

## Some Environmental Programs in Switzerland\*

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### Abstract

As a result of the fact that Switzerland is about seven times more densely populated than the USA (and even more if the uninhabitable area is taken into account), that the gross social product per area unit is also about seven times greater, and that the traffic density per area unit is about four times greater than in the USA, many environmental problems are particularly accentuated. Given as key words: Population limitation, space planning, traffic density, public transport, the energy problem, environmental economy and legislation, water conservation, air hygiene, agricultural adaption, maintenance and development of the mountain areas. Today, about \$ 1000 millions or \$ 160 per inhabitant are spent annually in Switzerland on environmental protection, about half of it from public funds and half by private industry. As Switzerland is small, many tasks are carried out on a private basis, or semi-officially. Approximately \$ 750 millions (or \$ 120 per inhabitant) are spent annually in Switzerland on research, about \$ 150 millions by public bodies and about \$ 600 millions by industry (chemical industry about \$ 400 millions).

Applied research is traditionally carried out mainly in the field of water conservation (e.g. the problem of eutrophying by phosphates) and, in industry, into the side effects of chemical products. In addition, a series of institutes is concerned with the task of supervision, carrying out measurements in connection with, for example, lead, mercury, halogenated and non-halogenated organic compounds, and inorganic gases such as carbon monoxide and sulphur dioxide. The results obtained by analytical institutes at the universities and in industry also partially benefit environmental research. For legislation, reference is also made to the results of research in other countries, which are evaluated for this purpose in various places.

### 1. Introduction

Before getting down to the real subject of protection of the environment, including research, analysis and toxicology in the context of environmental studies, with regard to Switzerland, some comparisons between this country and the USA will assist understanding of the special problems involved.

First of all some figures on Switzerland and the USA: Fig. 1 shows that Switzerland's population is approximately 7 times denser than the U.S.'s population and that of the higher number of persons gainfully employed relatively a higher percentage is employed in industry and agriculture.

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Fig. 1

Statistical comparison: Switzerland/USA

	Switzerland	USA
Area	41,300 sq.km	9,360,000 sq.km
Inhabitants	6,300,000	209,000,000
Inhabitants per sq.km	154	122
Employed population	3,000,000	83,900,000
Employees as % of population	48 %	40 %
Employed in agriculture	8 %	4 %
Employed in industry	48 %	28 %
Employed in transport and in the services sector	44 %	59 %

Fig. 2 shows that with roughly the same GNP per inhabitant Switzerland's gross national product per unit of area is roughly 7 times greater, the density of traffic about 3 times greater and foreign trade turnover relatively 6 times larger. Since the proportion of uninhabitable areas is considerable, the concentration is still greater.

Fig. 2

Statistical comparison: Switzerland/USA

	Switzerland	USA
No. of motor vehicles	1,700,000	117,000,000
Vehicles per head of population	0.27	0.56
Vehicles per sq. km	41	12
Gross national product (GNP) (in millions of dollars)	34,000	1,150,000
GNP per head of population \$	5,300	5,600
GNP per sq. km \$	800,000	124,000
Exports as % of GNP	23.4 %	4.2 %
Imports as % of GNP	29.4 %	4.4 %
Research expenditure (in millions of dollars)	750	28,300
Research expenditure per head of population \$	120	135
Research expenditure (industry) (in millions of dollars)	600 = 80 %	19,500 = 69 %

A large sector of the population is of the opinion today that *space in Switzerland is limited* and that further material growth is therefore also subject to limitations. Demands are being made in particular for improved town-and-country and traffic planning. The mountain regions should be preserved and developed and agriculture adapted to meet long-term objectives. Since 1950 the population has increased by 32% mainly

by immigration, the real gross national product by 128% and energy consumption by 228%. Today Switzerland's population growth has virtually come to a halt. On the *energy problem* the same kind of discussions are taking place as in the USA: How many nuclear power stations should be built during the next few years? What measures should be taken to avoid side effects? What economies should be made in power consumption? Will the present shares in the energy sector of 75% liquefied fuels and 15% electricity as sources of power persist?

The MIT study *Limits to Growth* by Professor FORRESTER and Professor MEADOWS made a rather greater impression in Switzerland than in the USA and intensive discussions are going on as to the practical consequences to be drawn at regional level from this global model. In the area of environmental research, for example, the economist Professor H.C. BINSWANGER and the physicist Dr. T. GINSBURG are working on a joint research project entitled *The transition from economic growth to economic-ecological equilibrium*, which consists of three system components:

- Ecological-technological aspects (e.g. use of energy and land resources; timely development of new technologies).
- Economic and business management aspects (including the recognition of key factors in systems, fringe requirements, and the avoidance of crisis situations).
- Socio-psychological aspects and social value systems.

## 2. Organization of environmental protection in Switzerland

In Fig. 3 some Swiss institutions concerned with environmental programs are arbitrarily enumerated.

Fig. 3

Major Swiss authorities and organizations concerned with problems of environmental pollution.

- Federal Office for Protection of the Environment, Berne
- Federal Office of Health, Berne
- Advisory Commission on Water Protection
- Federal Commission for Air Hygiene
- Swiss Society for Environmental Protection
- EAWAG (Federal Institute for Water Resources and Water Pollution Control) and EMPA, Dübendorf
- Federal Institute of Technology, Zurich e.g. Institute for Hygiene and Work Physiology
- Federal Institute of Technology, Lausanne e.g. Institute of Environmental Engineering
- University of Zurich, e.g. Institute for Preventive Medicine
- Federal Institutes for Agricultural Experimentation
- Cantonal chemists; cantonal health inspectorates
- Swiss Chemical Industry
- Institute of Toxicology (planned)
- Swiss Association for Environmental Research

According to Professor H. AEBI, President of the Swiss Scientific Council, it is planned that closer cooperation will take place between the Scientific Council, national funds (which disposes annually of about 30 millions of \$) and the successor to the Allemann Committee for the promotion of economically motivated research,

and also that, in particular, action will be taken to promote socially-orientated areas of research such as educational research, research into mass communications, information and documentation, political sciences, sociology, psychology, preventive medicine, epidemiology and especially the environmental sciences\*.

In the *Swiss government* the Department of the Interior is responsible, *inter alia*, for social affairs, education and protection of the environment. In connection with the latter it has at its disposal the services of the *Office for Environmental Protection* (without laboratories) which is directed by Mr. F. BALDINGER. A major part of its activities lies in the drafting of legislation and ordinances.

*The Swiss Society for Environmental Protection* (under the chairmanship of Professor Dr. M. SCHÄER) is, besides 170 smaller societies, a private organization. Its activity is mainly political, thus providing support for the work of the Swiss government. The society does not have its own laboratory facilities but can call on the services of many scientific advisers. Currently its main activities comprise:

- a) Participation in the drafting of federal legislation on protection of the environment.
- b) The elaboration of a concept for Switzerland's policy in the sphere of energy resources.
- c) The preparation of a concept for Switzerland's motor vehicle traffic combined with promotion of public transportation systems.
- d) Propagation of the idea of protection of the environment among individual citizens and in households.

The EAWAG (*The Federal Institute for Water Resources and Water Pollution Control*), Dübendorf (founded in 1946), under its directors, formerly Professor Dr. O. JAAG and presently Professor Dr. W. STUMM, is an associated institute of the Federal Institute of Technology in Zurich. Its staff of 60 graduates and 60 assistants is engaged on research, teaching and counselling in the fields of urban settlement, water protection and the management of refuse and wastes. Since 1970 the institute has been housed in new offices, laboratories and experimental stations in Dübendorf. Its annual operation budget runs to approximately 1,200,000 dollars. Associated external departments include a lake research station, founded in 1916, at Kastanienbaum on the Lake of Lucerne, an International Reference Centre for Wastes Management and a documentation library on international literature on blue algae. EAWAG also participates in the joint European research projects of COST (Coopération Internationale dans le Domaine de la Science et de la Technique) on micropollution of on sludge properties and on the treatment of sewage sludge.

