the development of a methodology for their estimation should be prosecuted on a universal, international scale, since this would make it possible to obtain maps of the probable biological effects of various media (air, water, soil, food) for populated areas, regions, and the planet as a whole. This would in fact serve as a guide in the adoption of solutions.

It is necessary to go over to a new philosophy of the organisation of the life cycle of any article, any material, and any substance. This cycle must include in a unique whole the extraction of the raw material, transport, conversion of the raw material into the product, the utilisation of waste, ecologically clean employment of the product, and methods for its complete utilisation after the article has fulfilled its function (purpose). This in fact constitutes a closed "supercycle".

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Polychloropolycyclic xenobiotics

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Xenobiotics from a number of polychloropolycyclic compounds (PCPC) of the dioxin type such as 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF), their more highly chlorinated derivatives and also 3,3',4,4'-tetra-3,3',4,4',5-penta- and 3,3',4,4',5,5'-hexachlorobiphenyls (Table 1) are some of the most dangerous ecotoxicants passed into nature from the production of the chloro-compounds and from technologies based on the use of chlorine and its compounds.

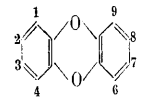
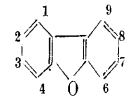
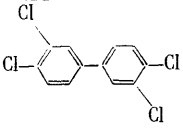
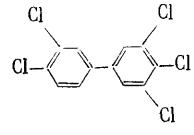
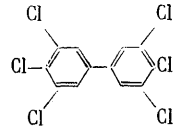
Some general properties of these xenobiotics (compiled in 1984) are given in a short review.[1] However, during the past five years the number of scientific publications on PCPC has more than doubled. Among the more than 1600 studies there are monographs, handbooks, and large reviews of the various aspects of the PCPC problem, summarising results on national and international programmes, results of national and international scientific meetings and conferences. New information, a significant part of which is presented in the proceedings of international symposia on 'Dioxin and Related Compounds',[2–5] has enabled a more ordered concept to be created of PCPC as poisons, ecotoxicants, on their influence on contemporary medicine and on the ecological situation. The most important conclusions are given below.

I. Toxic effects

Acute toxicity for warm-blooded animals is not now considered to be a criterion of the danger of PCPC for man. The primary and secondary effects of PCPC on an organism and their consequences, which depend substantially on the habitat and conditions of existence of the organism, have proved to be more important in this regard.

The primary effects of 2,3,7,8-TCDD and its analogues are linked with the high specificity of these xenobiotics towards the cytosolic A*h* receptor controlling primarily the activation of genes A1 and A2 (on the 15th human chromosome) and the set of non-specific monooxygenases, viz. cytochromes P-4501A1 and P-4501A2.[6] Recently a third locus activating the A*h* receptor has become apparent and has been investigated.[7] Participation of the complex of 2,3,7,8-TCDD with the receptor has also been shown in the suppression of a gene on the 16th human chromosome producing menadioneoxidoreductase.[8] A high affinity has been established for dioxin-type PCPC towards the nuclear thyroxine receptor and an increase in thyroxine receptor concentration has been shown in the nuclei of cells of animals poisoned with 2,3,7,8-TCDD.[9] These data suggest that the action of PCPC is directed towards a series of regulatory mechanisms of the living cell, selected in the course of evolution, started by receptor proteins with a single type of active centre. Haem, which is sterically accessible for planar PCPC, emerges as the most probable target, since of natural substances only the iron-porphyrins are capable because of their geometric and electronic parameters of interaction with all the known inducers of the dioxin type.[10]

Table 1. List and relative danger of polychloropolycyclic compounds.

Compound*	Relative danger	Compound*	Relative danger
			
2,3,7,8-TCDD	1.0	2,3,7,8-TCDF	0.1
1,2,3,7,8-PCDD	0.5	1,2,3,7,8-PCDF	0.01
1,2,3,6,7,8-HxCDD	0.1	2,3,4,7,8-PCDF	0.5
1,2,3,7,8,9-HxCDD	0.1	1,2,3,6,7,8-HxCDF	0.1
1,2,3,4,7,8-HxCDD	0.1	1,2,3,4,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDD	0.01	1,2,3,7,8,9-HxCDF	0.1
octa-CDD	0.01–0.001	1,2,3,4,7,8,9-HpCDF	0,1
		octa-CDF	0.01–0.001
	0.001		0.3
	0.01		

Footnote. Relative danger is given for carcinogenic risk.
* HxCDD is hexachlorodibenzo-*p*-dioxin; HpCDD is heptachlorodibenzo-*p*-dioxin; HxCDF is hexachlorodibenzofuran; HpCDF is heptachlorodibenzofuran.

