameters affected by the chemical industry have greatly deteriorated. This is decidedly not true for some of them, especially so for the situation at the workplace.

1. *Occupational safety.* Contrary to the majority of the products which leave a chemical plant, most of the materials used in the processes are by definition reactive chemicals and thus more or less hazardous to man in various ways. It is therefore the rule to avoid as far as possible direct skin contact with chemicals or their inhalation and ingestion as vapors or dust. Progress made in the course of the past decades in these respects is due mainly to the replacement of open by closed reaction vessels, improved ventilation, protective clothing, better knowledge of the toxic

properties of materials and better instruction of the workers. For many hazardous chemicals official workplace concentrations in the atmosphere (MAK, TLV) have been fixed and their observation is controlled by measurements, or so called man-monitoring. The modern developments in analytical techniques have greatly extended the simplicity, sensitivity and specificity of such measurements. A great part of the work force, that is all those exposed to hazardous substances, are subject to regular prophylactic medical examination.

As a consequence of all these measures, morbidity and mortality patterns of chemical workers in typical industrial countries nowadays are not different from those of the general population. This is also true in the special case of cancer, where modern production practices and the elimination of the most notorious chemical carcinogens of the past such as β-naphthylamine and benzidine, have resulted in the practical disappearance of the formerly dreaded cancers in the dyestuffs industry, for instance in Basel.

According to a careful recent study, it is very unlikely that working in a chemical laboratory under reasonable hygienic conditions poses any increased cancer risk.

Due to the virtual disppearance of occupational cancer as an acute problem in our plants the relative importance of other health problems such as bronchitis due to irritant influences of all kinds (including smoking) and allergies has increased. But here also the situation in the chemical industry is not significantly different from that in the general population. Finally it has to be added that typical chemical accidents such as acute poisoning or corrosion are the exception in the workplace as compared to the ordinary 'household' or mechanical accidents.

This relatively happy state of affairs does not prevent those responsible in industry, in close collaboration with the authorities, to work constantly at improving the exposure situation in the chemical works and increasing our knowledge of the toxicological properties of the thousands of substances handled. More on this problem later.

2. *Product safety.* Chemical end products, contrary to the reactive chemicals in the plant, are typically stable compounds. Dyestuffs, for instance, have to remain unchanged in high dispersion on textiles fibers under very adverse conditions for years; artificial fibers and plastic materials likewise have to retain their characteristics for extended periods. This desirable stability has its negative side, as we will see later. But because of the inherent unreactiveness of a great many chemical products their direct toxicological potential is usually low. Leaving aside the agrochemicals, the potentially bioactive classes of products which come into contact with consumers are essentially the pharmaceuticals, and artificial additives for the food industry; flavors, sweeteners, stabilizers, antioxidants etc.

All these are extensively regulated and apart from unlawful misuse pose very small risks as compared to the benefits of their application. We will not further consider them here.

The situation is different with certain technical chemicals which can pose risk to the user and the environment especially when the stability dilemma comes into play. A special class in this respect are the halogenated hydrocarbons, like PCB for example, which were used in huge quantities in different technical fields before it was realized that their technically desirable stability led to very long residence times in the environment and the phenomena which Bickel (this issue) has gone into already.

These and other experiences of the past, that in some cases actually have led to widespread pollution of the environment and to accumulation effects in organisms are interminably used as arguments in support of the common opinion that more regulation of chemical products is needed. The demands include more and better testing for chemical and biological properties before beginning production or introduction in the marketplace, all this naturally with the intention of establishing restrictions of use or bans.

The necessity for a sufficient characterization of the behavior of chemical products that can affect man or the environment is recognized by the chemical industry, and of course has been practised increasingly for a long time. But we are also aware that our knowledge is limited (and will never be complete) because the number of compounds is enormous, the systems and interactions to be investigated are extremely complex and the testing methodology is in many cases far from adequate. In addition some of the really serious incidents being widely cited in support of the necessity of more testing were produced by new effects which could not have been predicted and for which therefore nobody could have tested at the time. The most illustrative cases in point are the thalidomide and, in a way, the SMON tragedies and the PCB poisoning in Japan. The occurrence of incidents of a similar nature will in principle never be completely excluded, although their consequences can of course be alleviated by the sharpened awareness of their possibility.