\* See also H. AEBI, "Science and Protection of the Environment", NZZ, August 27, 1973.

The *Federal Institutes for Agricultural Experimentation* are located at Wädenswil, Reckenholz and Tänikon in the north-east of Switzerland, at Liebefeld (near Berne) and in Lausanne. In addition to the department for agronomy and forestry at the Federal Institute of Technology in Zurich these test centres are concerned with training, research and counselling with the particular objective of promoting agricultural production in Switzerland. For some time these institutes have been working on the side effects of chemicals in agriculture and on new systems such as, for example, biological horticulture.

The *Cantons* have their official cantonal chemists, their public health inspectorates and other specialized departments.

An important role in all sectors of environmental protection is played by the *chemical industry*, especially in Basel<sup>1</sup>. Over the next ten years the *chemical industry* in Switzerland will allocate 15 to 25% of its capital investment and 7 to 10% of its manufacturing costs to protection of the environment<sup>2</sup>. This will, of course, result in increased product cost prices. Once the backlog of protective measures has been cleared the industrial sector will no longer talk of the cost of protecting the environment because new processes and installations will in any case be tailored to safeguard the environment and one does not, after all, regard additional costs for the safety and protection of workers as a subject for debate. Production processes are being modified to reduce their adverse effect on the environment. The development of special equipment and methods for the identification of micro-pollution is being intensified. The philosophy of protection of the environment within the factory is being propagated and "cost consciousness" in the form of allocating the increased production cost stemming from protection of the environment on a product-by-product basis (the "originator" principle) is being extended. Research into the ecological and toxicological effects of the product range and of by products is being carried out and appropriate advice is being passed on to users<sup>3</sup>. The chemical industry also attaches importance to cooperation with public authorities, e.g. through its BWL-Group (Ground, Water, Air). The industry also supports a large number of foundations and associations.

Professorships in toxicology are established within medical faculties at Swiss universities. Problems of toxicology are handled by, amongst other organizations, the Swiss Institution for Accident Insurance (SUVA), while the Swiss Toxicological Information Centre in Zurich under the direction of Professor Dr. F. BORBELY provides telephone information on some 10,000 cases of acute poisoning every year<sup>4</sup>. In the various cantons, too, offices providing information on poisons are being developed. A Federal Institute for Environmental Toxicology at the Federal Institute of Technology, Zurich, is currently in the planning stage. The functions of

this new institute will include the acquisition of necessary documentation, coordination with other institutes in Switzerland and abroad, the carrying out of relevant social research in the fields of ecological micro-analysis and toxicity, the training of qualified personnel and the providing of advice to organizations and individuals.

The *Swiss Working Group for Environmental Research* was formed in 1972. The scientists who are members of this association improve coordination in the sphere of environmental research and work out a policy for Swiss efforts in this area.

As far as *legislation* is concerned there exists an article 24<sup>septies</sup> in the Swiss Constitution about the protection of the environment. Special laws refer to protection of water, to the occupational health and safety and to the handling of poisons. Laws for the protection of the atmosphere and against noise are in preparation, as well as additional administrative regulations.

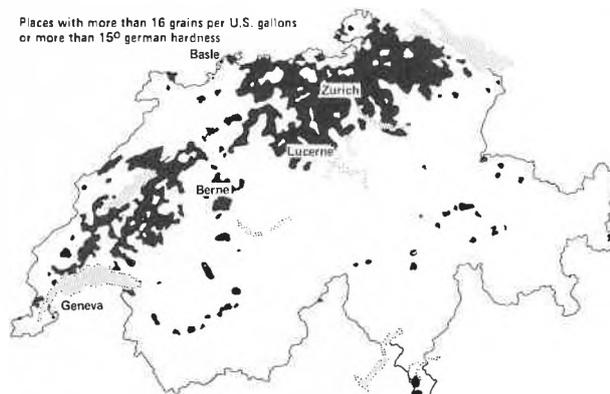
In the following chapters some typical examples within Swiss environmental programs are selected:

### 3. Waste Water Research in Switzerland

Monitoring of water pollution is similar to other industrialized countries. The *condition of Switzerland's waters varies greatly*. For natural reasons the degree of water hardness shows marked variations, sometimes as between one locality and the next, and ranges from extremely soft water in the granite and gneiss regions of the Alps and in the south of Switzerland to extremely hard water in many places in the west and north-east of the country. A map exists showing the geographical distribution of water hardness in Switzerland:

Fig. 4

Places with more than 16 grains per U.S. gallons or more than 15° german hardness



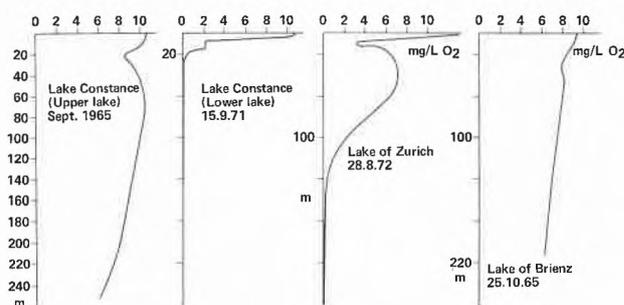
The mean coefficient per head (*m.c.h.*)<sup>5</sup> for *water consumption* in Switzerland varies between 100 litres per day in the mountain regions, 600 litres per day in the towns and 1000 litres per day in the holiday resorts. The *biochemical m.c.h.*<sup>5</sup> rose in Switzerland over the last twenty years by approximately 20% and amounts to 75 grammes per day for unpurified crude water and to 50 grammes per day for purified water. The *m.c.h.* for

sewage sludge<sup>5</sup> is generally assumed to be 1.5 litres per day with a water content of 95%. The *m.c.h.* for phosphorus<sup>5</sup> has risen to approximately 4 grammes per day. In Switzerland roughly one-third of phosphates originate in agriculture, one-third from natural sources, and one-third from domestic waste water (including the residues of washing products). The degree of water pollution also varies considerably. At the present time *one half of all waste water and sewage is being purified by mechanical-biological techniques*. In some localities—still few—there is a *third purification stage* in which noxious substances, especially phosphates, are flocculated out. For the Lake of Constance and the Lake of Geneva there are international commissions for water protection with special laboratories in the different countries involved.

Since we have especially problems of eutrophication and since according to W. STUMM (EAWAG, Dübendorf) 1 mg of phosphorus can create 100 mg of algae with an oxygen consumption of 140 mg, an important part of environmental research in Switzerland deals with this phenomena—especially at the EAWAG. The different lakes behave quite different—also in different years—which is shown when test samples are distributed both vertically and horizontally. Fig. 5 shows the oxygen content of Lake of Constance, of the Lake of Zurich and of the very clean Lake of Brienz.

Fig. 5

Oxygen content of 4 Swiss lakes towards the end of the stagnation period (autumn) in recent years<sup>5</sup> (H. Ambühl)



E. THOMAS<sup>7</sup> has found that the epilimnium (depths greater than 20 metres) in the lower section of Lake Constance contained, approximately, 12,000 tons of oxygen prior to 1940, 7000 tons in 1943, 10,000 tons from 1955 to 1960, 8000 tons in 1961, 7500 tons in 1964 and again 18,000 tons in 1970. Around 1920 the density of algae cells was 40 per cubic meter, around 1965 70,000 algae cells per cubic meter. In the meantime both the colour and transparency of the water have shown marked improvement. This positive development is one result of the introduction of the third stage of purification of sewage, but is also attributable to the favourable weather conditions of recent years which resulted in an

increased inflow of water. The cleaning up of the Lake of Zurich has also produced positive effects.

The chemical oxygen requirement of the Rhine at Schaffhausen amounts to approximately 5 mg/l, at Basle roughly 10 mg/l and at Düsseldorf approximately 20 mg/l<sup>8</sup>. The biochemical oxygen content of the Upper Rhine has fallen since 1954 from 10 mg/l to 8 mg/l (in the Lower Rhine from 5 mg/l to 1.6 mg/l)<sup>9</sup>. It has been proposed by A. E. CHEVALLEY (see NZZ, August 17, 1973) to inject 14400 tons of oxygen per hour into the lake of Geneva.