On passing into an organism PCPC act as inducers of extended false responses enabling the accumulation of a series of biocatalysts-haemoproteides in quantities dangerous for cell and organism function. Essentially, the regulatory mechanisms affected by these xenobiotics lead to a disturbance of the protective mechanisms of the

organism towards xenobiotic and toxic products of metabolism, to disturbance of hormonal metabolism and suppression of the immune system. Consequently the primary effects of PCPC are linked mainly with disturbance of the genetically controlled adaptation mechanisms of the organism to its surroundings. Thus even weak PCPC affections, manifesting as a constant discomfiture of the organism, high fatigue, reduced physical and mental ability and increased susceptibility to infection, may lead to dramatic consequences under conditions of additional, normally readily endurable, physical, chemical, biological and psychological stress.

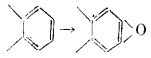
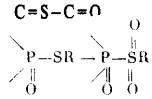
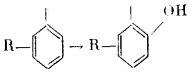
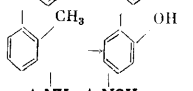
Secondary effects of PCPC on the organism are initiated by the biocatalyst-haemoproteides induced by them, of which only cytochromes P-4501A1 and P-4501A2 have been adequately studied. Accumulation of the latter is dangerous for two reasons. In the first place complexed with PCPC they trigger the mechanism for transforming the energy resources of the cell to the conversion of O_2 into $O_2^{\cdot}$, H_2O_2 and $HO^{\cdot}$, which leads to a mutagenic effect, the biodegradation of hormones, vitamins and lipids which are sensitive to oxidation, disruption of biomembranes and disturbance of the functions of membrane-bound complexes. Immune cells are particularly susceptible to similar actions. Secondly these biocatalysts participate in the biotransformation of a great number of xenobiotics and normal metabolites by converting them into hydroxylation and epoxidation products (Table 2). As a result there is increased biodegradation of several low molecular hormones, neuromediators, vitamins, aromatic aminoacids, drugs and bioactivation of foreign substances of which precursors of aflatoxin B_1, nivalenol, carcinogens, neurotoxic substances and strong nerve poisons are particularly dangerous. All these secondary effects of PCPC aid suppression of the primary effects and, in the presence of certain xenobiotics, to the appearance of ecological illnesses.

The effect of the accumulation of nuclear thyroxine receptors stimulated by PCPC has not yet been studied. It is only possible to suppose that it is equivalent to the known effect of hyperthyroidism (activation of oxidation processes, uncoupling of oxidative phosphorylation, general emaciation of the organism), appearing at an excess of hormones of the thyroid gland. In reality the symptoms of heavy PCPC poisoning coincide with the features of hyperthyroidism.

The ecotoxicity of PCPC is caused not only by their negative action of fauna but also by the particular sensitivity to them of aerobic microorganisms, the protective mechanisms and flexible metabolism of which are controlled by a system of haem-containing monooxygenases. Anaerobes and photosynthesising organisms are significantly less sensitive to them. Consequently the accumulation of PCPC in nature and their inevitable concentration in the organic phase converts the latter into an unfavourable habitat primarily for aerobic organisms which determine the ability of ecosystems for self-restoration. The inevitable consequence of this in soil ecosystems is an expansion of habitats of anaerobes and, linked with this, biodegradation of humus and impoverishment of soils. In aqueous ecosystems PCPC extend the habitats of various algae, the accumulation of which leads to deoxygenation of the medium and acceleration of the degradation of the system.

Thus both at the level of organisms and at the level of communities of organisms PCPC destroy the most vulnerable regulatory mechanisms of living matter which determine their capability for autorestoration under aerobic conditions. A viability regulatory link weakened by PCPC endures further destruction by any other stresses. Consequently the assertion is correct that after appearing and accumulating in the biosphere PCPC of the dioxin type remain an important factor determining the increased sensitivity of man and nature to any anthropogenic influence.

Table 2. Known effects of cytochromes P-4501A1 and P-4501A2.