Unfortunately, the flood of new regulation resulting from developments in the public opinion, mainly stemming from incidents of the kind mentioned, has in some countries primarily led to the creation of enormous bureaucracies whose activities place a heavy load on industry in the form of administrative and experimental duties which seriously hamper its economic and innovative potential. I doubt somewhat whether society reaps benefits in the form of real mitigation of risks which are commensurate with the

costs and losses of all this. But I shall come back to regulation later on.

3. *Process-derived wastes.* These occur as exhausts potentially polluting the air, as waste water and in the form of liquid and solid waste products.

One area where the situation in the chemical industry today has decidedly much improved over conditions in the past is air pollution by solid and gaseous, hazardous or obnoxious materials. The use of closed reaction systems and installations for the absorption of gaseous reaction by-products, such as halogen-, sulfur- and nitrogen compounds have resulted in the virtually complete elimination of most emissions. These emission control devices are today integrated components of chemical apparatus and are no longer specially labelled as 'environmental protection devices'. The continued reduction of emissions, e.g. of solvent vapors which are more difficult to retain, but also as a rule less hazardous, is however a concern.

As a consequence of this generally favorable situation the allegations that the surroundings of chemical plants or the population at large are exposed to increased health and particularly cancer hazards by airborne emission are not founded on any objective evidence, at least under civilized conditions.

More problematic are the 2 other relevant sectors of waste management: waste water and solid chemical waste. I do not want to go into technicalities but a few general remarks seem appropriate.

Wastes in any form are an unavoidable by-product of chemical processes, for technical and thermodynamic reasons. The reduction of wastes is nowadays integrated into the objective of process optimization because waste disposal has become a very important cost factor for many chemical processes. In this sense the slogan 'clean (or no waste) technologies' is utopian and 'low waste technologies' is a matter of course for our industry. Finding the most effective way of reduction of the waste load in water and of solid wastes to be disposed of can safely be left to the self-interest of the industry, within the framework of existing regulation, including limit values for certain critical substances like mercury and other heavy metals, persistent organic chemicals etc.

Time does not permit me to go into details, but I should like to stress that the disposal of solid waste, especially when containing the critical components mentioned, is and will be among the most serious concerns of our industry in the future, not so much because of the unavailability of suitable technologies but owing to the difficulty or impossibility of putting them into practice, mainly for political reasons. The situation has some resemblance with the problems surrounding radioactive waste.

4. This leads to the problem of *public environmental protection* which has to deal among other things with the safe disposal of the bulk of chemical production which ends up in refuse as discarded consumer products. As with chemical process waste, incineration of the refuse is the method of choice if it is conducted at temperatures sufficiently high for mineralizing even the most stable organic substances, which are introduced with the waste or can be formed from a multitude of precursors in the low-temperature regions of a furnace. In addition, effective scrubbing of the combustion gases to eliminate hazardous heavy metals and acidic components has to be provided. Unfortunately the story does not end here because incineration again produces waste: slag, ashes and scrubbing liquids, in which the incombustible hazardous substances, heavy metal compounds and inorganic salts, are concentrated. For these, controlled landfills or underground deposits are the last resort.

It is probably illusory to expect that sizeable reductions in the quantity of communal refuse, or of the contents of critical substances in it, by disciplined action of the consumer or fundamental changes in our consumer behavior will easily be possible in order to mitigate the task of public waste disposal. Of course every initiative and sensible measure in this direction is in principle to be supported, as well as endeavors to recover more of the valuable materials for recycling. Let us, however, beware of wasting our efforts in noble and idealistic, but ineffective and losing fights against the windmills of the law of entropy. Manufacture and use of goods are as a rule accompanied by mixture, dilution and dispersion of the materials applied, and the unscrambling of scrambled eggs is at least a very difficult process.