As the quantities available of oxygen, nitrogen and phosphorus are not proportional to the vegetable cell's needs of the various substances, supplies of the latter are used up at different speeds<sup>5, 10</sup>. In Switzerland it is generally phosphorus which is first totally consumed, with the result that algae growth is controlled. E.g. the phosphorus content of the Lake of Lucerne has on average increased from 1963 to 1971 from 15 µg/l to 25 µg/l, although there were large variations.

Fig. 6

Horizontal distribution of concentrations of phosphorus, nitrate and total pigments in an arm of the Lake of Lucerne.

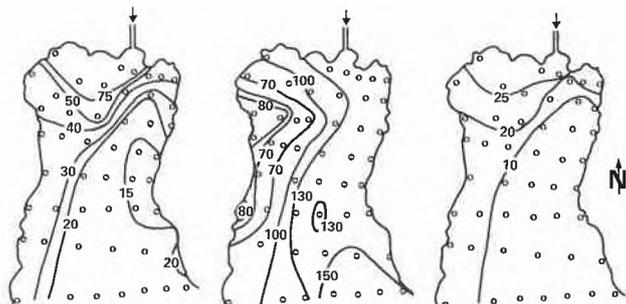


Fig. 1a Horizontal distribution of the total phosphorus concentration in the Bay of Horw (data in µg P per litre)

Fig. 1b Horizontal distribution of nitrate concentration in the Bay of Horw (data in µg N per litre)

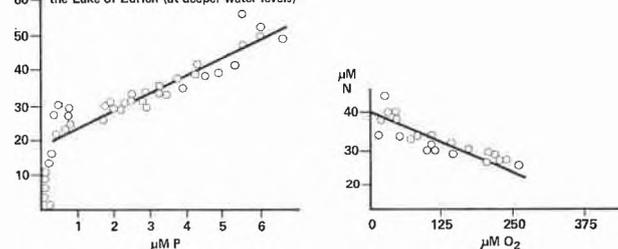
Fig. 1c Horizontal distribution of total pigment in the Bay of Horw (data in µg per litre)

Fig. 6 indicates that a correlation exists between algae production and the concentration of phosphorus, but not with the concentration of nitrates.

The stoichiometric correlations between dissolved nitrogen and phosphorus content and between these two factors and oxygen content were measured in the Lake of Zurich<sup>12</sup>.

Fig. 7

Correlation of the concentrations of dissolved nitrate, phosphate and oxygen in the Lake of Zurich (at deeper water levels)



It can be seen, as already suggested, that where the phosphorus content is zero the nitrate content is still considerable.

Besides university institutes and the chemical industry the Swiss textile industry is also making great efforts to bring pollution levels in waste waters under control. Symposia took place on this subject in Baden, near Zurich, on February 5, May 6 and October 28, 1972<sup>13</sup> during which it was emphasized that material balance sheets are essential if we are to identify the

Fig. 8

Example of day-long tests carried out in flowing water approximately 1 km below the entry point of effluent from a textile finishing plant.

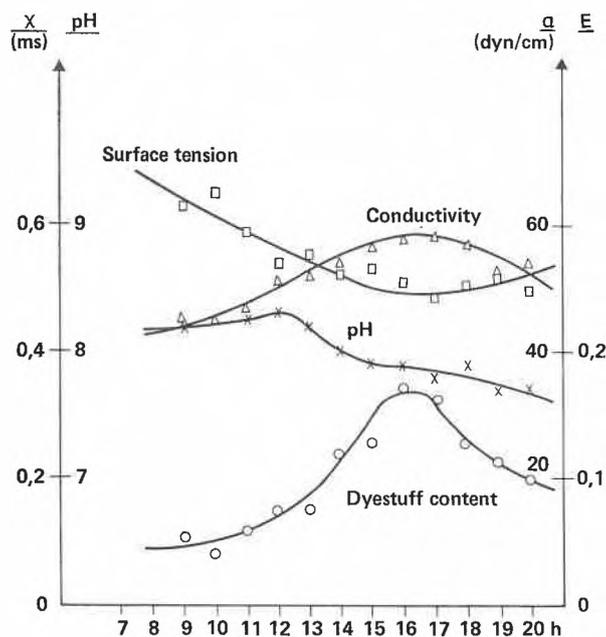


Fig. 9

Elimination of dyestuffs in the effluent purification plant of a textile finishing factory.

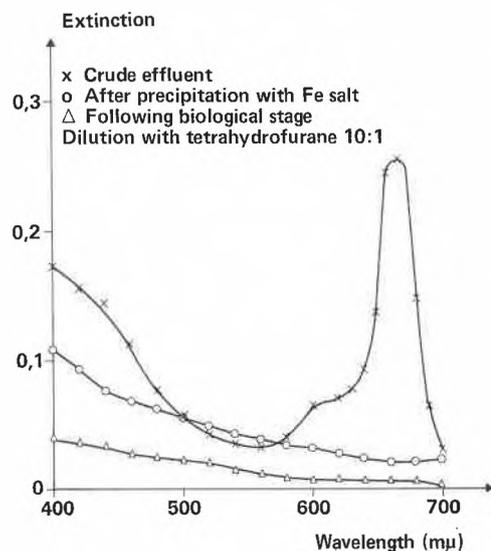
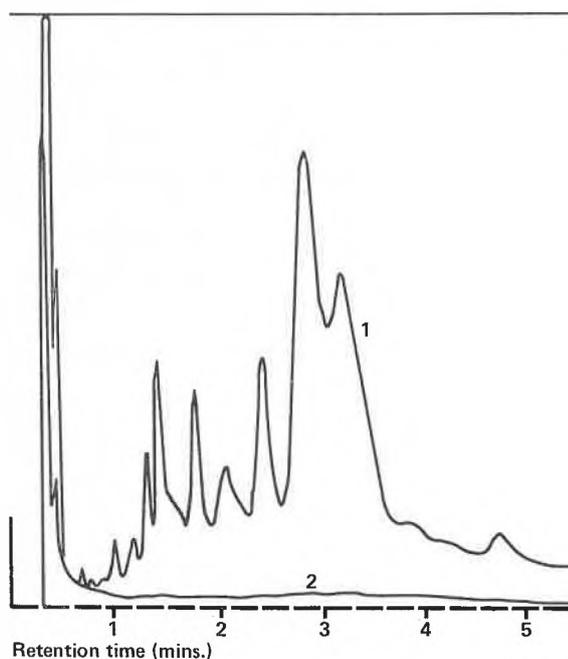


Fig. 10

Gas chromatographic evaluation of effluent in an experimental purification plant in a textile finishing plant (W. Schefer) before and after treatment.



Graph 1: Mixed crude effluent

Graph 2: After three-stage purification by flotation, oxidation and filtration

Carbon disulphide extracts

relevance of waste substances, and also that sampling and analytical measuring techniques must be improved<sup>14</sup>. It is promising to treat the wastes with ferric chloride, neutralizing them to precipitation and filtering them.

In the river Thur the colour of the waste effluent is primarily red because the blue and black dyestuffs are retained in the mechanical-biological purification plants (probably on account of their greater molecular weight, but also in some cases on account of hydrolysis to products which are not easily soluble).

W. SCHEFER (EMPA, St.Gall) following the American example, advocates legally prescribed pollution limits for the textile finishing industry, limits which would then have to be achieved by technological measures<sup>15</sup>. In Figures 8, 9 and 10 W. SCHEFER gives interesting examples for possibilities of monitoring effluents from textile finishing plants.

#### 4. Environmental research in Switzerland on heavy metals

In Switzerland as in other countries a relatively large amount of work is done on lead and mercury in the absence of certainty that these substances are of prime relevance in the Swiss sphere of environmental poisons. Little knowledge is also available on organic metal compounds in the environment.