Biochemical effect	Reaction type	Consequence
Epoxidation of ethylenic bond, inhibition of epoxyhydrolases	C=C→C–C (O)	Bioactivation and stabilisation of mycotoxins, terpenoids, etc.
Epoxidation of arenes		Bioactivation of procarcinogens, promutagens, biodegradation of drugs
Epoxidation of thionephosphates	P=S–P=O	Bioactivation of pesticides
Epoxidation of dithiocarbamates	C=S–C=O	Biodegradation of disinfectants
Oxidation of thiol ethers		Bioactivation of neurotoxicity
ortho-Hydroxylation of substituted arenes		Bioactivation of neurotoxicity
Hydroxylation of CH_3 group		Bioactivation of neurotoxicity
N-Hydroxylation of arylamines and their derivatives	ArNH→ArNOH	Bioactivation of procarcinogens
Dealkylation of alkylaryl ethers	$ArOCH_3$→ArOH	Accumulation of phenols

II. Danger of 2,3,7,8-TCDD and its analogues to man

The danger of PCPC of the dioxin type to man is no longer the subject of discussion. It is no secret that pregnant women and children comprise a special group at risk of PCPC poisoning among people,[5] and that in regions of increased PCPC content in the environment the population and animals are characterised by increased deficiency of the immune system,[11] which may reach dramatic levels when other poisoning factors are superimposed. All the accumulated information leaves no doubt that PCPC are one of the decisive factors determining the currently observed process of reducing the geno-background of the human population in individual regions of the globe.

The subject of scientific investigations and discussions is now the problem of determining the degree of danger for man of these poisons, which is extremely important for the regulation of an effective complex of measures for health in the medical and ecological fields. Regretably there are no significant achievements in this area since mankind has proved to be unprepared to solve so important a problem.

The particular complexity of the PCPC problem is that these xenobiotics, which possess extraordinary biological activity, pass into nature as complex mixtures. The 17 main substances of this type are shown in Table 1. If one considers that many bromo-, nitro- and some methyl-substituted analogues possess a similar action their quantity grows severalfold. However even for the mixtures of

substances shown in Table 1 determination of the degree of danger is extremely complex. For this it is necessary to have reliable methods of determining the compositions of such complex mixtures qualitatively and quantitatively, to know the complete toxicological characteristics of each component and to make apparent the character of the mutual influence of substances after intake by the organism.

Up to the present time the US Environmental Protection Agency and a group of experts from the Scandinavian countries have developed the first methodology for assessing the degree of danger of PCPC to man.[12,13] It is based on the assumption that the danger of PCPC may be assessed according to carcinogenic risk, that the character of PCPC action on man and animal species is like the action of 2,3,7,8-TCDD and that the total effect of a PCPC mixture on the organism is equal to the sum of the effects of its components. Proceeding from these assumptions the dose of 2,3,7,8-TCDD considered safe on chronic administration proved to be 1 pg per kg body weight of man per day and indices of relative danger were found for all isomers relative to 2,3,7,8-TCDD (Table 1). This enabled a definite concentration of an isomer mixture to be represented by the equivalent concentration of 2,3,7,8-TCDD and its admissible quantity in various parts of the environment, in drinking water and in food to be regulated.

Results obtained using such methodology proved to be optimistic since it assumes consumption by adult man of water and food containing PCPC at concentrations up to 20–35 parts per trillion in 2,3,7,8-TCDD equivalents. Fish products and undefatted meat products are foods in which PCPC accumulates up to such concentrations. However, human milk must be considered to be dangerous for children in industrial countries since the concentration of PCPC in it exceeds that permissible by 2–10 times. In addition a mass of other information refers to such a conclusion optimistically.

In the first place on examining populations of persons, including volunteers, subjected to the action of PCPC, it was shown that these xenobiotics are retained significantly longer in man than in experimental animals. The time for the half-elimination of dioxin is 7 years from human lipid tissue, 1 year from monkeys and from several days to several weeks from other animal species. The absorption of dioxin is also appreciably greater in the human gastro-intenstinal tract (85% and more) compared with animals. It also turns out that highly chlorinated PCPC are retained longer than TCDD and TCDF. In animals, as in soil, they are subject to reductive dechlorination to more toxic compounds, which causes their unusual toxokinetics. Thus in animals poisoned with octa-CDD, symptoms typical of dioxin poisoning are displayed only after 13 weeks.[14] All these data cast doubt on the reliability of the methodology considered above for assessing the danger of PCPC to man. It does not consider the enhanced ability of these xenobiotics towards bioconcentration and retention by man, the inevitable result of which must be a strengthening of the long term after-effects of poisoning.