I hope to have shown where the problems of chemicals and the chemical industry are to be seen, as far as today's subject is concerned. They do not primarily lie on the production but mainly on the use side of chemicals, and if there are significant toxicological hazards caused by chemical products they are today not primarily direct ones but act by way of the physical environment. We have inherited a number of such problems from too indiscriminate and naive use, in a few cases also negligent or criminal misuse or handling of chemicals. Fortunately none of them seems to be on a really alarming level with the possible exception of lead (which I consider not to be a problem of the chemical industry). But we have to be careful not to let them increase. More important, we have to learn from these experiences and try to prevent repetitions in the future.

In this sense I believe the best way to master the potential toxicological problems assiciated with the chemical industry is to monitor carefully any significant increase of man-made organic chemicals (as well as heavy metals) in the compartments of the global environment, atmosphere, sea, and surface soil, and/or bioaccumulation effects. Modern analytical techniques have made this possible with sufficient sensitivi-

ty. On this knowledge can be based timely, well-considered corrective action on a national and, hopefully, international level.

I frankly admit that in our time, in which there is hardly a doubt left about the limitations of many of our material resources including the capacity of our environment to dilute and digest the refuse of nearly 5 billion humans, environmental laws are a necessity. They are, or should be the firm framework within which for instance the chemical industry can move in relative enterpreneurial liberty and with impunity, exactly as the behavior of the citizen is circumscribed by the rules, prohibitions and sanctions of the civil and penal legislation. But just as the individual is left with the legal and moral responsibility of leading his life within this framework and collides with it only in transgressing it, the chemical industry should be accorded the opportunity of responsible fulfilling the legal obligations by applying its own initiative, scientific, technical and business knowledge to arrive at economically optimal solutions. By this the best interests of society as a whole are served. The legal rules and norms should represent the best possible approximation of all interests of society, including economy and the industry. They should be of the nature of objectives rather than prescriptions, and their application should be possible with a minimum of bureaucracy.

All this is, of course, only possible when the two sides co-operate and have sufficient trust in each other. Although a part of the public seems to be convinced that the past record of our industry does not justify this confidence, there is abundant evidence that the overwhelming part of the chemical industry is conscious of its responsibility and ready for reasonable solutions of the common problems. Quite apart from ethical reasons such behavior is from a number of viewpoints, such as tight liability legislation, also clearly in the self-interest of industry.

Unfortunately the necessary constructive interaction between the chemical industry, the authorities and the public is constantly disturbed by the interminable rehashing (in an often distorted and scientifically incorrect manner) of the same old 'cases' of the past which from the state of knowledge of today appear as mistakes. They are well known indeed, and have been learnt from and dealt with as well as possible by technical measures and/or regulations. Many of the allegations moreover, concern matters outside the sphere of influence and responsibility of those accused. Future mistakes of course cannot be excluded and the learning process will have to continue. The chemical industry is prepared to carry its share of the responsibility of minimizing the hazards.

It is evident that our society will increasingly have enormous environmental problems, but I dare to say that, contrary to widespread belief, the chemical industry in the industrial countries of the West is not among the most prominent causes of them. On the contrary, it will have to play an important role in the vital endeavors to control the priority environmental problems in the fields of energy production and use, and land and soil use.

How safe are pesticides?

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Summary. Pesticide safety has not only been extensively assessed but also, as science has advanced, pesticide safety features have been continuously and significantly improved. Large scale industrial and government research can be expected to achieve further ameliorations. Academia is called upon to assist with relevant contributions.

When discussing chemicals in a recent publication, Ernst Otto Fischer, the Nobel Laureate, said: 'He who intimidates laymen by such things as newspaper articles without knowing anything about the dangerous dose, is, in my eyes, guilty. Seveso is not everywhere' (Fischer, 1982). When skimming our Swiss media one is indeed confronted with a continuing barrage of accusations (not by trained, but by self-made toxicologists) concerning the alleged hazards of chemicals, including pesticides. Personally, I believe that biologically active ingredients which are purposely brought into the environment are too important a matter to be the subject of ignorance, emotions, sloganism and ideologies. What is needed are scientific facts and assessments. With this in mind, I wish to submit four theses which I hope to defend with appropriate arguments and with some illustrative examples.