W. STUMM (EAWAG, Dübendorf) has attempted to draw up a balance sheet for lead in Switzerland<sup>16</sup>. The amount of lead introduced into the environment by human beings in Switzerland is far greater than that originating in natural processes.

Fig. 11

Societal flow sheet on Lead in Switzerland (W. Stumm)

	Lead total tons p.a.	Per surface g/sq. meter/year
Marine aerosol	10 <sup>-4</sup>	2 x 10 <sup>-9</sup>
Continental aerosol	0.4	10 <sup>-5</sup>
Erosion	250	6 x 10 <sup>-3</sup>
Released by combustion of petrol containing tetraethyl lead into air	1.200	0.03 *
From waste from industrial products into water and soil	12,000 approx.	0.3 **

\* For comparison: Average in the USA 0,02 g/sq. meter/year

\*\* For comparison: Average in the USA 0,08 g/sq. meter/year

According to the Swiss guideline policy laid down in 1966 the lead content of waste effluent should not exceed 1.0 mg/l. It is currently being considered whether this value should not be reduced to 0.1 mg/l. The concentration of soluble lead in Swiss rivers lies between 2 and 12 µg/l, which is within the range of the global mean natural lead content of lakes and rivers.

A series of research studies, measurements and commentaries exist on the subject of lead pollution from gasoline<sup>17, 18</sup>. As in the countries of the EEC, gasoline in Switzerland is permitted to have a maximum lead content of 0,63 g/l or half as much as the present permitted level in the USA. Commercial regular grade gasoline contains only 0.25 to 0.50 g/l of lead, while super grade gasoline has a lead content of between 0.45 and 0.63 g/l. From January 1, 1974 the content has to be reduced under 0.40 g/l.

Professor D. HOEGGER of Zurich spoke<sup>19</sup> in Amsterdam on various measurements (Fig. 12):

Fig. 12

Air pollution with Lead from traffic in Switzerland (D. Högger)

	1950	1963	1970	1971
Petrol consumption in Switzerland (tons)	308,000	1,254,000	2,110,000	2,360,000
Lead emission in Switzerland (tons)	130	555	1,108	1,236
Average lead content of street dust in Zurich (α/α) *	1.04	1.93	0.94	
Average lead content of air in the city of Zurich (µg/m <sup>3</sup> ) **	1.5	2.7	3.8	9.1

\* For comparison: Average of 77 U.S. Cities: 2.0 % (W.F. Hunt et al)  
Los Angeles: 3.4 % (T.-J. Chow)\*\* For comparison: Average in Philadelphia and Los Angeles Downtown: 3 µg/m<sup>3</sup>  
Maximal Concentration: Los Angeles 11 µg/m<sup>3</sup>, Philadelphia 8 µg/m<sup>3</sup>

In looking at the figures for 1970 and 1971 it must be borne in mind that it rained a great deal in 1970 and very little in 1971. The lead content of clover at a distance of 5 metres from the Geneva-Lausanne expressway has been found to be 83 ppm; at 20 metres 23 ppm;

and at 80 metres 8 ppm, all expressed as proportions of the dry weight. These findings are similar to measurements in the USA<sup>20</sup>. Today normal hay contains 10 ppm of lead (dry weight) and milk for human consumption 0.01 to 0.02 mg per litre of lead<sup>18</sup>.

From 1948 to 1972 M. LOB *et al.* determined, for various groups of individuals, the lead content of the blood and the coproporphyrine content of the urine in order to obtain valid data on the possible effect of lead on the health of human beings<sup>21</sup>. The average lead contents of the blood of different population groups are between 14 µg/100 g and 33 µg/100 g, which result is similar to the USA. Only workers in a lead cable factory had a lead content of 75 µg/100 g blood. According to an interesting comparison of H. A. SCHROEDER and I. H. TIPPON<sup>22</sup> the medium lead concentration in total adult human bodies is 122 ppm/ash in nine U.S. cities, 137 ppm/ash in San Francisco, 94 ppm/ash in the Far East, 78 ppm in the Middle East, 63 ppm in Africa and 62 ppm in Switzerland.

Despite the pollution of the environment by lead there is therefore no indication so far among the general public in Switzerland of any increase in the lead content of the blood, or of the levels of coproporphyrine or ALA in the urine, nor have any lead symptoms been detected in clinical tests. But since nobody can say just how far away we still are from the danger zone and since lead is accumulated in the human body, D. HOEGGER and M. LOB advocate a reduction of the lead content of petrol in line with the increase in the number of motor vehicles.

According to R. H. H. RICHTER and CH. SCHLATTER there are no cases on record in Switzerland of the poisoning of domestic or wild animals where this could be attributed with certainty to lead from vehicle exhausts<sup>18</sup>. In the case of herbivorous animals oral intake of lead exceeds respiratory intake by a factor of about 100. Ruminants and horses normally have 5 to 25 µg/100 g of lead in the bloodstream. Levels of up to 150 µg/100 g do not give rise to any clinical symptoms. In order to reach this level of lead content it would be necessary, after all, to increase the average lead content of the hay eaten by such animals by a factor of 15. R. ZUBER<sup>23</sup> has measured the lead contents of different organs of cows, as can be seen from figure 13.

From the last column it results that there is especially a concentration in the liver, the bones and the urine.

According to tests carried out by T. KELLER<sup>18</sup>, the roots of spruce trees assimilate very large quantities of lead from the soil, but this lead appears to remain in the roots, i.e. it is not mobile within the tree. 90% or more of the lead content of year-old spruce twigs and needles adheres to the surface of the plant and can be washed off with diluted acids and detergent solution. The polluted needles show impairment of CO<sub>2</sub> assimilation, but this is not necessarily connected with any possible lead toxicity.

Fig. 13

Lead contamination of cows (R. Zuber)	Lead content of dairy cattle on normal fodder	Lead content of dairy cattle fed for a prolonged period on hay with a lead content of 99 ppm.	Relationship between lead-polluted and lead-free fodder
Muscle (mg/kg fresh substance)	0,08	0,24	3 : 1
Kidney (mg/kg fresh substance)	0,14	1,58	11 : 1
Liver (mg/kg fresh substance)	0,08	1,66	21 : 1
Pelvic bones (mg/kg fresh substance)	1,33	24,99	19 : 1
Udder (mg/kg fresh substance)	0,05	0,56	10 : 1
Dung (mg/kg dry substance)	16,7	215	13 : 1
Urine (mg/litre)	0,04	0,80	20 : 1
Milk (mg/litre)	0,02	0,04	2 : 1
Blood (mg/litre)	0,11	0,14	1 : 1

Since lead tetramethyl and lead tetraethyl are rapidly destroyed in open-air conditions, only small quantities were found in the immediate vicinity of exhaust pipes<sup>24</sup> and none in Zurich's air<sup>25</sup>. In closed parking garages and car service workshops, on the other hand, the atmosphere contains on average 11  $\mu\text{g}$  of inorganic lead per  $\text{m}^3$  as suspended dust and 16  $\mu\text{g}$  of organic lead<sup>24</sup>.

In the following table W. STUMM<sup>16</sup> has worked out a material balance sheet for mercury. The concentration of mercury in the sediment of the more polluted Swiss lakes, and of the Rhone is similar to the concentrations found in the Lake Ontario, the Lake Superior and the Lake Erie<sup>26</sup>.

According to the Swiss guidelines laid down in 1966, the level of mercury content of waste effluent should not exceed 0.1 mg/l. It is currently being examined to reduce this limit to 0.01 mg/l.

The Swiss papermaking industry has not made use of mercury compounds for a number of years<sup>27</sup>.

The use of mercury compounds in agriculture is being carefully monitored and is restricted to the disinfection of seeds<sup>28</sup>. Depending on the preparation used, approximately 0.5 mg of mercury per sq. meter enters the soil annually, whereas the content of mercury from natural sources amounts to 8 to 22 mg per sq. meter. In order to reduce the utilization of mercury compounds the agronomic research stations are working on the resistance breeding of plants and on integrated and biological pest control.