Secondly material appearing in recent years indicates the significantly higher danger of PCPC poisoning of the immune system than the carcinogenic risk. Thus in experiments on primates using food containing 5 parts dioxin per trillion for a year a strong and extended (up to 4 years) reduction was shown in the number of immune cells and in the T_4/T_8 ratio which indicates the extremely strong suppression of cellular immunity by these poisons and primarily of lymphocyte-helpers. This needs watching over since contemporary illnesses such as AIDS, T_4-leukaemia, Legionnaires' disease, etc. are linked precisely with T_4 cell activity. The extemely strong dose-dependent influence of dioxin on the immune system after oral administration (from the suppression of interleukin-1 synthesis and the sensitivity of T-lymphocytes to it, suppression of antibody formation, viability of B-lymphocytes and their bone marrow precursors to atrophy of the thymus and depletion of lymphoid tissue) is linked with the direct inflow of this xenobiotic from the gastrointestinal tract to bone marrow and subsequent migration to the thymus with poisoned cells. This must explain the excessive distribution, in regions of PCPC accumulation, of illnesses such as viral hepatitis and various intestinal infections in people and intestinal infections, viral distemper and other illnesses in animals. In such regions the status of babies and children, whose immune systems are just being formed, is particularly dramatic, the treatment of infections is greatly hindered since PCPC increase the biodegration of drugs in man and induce resistance of microorganisms to them.

The sensitivity of the immune system to substances related to dioxin is only beginning to be investigated. First results show that the danger of polychlorodibenzofurans and biphenyls for animals linked with the risk of affecting the immune system is incomparably greater than the carcinogenic risk and in this respect they are probably more dangerous than polychlorodibenzo-*p*-dioxins.[15] This correlates with the special features of their interaction with iron-porphyrin as a result of which furans and biphenyls possess high substrate specificity to a wider collection of haemoproteides than dioxins.[16]

The study of the influence of PCPC on the immune system begun in recent years is a new, significantly more difficult step in the understanding of the secrets of the actions of these xenobiotics on living matter. Chemically the main difficulty of the investigations at this step is the need to develop uniquely sensitive methods for the qantitative determination of PCPC, since the information already existing enables their danger to be considered according to the risk of affecting the immune system at concentrations of the order of tens of parts per quadrillion. Not by chance evidently, the US national programme on dioxin even in 1985 provided for the development of a method for the analysis of 2,3,7,8-TCDD with a sensitivity greater than 10^{-15} g g^{-1}.

III. Sources of dioxin-type PCPC

Investigations in recent years have led to the uncontrolled development by man of technology based on the use of chlorine and its compounds. This development has forced planning of such problems as the possibility of creating ecologically harmless chloro-compound manufacture, an ecological foundation for further large scale chlorine manufacture, the use of inorganic chlorides, in electrochemical, pyrometallurgical processes, the use of chlorine-containing oxidising agents in processes for treating material of natural origin, etc. The investigiations have stimulated searches for the rapid development of technology unconnected with the formation or use of chlorine for obtaining caustic soda, potash, oxides of alkaline earth and transition metals, etc., since PCPC are formed in dangerous quantities in a vast number of the technologies using chlorine, its organic and inorganic derivatives, in the presence of carbon and its compounds.

It has been shown in several countries that in the industrial synthesis of organochlorine compounds, the processing and use of the products introduces the maximal quantity of PCPC into the environment. Particularly dangerous are the majority of high

temperature processes for chlorinating organic substances, pyrolytic processing, combustion of organochlorine compounds and the synthesis and use of so-called PCPC precursors in nature, which include tri-, tetra-, pentachlorophenols, polychloropyrocatechols and their derivatives, 3,4-dichloroaniline and its derivatives, polychlorobenzenes and other polychloroaromatic compounds, isomeric hexachlorocyclohexanes, including Lindane, etc. All these compounds are converted into PCPC not only on pyrolysis or combustion but also on metabolism *in vivo* and on oxidation in the presence of haemoproteides. The content of PCPC in dangerous organochlorine products varies within wide limits, from fractions of a gram to tens of grams per ton. On average it may be considered that the manufacture and use of a million tons of a chloro product introduces no less than a ton of PCPC into nature.

The cellulose–paper industry is the second dangerous source of PCPC. When bleaching cellulose pulp with chlorine, oxidation and chlorination of the lignins present in the pulp occur which is accompanied by the formation of PCPC and its precursors. Replacement of chlorine by its oxide, by hypochlorites, chlorites and chlorates do not prevent the appearance of PCPC, concentrations of which reach 400 parts per trillion in waste water and up to 40 parts per trillion in bleached cellulose. The preparation of one ton of bleached cellulose by this means introduces up to 1 g PCPC and hundreds of grams of their precursors into nature. PCPC are formed by a similar route on disinfecting water containing phenolic substances and lignins with chlorine.

Significant quantities of PCPC are formed on combustion of solid domestic waste. According to existing data, operating one incinerator for a year put from 1 to 100 g PCPC into the atmosphere, the main quantity of which is evolved with the effluent gases. The quantity of PCPC formed depends on the combustion regimen and the composition of the waste burned. Their content is increased by the presence in the waste of polychlorovinyl and other polymers, and of organic and inorganic compounds of chlorine.

Sources of PCPC which are still insufficiently clarified are electrochemical processes for the manufacture of oxides of magnesium, nickel and possibly other metals from their corresponding chlorides. It is considered that these processes are comparable with the cellulose–paper industry in quantity of PCPC discharged into nature.

The smelting or initial heating of metals in electric arc furnaces is accompanied by the formation of PCPC. They are found on smelting copper and in the preparation of intermediate products for steel alloy objects. Large quantities of PCPC are emitted by motor transport using organochlorine or organobromine additives in motor fuel or in lubricants.

The list already presented indicates the extremely wide scale of poisoning of the biosphere with PCPC which has taken place in the past 30–40 years all the more so since their high stability in nature enables their constant accumulation. It may be considered roughly that during the period the manufacture and use of tens of millions of tons of organochlorine substances have introduced into the biosphere tens of tons of PCPC and several million tons of their precursors which are also partially converted into PCPC in nature. The cellulose–paper industry, metallurgy and processing of domestic refuse introduce into nature no less a quantity of PCPC than the manufacture of chlorine compounds. The total volume of PCPC fed into nature may seemingly be estimated at several hundred tons. This vast quantity of such strong poisons is sufficient to induce global disturbance of the functions of the animal life of the planet. That is why it is not remarkable that all the industrially developed nations have allotted huge resources to the exposing and elimination of technological practices emitting into the biosphere PCPC in quantities even of the order of tens of grams per year.

IV. Protection of man and nature from PCPC

Protection from PCPC is an unusual problem which is impossible to solve by traditional methods. This is due to the unusual properties of the xenobiotics considered[1] and their remarkable persistence.[17] PCPC may be destroyed in the gas phase or in solution by UV irradiation or even by sunlight. However on passing into the environment they are absorbed by inorganic materials and become insensitive to radiation. Their stability increases on passing into an organic phase and especially in living organisms where they accumulate. Only aerobic cells detoxify PCPC at a low rate. However on trying to degrade PCPC by such powerful oxidising agents as superoxide anion radicals and hydroxyl radicals, the latter destroy themselves. This guarantees the extended preservation of PCPC in nature (time for half-destruction is from 10 to 30 years or more), their ability to migrate along food chains or with water streams and transfer across borders into complexation with organic substances.

Several approaches have been studied in the search for methods of protection of man and animals from PCPC. The influence of natural antimutagens (vitamins A, B_1, E, C, etc.) on the toxic effects of dioxin has been studied in animal experiments. Competitive inhibitors of PCPC binding to bioreceptors have been studied as possible therapeutic agents. Only some reduction of dioxin effects on animals has been obtained in these cases. Evidently the formulation of a solution to the problem as the creation of a single cardinal method of protecting man from PCPC is not valid. In addition our investigations have enabled consideration of methods of prophylaxis and therapy of a series of ecological disorders arising as the fault of PCPC, primarily for groups at enhanced risk (pregnant women, babies, children).

With the aim of cleaning up the medical and ecological situation in regions of PCPC accumulation there is particular interest in the complex of programmes which, judging by available data, are being carried out in the industrially developed nations. The aim of one of them is to obtain a sharp fall in the technological burden on man and nature in affected regions. This provides:

elimination of the flow of PCPC to nature;

ecologisation of pesticides and of methods of applying them, optimisation of preparations and medicinal chemicals for living conditions and industry;

ecological standardisation of the manufacturing and agricultural industries.