Fig. 14

Societal flow sheet on Mercury in Switzerland (W. Stumm)

	Mercury total tons p.a.	Per surface g/sq. meter/year
Marine aerosol	$10^{-4}$	$2 \times 10^{-9}$
Erosion	0.8	$2 \times 10^{-5}$
Continental aerosol, including evaporation from the earth's crust	0.8 - 8	$2 \times 10^{-4}$
Hg released into the atmosphere as a result of the use of fossil fuels (Switzerland) with a content of 5 ppm, when 10 % of the ash enters the atmosphere.	6	$1,5 \times 10^{-4}$
Artificial Hg load from increased Hg concentration in sediments.	5	up to $1,2 \times 10^{-4}$
Wastes from Mercury consumption (water, soil)	45	$10^{-3}$

The tolerance limit for fish and canned fish products is 0.5 ppm as in the USA and this limit is also being extended to apply to other forms of meat and feeding-stuffs. The cantonal chemist for the city of Basle investigated the mercury content of fish from the Rhine. Levels of 0.2 to 1 ppm (average level 0.47 ppm) were found in the flesh of such fish, and an average mercury content of 3 ppm, with levels in individual cases of up to 15 ppm, were found in the livers of these fish<sup>29</sup>. Since the amount of fish eaten in Switzerland on average is low, and in view of the fact that fish livers are generally discarded when fish are gutted before cooking, this level of mercury content can still be tolerated.

##### 5. Environmental research in Switzerland on halogenized hydrocarbon substances (including pesticides, PCB and solvents)

These investigations were carried out in Switzerland mainly in industry, at agronomic experimental stations and by cantonal chemists. As examples of measurements carried out by the latter, the results of a number of experiments conducted by the cantonal chemists for the city of Basle, M. REFARDT and M. SCHÜPBACH, are quoted here<sup>29</sup>. Approximately 10% of Swiss cheeses and roughly 70% of imported French cheeses were the subject of complaint due to the fact that they contained excessive insecticides. Average insecticide content was:

Fig. 15

Insecticides in cheese (M. Refardt, M. Schüpbach)

	Maximum permissible limits ppm	Insecticides in Swiss cheeses ppm	Insecticides in French cheeses ppm
Lindan & $\alpha$ HCH	0.10	0.08	0.15
Heptachlorepoxyde	0.12	0.00	0.10
DDT & metabolites	0.12	0.07	0.05
Dieldrin	0.12	0.03	0.04
Hexachlorobenzene	0.30	0.04	0.04

Certain samples of milk and butter had also to be destroyed due to the fact that they contained excessive quantities of lindan. The sale of eggs and frozen whole egg from Eastern Countries was also prohibited because of excessive DDT content. It is interesting that cigarettes contain, on average, 13 ppm DDT. In smoking tests carried out at the cantonal laboratory in Lausanne it was shown that 8 to 15% of DDT residues were still present in smoke condensate. In the case of heavy smokers this residual DDT load from cigarettes has a greater effect than that from foodstuffs. In Basle breast milk from healthy mothers contains on average 1 ppm hexachlorobenzene and 5.5 ppm DDT and metabolites. Since 1962 no DDT is produced anymore in Switzerland.

A relatively large number of investigations are carried out on the content of organic chlorine compounds in the Rhine. Approximately 5 to 10% relate to herbicides and pesticides, but the majority is accounted for by solvents. The Upper Rhine (flowing out of Switzerland) contains roughly 5 ppt PCB whereas the Main has a content of 80 ppt PCB. The Rhine at Bingen has an average daily "throughput" of approximately 25 kg lindan, 2 kg PCB, 1 kg endosulfan and 0.1 kg DDT<sup>30</sup>. Fish in Lake Constance contain 0.2 ppm PCB, while those at Karlsruhe and Düsseldorf contain 8 ppm and 17 ppm PCB respectively, whereas fresh waterfishes in the USA contain 0.2 to 100 ppm on wet weight.

Figures 16 to 18 give a selection of typical scientific projects which have been accomplished by the Swiss chemical industry. It has been found that in the dege-

Fig. 16 (H. Geissbühler, G. Voss)

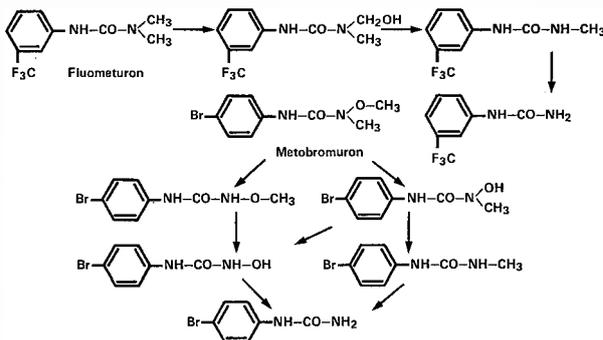
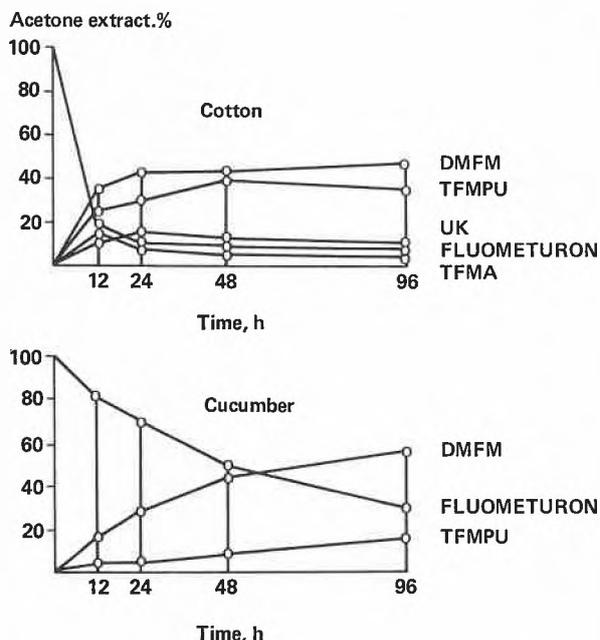


Fig. 17

Amounts of <sup>14</sup>C-labelled fluometuron and its radioactive metabolites as a function of time in cotton and cucumber leaves. DMFM, 3-(3-trifluoromethylphenyl)-1-methylurea; TFMPU, 3-trifluoromethylphenylurea; TFMA, 3-trifluoromethylphenylamine; UK, unknown metabolite (H. Geissbühler, G. Voss)

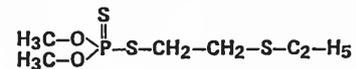


neration of *halogenized urea herbicides* in animals, in vegetable matter and in the soil, N-demethylation or N-demethoxylation occurs<sup>31</sup>.

The same scientists have been able to show that these primary urea substances in animals and plants are not further hydrolysed to produce the appropriate anilines. In contrast, this reaction does take place in the soil in the presence of special micro-organisms. On the other hand it was established that β-D-glucosides occur in plants<sup>32</sup>.

*Thiometone* is a systemic insecticide to combat plant lice (aphids) and spider mites<sup>33</sup>.

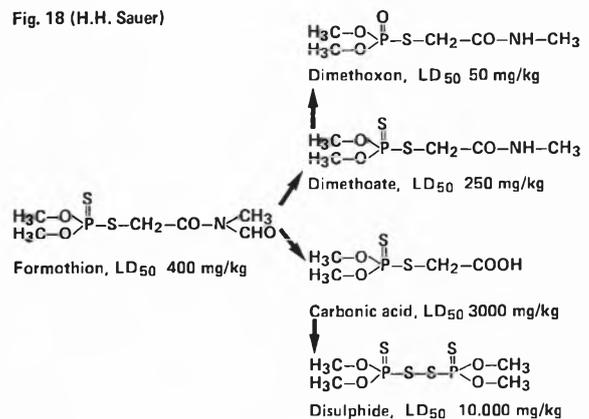
Thiometon (O. Jucker)



It is relatively non-toxic to warm blooded animals. Residual analysis based purely on measurement of the inhibition of cholinesterase is not suitable as the limit of enzymatic identification is roughly 10 ppm. Nor do colour or precipitation reactions lead to success. On the other hand thiometone—which is not stable in plants—and its metabolites, the sulfoxide and the sulfone, can be very effectively separated by paper chromatography and identified with bromine and fluoresceine with an identification limit of 0.04 ppm.

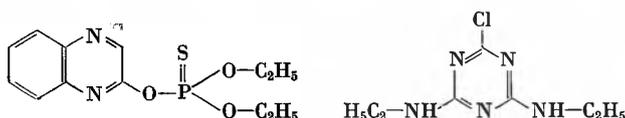
*Formothione* has an oral LD<sub>50</sub> in rats of approximately 400 mg/kg and is the active substance in the systemic insecticide Anthio<sup>34</sup>. The half-value time of this compound is approximately one day and the following metabolism has been established:

Fig. 18 (H.H. Sauer)



It is interesting to note here that, while considerable quantities of the more toxic dimethoates and dimethoxones occur, the less toxic by-products, carbonic acid and disulphide, operate synergistically with the result that greater long-term effects with lower quantities of the insecticide can be observed. Just how thoroughly the chemical industry provides documentation on new pesticides can best be judged from the example of Anthio 33. There are three brochures in existence:

*General Aspects* with 37 pages, *International Recommendations* with 21 pages and *Bibliography* with 20 pages and 170 items. This literature contains data on the following aspects: Analytical identification methods with an identification limit of 0.06 ppm, the nature of biological effects, metabolism in rats (non-toxic by-products occur which are eliminated), teratogenic, embryo-toxic, neurotoxic and chronic tests on rabbits, rats and dogs (no effects were observed in normal use), and finally on regulations for utilization and first aid measures. Residues of contact and stomach insecticides such as Ekalux 25 (active substances: quinalphos and its metabolite) and triazine herbicides such as Simazine



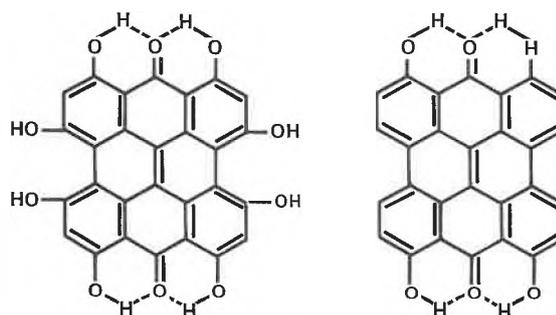
are best separated and identified by extraction, cleaning e.g. on Florisil or alumina oxide and sodiumhydrogen sulfate, followed by concentration, and gas chromatography using, for example model 1740-1 Varian Aerograph gas chromatography equipment<sup>35,36</sup>. Approximately 80% of the substances can be reidentified and the identification limit is in the region of 0.002 ppm.

## 6. Environmental research in Switzerland on non-halogenized hydrocarbons

As in other countries non-halogenized hydrocarbons in the environment originate to more than 50% from traffic, to about 10% from heating systems and to a small amount from industrial accidents. In Basle a *benzpyrene* level of 2 to 15  $\mu\text{g}/1000\text{ m}^3$  air was established in 1963 (for comparison: San Francisco 7.5  $\mu\text{g}/1000\text{ m}^3$ , London 46  $\mu\text{g}/1000\text{ m}^3$  and Hamburg approximately 200  $\mu\text{g}/1000\text{ m}^3$ )<sup>17</sup>. The quantity of benzpyrene inhaled by an inhabitant of Zurich is probably approximately the same as that inhaled by a person smoking 5 to 6 cigarettes per day, i.e. an annual amount of approximately 70  $\mu\text{g}$ . This is roughly the same amount as in Los Angeles and San Francisco, which have an oxidizing atmosphere, but something like 5 times less than is the case in other American cities where, as in Zurich, the atmosphere is reductive<sup>37</sup>. In respect of the quantities of polycyclic aromatics in waters<sup>38</sup> the basic concentration in ground water is 10 to 40  $\mu\text{g}/\text{m}^3$ , the Rhine at Stein am Rhein and Lake of Zurich in summer, autumn and winter contain app. 40  $\mu\text{g}/\text{m}^3$ , the Lake of Zurich in spring contains app. 100  $\mu\text{g}/\text{m}^3$ , the Rhine at Rheinfelden, near Basle contains app. 300  $\mu\text{g}/\text{m}^3$ , the Middle and Lower Rhine app. 2000  $\mu\text{g}/\text{m}^3$  and the effluents from biological sewage plants contain about app. 50,000  $\mu\text{g}/\text{m}^3$ .

The quantities measured in Swiss rivers and lakes are, *per se*, too low to be significant for carcinogenesis since larger quantities are ingested orally with foodstuffs and because 3.4 benzpyrene assimilated orally is much less of a hazard than if absorbed through the skin. In this connection reference should be made to the important scientific studies carried out by a Swiss in the USA, Dr. M. BLUMER in Woods Hole. Dr. BLUMER differentiates between natural and synthetic organic compounds in the water and in the earth. He was able to demonstrate the occurrence in fossilized water lilies in the Bernese Jura Mountains of fossilized organic pigments, namely polycyclic hydroxyquinones such as, for example:

Organic pigments in petrifications in the Swiss Jura (M. Blumer)



He also found natural 3.4 benzpyrene in various soils.

*Lower molecular organic pollutants* (with boiling points between 60°C and 200°C)—in the air and in particular vehicle gasoline—were determined by K. and G. GROB<sup>25</sup> using a gas chromatograph manufactured by Carlo Erba, of Mailand and model CH 5 Varian MAT mass spectrometer. The air components were first enriched with very fine-grain active carbon (25 mg carbon to 100 to 20,000 liters of air) and were subsequently extracted with carbon disulphide or recovered by evaporation. Recovery under the conditions described was complete.

As can be seen from Fig. 19 the organic pollutants in the Zurich city atmosphere consist mainly of unchanged gasoline from motor vehicles.

The only compounds in the air not found in gasoline were tetrachlorethanes (16) or limones (39a). The latter is a natural pollutant from vegetable sources.

The presence of heptane (4) and octane (10) are mainly attributable to gasoline, whereas nonane (18), decane (27), undecane (39) and dodecane (49) have their origin in diesel oil or domestic heating oil. A number of iso alkanes also originate from diesel oil.

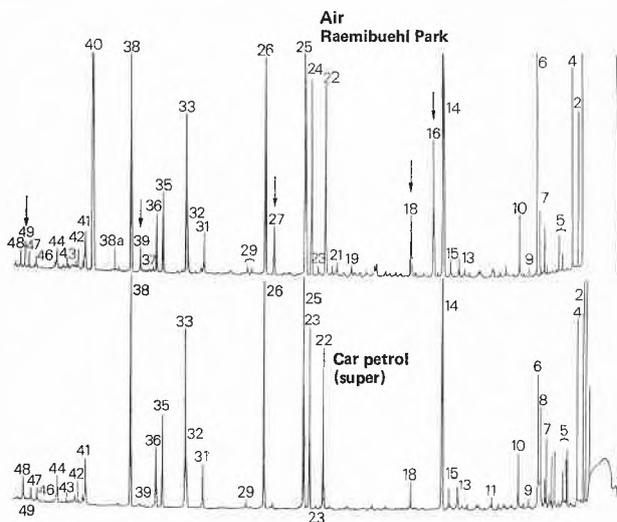
In Zurich and in Baden the following average levels for 1964/65 were measured: 0.01 ppm isobutane, 0.02 to 0.03 ppm *n*-butane and 0.01 to 0.03 ppm isopentane, which is about half the measured levels in Los Ange-

Fig. 19

## Hydrocarbons in Zurich Air (K. Grob and G. Grob)

Top: 100 litres of air vacuum-fed through a filter containing 25 mg active carbon; filter extracted with carbon disulphide; 2 microlitres of the solution injected directly into capillary glass column 88m/0.32 mm, coated with Ucon LB 550 and Ucon HB 280, at 25°C then programmed to 120°C.