Simultaneously a programme for protecting the population is being put into practice which is directed towards the partial disconnection of man from the PCPC biotransfer chain (cutting down of the consumption of dangerous food products, creation of new food sources from safe production) and the increase of man's resistance to PCPC (vitaminisation of drinks and food products, optimisation of food sources for amino acid composition, phospholipid content, etc.). Apparently the development of a complex of drugs intended for the treatment of ecological illnesses is also included.

Much attention is being paid to the ecologisation of landscapes around populated localities, in recreation zones and in plant growing areas. The aim of this programme is the creation of optimal

conditions for the development of aerobic microflora and the maintenance of constantly high activity for them. In the complex of agrotechnical and agrochemical measures developed a major role is played by a wide application of organic and microbiological fertilisers and also to growth stimulators and the development of lower and higher plants.

Significant results, obtained from putting into practice a complex of programmes in Japan, USA, Canada, FRG, and other countries in which huge quantities of PCPC have passed into the environment, indicate that mankind cannot now disregard the presence of these poisons in the biosphere and is obliged for many future decades to build up specially new conditions for his poison-free existence and cleaning of the environment. An unsafe medical situation and a multitude of regional ecological outbursts in our country are undoubtedly connected with underestimation of world-wide practice on the route and scale of using chlorine and its compounds and also of attempts to protect man and nature from the technological activity under conditions of enhanced PCPC content in the environment.

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Main directions for reducing the ecological burden when using pesticides

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The influence of human society on the environment began in the period when people moved from gatherings in dense forests to farming and animal husbandry. The process developed particularly intensively in the period of scientific-technical revolution and the creation of various branches of industry. Each branch of modern industry makes its 'contribution' to the action on the environment. Thus combustion of coal and lignite mined at the present time leads to contamination of the environment by powerful carcinogens such as benzopyrene and benzanthracene.[1,2] Combustion of coal alone leads to the discharge of about 3000 tons of mercury into the environment[3] and a significant quantity of sulphur dioxide and other harmful products. It is sufficient to say that in the USA alone about 200 000 000 tons of various chemical compounds pass into the environment each year. Contaminants such as polychlorobiphenyls (used in the electrical industry), polychlorodibenzofurans and polychlorodibenzo-*p*-dioxins formed on combustion of municipal refuse, or when bleaching paper with chlorine and in many other cases are a serious danger. It is possible to form an opinion on the danger of this group of substances only from their acute toxicity for mammals. Thus the LD_{50} of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin for guinea pigs is 0.6–2 μg kg^{-1}, and for monkeys 70 μg kg^{-1}.[4] In addition these compounds possess carcinogenic, teratogenic and immunotoxic actions. The safe concentration of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin in drinking water is considered to be 0.000035 μg $litre^{-1}$.[5] Pesticides as contaminants of the environment amount to less than 1% of total contamination, however since they are physiologically active compounds serious attention is paid to them and there is discussion in print on the expediency of their practical use. In addition it is impossible to obtain high and consistent harvests without the application of pesticides for the protection of plants against vermin, diseases and weeds.[6,7] The application of pesticides is spreading without interruption. In 1986 a total of US$17.4 billion worth were used, in 1987 $20 billion, and according to a forecast their consumption in 1990 will rise to $21 billion.[8]

The consumption of pesticides in various countries in 1987 was as follows (in $ millions): USA 4450, Japan 3450, France 3400, USSR 1075, Brazil 875, Italy 860, FRG 855, Great Britain 760, Canada 545, India 510, Spain 485, Chinese People's Republic 465, Australia 399, Hungary 320, South Korea 280, Denmark 240, Netherlands 210, Argentina 205, Indonesia 170 and Mexico 155. The consumption of pesticides in 1987 according to preparation types was (in $ millions): herbicides 8600, insecticides 6100, fungicides 4100 and others 1200. It should be noted that the data given cover only 20 countries, the largest consumers of pesticides.[8]

The influence of pesticides and other xenobiotics depends on the following main properties: persistence, acute and chronic toxicity for various forms of living organisms, decomposability under the action of various forms of living organisms (biodecomposition) and the presence of various negative effects from small doses of preparation over an extended time. Pesticides are subdivided into six