Below: Solution of super grade petrol and carbon disulphide (1,000 : 1) chromatographed under conditions identical to those for the solution of atmospheric substances. For key to signals see table below. Signals in respect of substances occurring exclusively in the air or in greater concentration are indicated by arrows.



## Key to the substances identified in the illustrations (K. Grob and G. Grob)

1 n-hexane	14 toluene	27 n-decane	40 inner standard (1-chlorooctane)
2 isomeric heptane	15 isononane	28 isodecane	41 1, 2, 3-trimethyl benzene
3 isoheptane	16 tetrachloroethane	29 iso undecane	42 propylmethyl benzene
4 n-heptane	17 isonones	30 ethenyl benzene	43 C <sub>4</sub> benzol
5 isomeric octanes	18 n-nonane	31 propyl benzene	44 ethyldimethyl benzene
6 benzene	19 isodecane	32 4-ethyl toluene	45 benzaldehyde
7 isooctane	20 n-nonene	33 3-ethyl toluene	46 ethyldimethyl benzene
8 isooctene	21 isodecane	34 ethenyl benzene	47 isopropylmethyl benzene
9 isomeric octanes	22 ethylbenzene	35 2-ethyl toluene	48 isopropylmethyl benzene
10 n-octane	23 isodecane	36 1, 3, 5-trimethyl benzene	49 n-dodecane
11 isonones	24 p-xylene	37 iso-undecane	50 indene
12 isonones	25 m-xylene	38 1, 2, 4-trimethyl benzene	51 1, 2, 4, 5-tetramethyl benzene
13 isomeric nonanes	26 o-xylene	39 n-undecane	52 1, 2, 3, 5-tetramethyl benzene
		39 a limones	

les<sup>37</sup>. It was possible to identify indene (5) and benzaldehyde (45) directly behind the exhausts of motor vehicles but not in the atmosphere: they are therefore obviously short-lived compounds<sup>25</sup>. On the other hand, relatively high quantities of aromatics were detected, e.g. on Friday March 17, 1972 between 7.30 a.m. and 8.00 a.m. (rush hour) as is shown in the following table:

Fig. 20

## Aromatics in Zurich streets (K. Grob and G. Grob)

	Milchbuck (highest concentrations)	Average of 9 measuring locations
Benzene	74 ppb	app. 35 ppb
Toluene	121 ppb	app. 50 ppb
m-Xylene	48 ppb	app. 20 ppb
n-Nonane	4 ppb	app. 2 ppb
n-Decane	2 ppb	app. 1 ppb

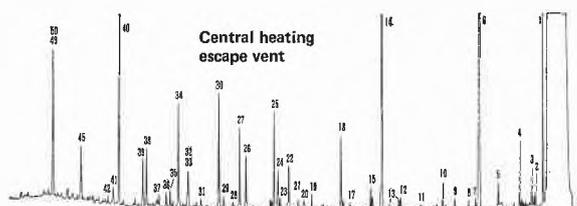
For comparison: Toluene in Los Angeles: 90 ppb (W.A. Lonneman et al)<sup>39</sup>

From Fig. 21, which with respect to concentration is also comparable with Fig. 19, it can be seen that approximately the same amounts of waste fumes are found in the outlet vent of central heating systems. Central heating thus plays a minor part as a source of pollution for organic substances. At Zurich-Kloten airport only relatively weak signals of normal alkanes and benzenes were found, owing to the fact that the kerosene in jet engines is very largely consumed.

Fig. 21

## Comparison of waste fumes from a central heating vent and the atmosphere at Zurich-Kloten Airport in a gas chromatogram.

In each case 100 litres of waste fumes was collected and analysed under identical conditions as for Figure 1. Above: undiluted waste fumes from the central heating escape vent of a three-family house, collected with the heating flame ignited. Below: Samples collected between the west runway and the west hangar of Zurich Airport at midday during a quick succession of take-offs. A light northwest wind bore the fumes to the measuring point. For the strangement of the signals see the table.



Mainly normal alkanes, together with pyrolysis products such as benzenes (6); total of organic substances not greater than in an urban atmosphere.



Mainly normal alkanes, some benzenes (6), on the whole low pollution owing to the high degree of combustion in jet engines.

According to the guide line policy laid down in 1966 on the properties of waste effluents to be discharged, the level of hydrocarbon content must not exceed 10 mg/l where such wastes are discharged into rivers, or 20 mg/l where the effluents enter a sanitation system connected to a mechanical-biological sewage plant. Determination of hydrocarbon content is carried out by the extraction of pentane and infra-red spectroscopy.

A recent study showed that the total level of organic carbons in Zurich's water supply was less than 1 mg C/l; less than 1 mg C/l in the Lake of Zurich and approximately 8 mg C/l after the river Aare enters the Rhine<sup>8, 40</sup>. The average level of inorganic carbons was approximately 5 times greater. It is interesting to note that these figures fluctuate depending on the water level, apparently because the self-cleaning effect is better when the water level is dropping (faster rate of flow). In addition to chlorinated organic compounds, more highly alkylated benzenes (e.g. butyltoluene, diethylbenzene,

tributylbenzene, and diphenyl), phthalic acid esters and butyl-substituted cresols were found.

Switzerland's surface waters—and particularly their sediments—contain substantial quantities of petroleum products. As a result of motor vehicle traffic approximately 1600 tons of lubricating oil and roughly 5000 tons of petrol (*via* the atmosphere) enter these waters annually. This represents approximately 7 g hydrocarbons per m<sup>2</sup> per year<sup>41\*</sup>.

**7. Environmental research in Switzerland on air hygiene (with special reference to inorganic gases such as SO<sub>2</sub>, CO, NO<sub>x</sub>, O<sub>3</sub>, HF)**

Fig. 22

The air in the city of Zurich contains, on average, the following pollutants:

20	ppm	carbon monoxide	
0.1	ppm	aromatics	(0.05 ppm toluene + 0.03 ppm benzene + 0.02 ppm m-xylene)
0.07	ppm	aliphatics	(0.01 ppm isobutane + 0.03 ppm n-butane + 0.03 ppm isopentane)
0.04	ppm	sulphur dioxide	
0.03	ppm	formaldehyde	
0.03	ppm	nitrogen dioxide	
130	µg/m <sup>3</sup>	floating dust	(containing 8 µg/m <sup>3</sup> 3.4 benzpyrene and 5 µg/m <sup>3</sup> lead oxide)

For comparison: Average of Chicago, Cincinnati, Denver, Philadelphia, St. Louis and Washington: 42

5	ppm	carbon monoxide
0.04	ppm	sulphur dioxide
0.03	ppm	nitrogen dioxide
100	µg/m <sup>3</sup>	floating dust

The composition shown here is typical for a city in central Europe. According to a study carried out in 1972 by the OECD, SO<sub>2</sub> occupies—in terms of priority—the leading position in central Europe whereas, in the United States, it is only in position no. 8<sup>43</sup>.

W. STUMM (EAWAG, Dübendorf) attempted to estimate the sulfur dioxide cycle in Switzerland<sup>16, 44</sup>. The concentration in the air of Switzerland correspond pretty closely to the level which one might expect in view of the annual consumption of heating oils. Obvious-

\* Since this lecture in Athens in April 1973 K. and G. GROB have published another important paper about organic pollutants in different waters in Zurich (see NZZ of September 10, 1973). Although their experiments are still progressing, they found provisionally the following order of magnitude of pollution:

Source of the water	Gasoline from motorcars	Tetrachloro-ethylene	Hepta-decane (natural from algae)
Lake: Surface	2,0 ppb	0,05 pph	20 ppt
Lake: Depth	0,1 pph	0,08 pph	2 ppt
Spring Water	0,1 pph	0,002 pph	0,6 ppt
Groundwater	0,8 pph	0,2 pph	0,1 ppt
Accident with Heating Oil	20,0 ppb	1,5 pph	

It can be concluded that the drinking water is still very clean. However K. and G. GROB suggest that one should know more about the source (gasoline from the individual traffic precipitated from the atmosphere is most important), about the differentiated dangers of the different pollutants and about the interactions between atmosphere and waters, as well as about the role of natural and artificial filtering systems.

ly this source of sulfur input has already outstripped the natural processes in terms of importance.

Fig. 23

Societal flow sheet on Sulfur in Switzerland (W. Stumm) (SO<sub>2</sub> is calculated by its sulfur content)

	g/sq. meter/year
In rain (For comparison: average in West Germany peak level in industrial regions up to	1,4 (8,9) (100)
Re-circulated by the sea (calculated from global rating)	0,06
Erosion	0,3
Combustion of heating oil in Switzerland (Consumption 1969: 7.5 x 10 <sup>6</sup> tons of oil with an average sulphur content of 0.6 %)	1,1

The SO<sub>2</sub> content of the air in Swiss towns is on the increase, since the amount of oil consumed is rising faster than the rate at which the sulfur content of oil is being reduced<sup>17, 29, 37, 45, 46</sup>. The maximum average daily level in December reached approximately 30% of the winter load limit of 0.3 ppm SO<sub>2</sub> imposed by the Federal Commission for Air Hygiene in 1964. The maximum concentration during a period of twenty-four hours tend to be rather less favourable than those for the majority of German cities, in particular Munich, Frankfurt and Cologne<sup>45</sup>, in spite of the fact that the winters of 1970/71 and 1971/72 were relatively warm.

The sulfur dioxide content of the atmosphere in rural regions is still low, amounting to a daily average of less than 0.01 ppm, even in areas with industry, such as cement factories and refineries<sup>17, 47</sup>.

Coniferous trees are particularly susceptible to danger from SO<sub>2</sub> since their organs of assimilation build up concentrations of SO<sub>2</sub><sup>17</sup>. Crops go through critical periods such as, for example, the period of blooming. An annual average of 0.02 ppm SO<sub>2</sub> can lead to a slower rate of growth in coniferous trees and an annual level of 0.07 ppm SO<sub>2</sub> can result in the extinction of such trees<sup>47</sup>. The situation in Basle is that only robust plane trees, robinia (false acacia) and pointed-leaf maple trees can be planted and these reach a maximum age of only 60 years instead of 100 to 300 years. Limes, whitethorns, rowans and chestnut trees can no longer stand up to the atmosphere<sup>48</sup>.

The measurement technique used for SO<sub>2</sub> is that developed by WEST and GAEKE Baton Rouge using an aqueous solution of sodium tetrachlor-mercurate with p-rosaniline hydrate of chlorine and formaldehyde acidified with hydrochloric acid, or the automatic monitoring with so-called Liesegang bells or for instance an Ultragas VES analyser manufactured by the Westhoff Company<sup>29</sup>.

In regard to legislation on the subject of air hygiene D. HOEGGER and the Federal Office for Energy<sup>47, 49</sup> postulate the objective of keeping the atmosphere as clean as possible (see Fig. 24).

Fig. 24

The following measures to combat air pollution by sulfur dioxide are under consideration in Switzerland (Federal Office for Energy):

- improved control of oil heating systems
- limiting of the sulphur content of oil for domestic heating to 0.5 %
- limiting of the sulphur content of oil for industrial use to 2 %
- improved insulation of houses with a view to reducing fuel consumption
- promotion of remote heating installations for residential areas.

The general level of air pollution should not exceed the 1970 level, which means further reduction of the sulfur content in oil. Where hazards already exist reduction of pollution should be effected. This would be simpler than laying down limit values for emissions and monitoring such values. It is unclear, however, how local variations should be handled.

For carbon monoxide-monitoring self-registering Uras devices manufactured by HARTMANN and BRAUN and Unor-co analysers are used<sup>29, 37</sup> in different cities in Switzerland. As shown in Fig. 22 the levels found at specific places were rather high and reached up to 40% of the maximum concentration which would be allowed for occupational safety. It is discussed to overtake the U.S. legislation<sup>50</sup>.

A test study carried out on 71 traffic policemen in Zurich showed that prolonged exposure to 20 ppm carbonmonoxide results, in the case of non-smokers, in approximately 4% CO haemoglobin. A level of more than 5% can lead to certain disturbances of the central nervous system (impairment of the sense of time and of vision) and to heart and circulatory symptoms<sup>51</sup>. Since in the case of smokers a further 6% CO haemoglobin is formed, the risk here is greater.

The levels measured in Switzerland for nitrogen dioxide and ozone are roughly ten times smaller than those in Los Angeles. Since solar radiation is also lower, no oxidizing smog nor has any peracyl nitrite been observed yet, mainly because Switzerland's atmosphere tends to be of a reductive nature.

The second report of the Federal Commission for Air Hygiene 1962–1967 contains data on fluorine as hydrogen fluoride, silicon fluoride, aluminium fluoride, etc., in the atmosphere<sup>17, 23</sup>. This is an immission which is quite important in some areas with alumina and ceramic industry such as the lower Rhone Valley and the neighbourhood of Rheinfelden; concentrations of fluor amounting to 5 to 25  $\mu\text{g}/\text{m}^3$  were measured. Cattle in the Valais show symptoms of fluorosis, and deaths among bees have also been observed as a result of the ingestion of pollen containing fluorine. For plants—particularly apricots and vine—fluorine is roughly 100

times more toxic than  $\text{SO}_2$ . Assimilation performance shows marked impairment. Peroxidase activity (this enzyme controls lignification (becoming woody) of the vegetable tissues) increases<sup>17, 52</sup>.

## 8. Conclusions

Within a short review it is not possible to give a complete and fair summary of all the environmental programs under way in one country. Of course besides the sciences the arts are important, besides short sight questions long term questions have to be answered and total approaches have to be considered. Since the Halifax-Athens-Symposium deals with the analytical chemistry of pollutants the present paper is more related to the actual work done in Switzerland as far as air and water hygiene, leaving out the important fields of environmental research on soils, solid wastes, agriculture, food and toxicology. This is again a very arbitrary selection within a very complex field of research. Some examples demonstrate however that there is an activity in Switzerland in this nowadays so important area. Perhaps what is needed in Switzerland as well as in other countries is an evaluation of the relevance of the different questions to elaborate a list of priorities: It is just not possible in a small country to work in every field which seems to be interesting. On the other side it has to be taken in account, that some basic informations are still missing to make an evaluation of the relevance of many questions possible not speaking of the interdependence between problems and sciences and arts. This needs additional research work and an improved information exchange between the different countries to avoid double work.

An other field where there is still much to do in view of future shortage of raw materials and to avoid pollution is of course recycling, which neither could be covered sufficiently within this paper. In the industry sludge of iron oxid, wastes of sulfuric acid and solvents are for instance recycled<sup>1, 53</sup>. Apart 1.3 million tons of domestic refuse, 1 million tons of commercial and industrial waste and 1 million tons of sewage sludge have to be disposed in Switzerland annually<sup>54</sup>. Expenditure on collection and processing refuse is probably of the order of 100 million dollars or 16 dollars per head of population. 1.7 kg of sulfur dioxide, 1.4 kg of chlorhydrogen and 0.6 kg of nitrogen oxide are emitted for every ton of refuse incinerated. Actually 20,000 tons of fertilizers could be recycled annually from refuse<sup>54</sup>. It may just be mentioned that special institutes make research for the utilization of refuse slag in road construction<sup>55</sup>. From 180 kg of combustible refuse per head of population one gets 65 kg of crude refuse slag. It contains the same components as Portland cement. Its resistance and stability are consequently unaffected to a surprising degree by water and frost. Its grain structure is also favourable.

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