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Assessment of pesticide residue for food safety and environment protection

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Abstract : Since the chemical pesticides have been played a major role in crop protection practices during last 5 to 7 decades, social concerns on the pesticide residues in and on food commodities as well as environmental compartments have also growing with endless demands and interests. Most national regulation authorities over the world have paid a special attention on the data requirements for pesticide registration. In addition, even the registered pesticides also should follow the re-registration process, which meets today's guidelines and regulatory triggers and safety profiles. More recently, a defined interest in the international bodies has given to the global conservation program from the environmental contamination; these involves persistent organic pollutants (POPs), endocrine disrupting chemicals (EDs), biocides, etc.. In order to secure the food safety and keep our circumference sound, in-depth efforts getting information from global networks have perpetually to be given under relevant national agencies. At the same time, a nation-wide survey of the residues has also to be in operation to monitor the tendency of the toxicant in/on foods, feeds, and environmental segments. In final, the scientifically assessed results on safety should be opened to the public to provide the right-to-know for the consumers.(Received October 23, 2000; accepted December 3, 2000)

Key words : Persistent organic pollutants (POPs), Endocrine disrupting chemicals (EDs), Codex alimentarius, Maximum residue limits (MRLs).

Introduction

The role of the agrochemicals in modern agriculture is continuously evolving and its contribution to crop protection and environmental policy is ever more significant. Linking science and policy is a cornerstone of the work for regulation authority as well as industry. Before a pesticide may be on the market and used in the most countries over the world, national authorities evaluate the submitted pesticide thoroughly to ensure that it will not harmful for health or environment. Pesticides that pass these evaluations are granted a license or registration that permits their sale and use according to requirements set by the responsible authorities to protect human and the environment .

Pesticides are widely used in producing food and feed. These pesticides may remain in small amounts in or on agricultural produces and their processed products. To ensure the safety of the food, most government authorities regulate the amount of each pesticide that may remain in and on foods or environmental compartments.

Since most countries have driving policies for economic development during last several decades, deterioration of global environment is being accelerated almost all the sphere of world. In June 1992, the summits from 118 countries agreed to organize international cooperation system for basic legislation on environmental regulation Rio Declaration. The goal of the declaration was intended to achieve harmonization of environmental protection and economic development; thus to attain the sustainable development in global economy. Since then, various kinds of meetings, symposiums and discussions have been made to get a harmonized solution in agriculture and environment relations among international bodies. One of these activities, OECD's Joint Meeting on Agriculture/Environment Committee developed 13 indicators for assessing the effects of agricultural activities on environment, in which pesticide use and risk indicators are involved.

This paper deals with current status and future trends on food safety and environment protection by pesticide residues resulting from crop protection activities.

State-of-the-art on pesticide residues

Food safety in relation to *Codex Alimentarius*

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Throughout much of the world, an increasing number of consumers and most governments are becoming aware of food quality and safety issues and are realizing the need to be selective about the foods people eat. It is now common for consumers to demand that their governments take legislative action to ensure that only safe food of acceptable quality is sold and that the risk of food-borne health hazard is minimized. Since the first step were taken in 1961 to establish a Codex Alimentarius, the Codex Alimentarius Commission the body charged with developing a food code has drawn world attention to the field of food quality and safety. During the past three decades or more, all important aspects of food pertaining to the protection of consumer health and fair practices in the food trade have come under the Commission's scrutiny.

In order to foster consumer protection worldwide, there have been several Agreements internationally on food safety. The United Nations General Assembly Guidelines for Consumers Protection in 1985 stated that When formulating national policies and plans with regard to food, Government should take into account the need of all consumers for food security and should support and, as far as possible, adopt standards fromm the FAO's. and the WHO's Codes Alimentarius.. The FAO/WHO Conference on Food Standards, Chemicals in Food and Food Trade (in cooperation with GATT) in 1991 agreed that The process of harmonizing national food regulations to bring them into line with international standards and recommendations was an urgent one, which needed to be accelerated꿿 and that Provisions essential for consumer protection (health, safety of food, etc) should be the focus of emphasis in Codex Standards.. The Agreement on the Application of Sanitary and Phytosanitary Measures and the Agreement on Technical Barriers to Trade in 1995 formally recognized; International standards, guidelines and recommendations, including the Codex Alimentarius, as reference points for facilitating international trade and resolving trade disputes in international law. The FAO World Food Summit in 1996 committed itself to "Implement policies aimed at... improving physical and economic access by all, at all times, to sufficient, nutritionally adequate and safe food and its effective utilization." and to "Apply measures, in conformity with the Agreement on the Application of Sanitary and Phytosanitary Measures and other relevant international agreements, that ensure the quality and safety of food supply..."

Codex Alimentarius achieved a quite large number of outputs by holding more than 30 conferences or meetings since 1963 as summarized in Table 1.

Table 1. Achieved results from Codex Alimentarius activities

Food standards for commodities	237
Codes of hygienic or technological practices	41
Pesticide evaluated	185
Limits for pesticide residues (MRLs)	3,274
Guidelines for contaminants	25
Food additives evaluated	1,005
Veterinary drugs evaluated	54

Pesticide is occupied a core portion among the achieved outputs of Codex activities. In particular, maximum residue limits of pesticides (MRLs) in and on foods and feeds are referenced as national standards of member countries on food safety. MRLs still however act as potential barriers in the international trade of agricultural produces because use patterns of pesticides for local agricultural practices are different from nation to nation and residue levels are entirely depended upon climatic conditions. In addition to these, MRLs also vary with intake level of each food commodities from nation to nation.

Fig. 1 illustrates the scheme on the setting-up of MRLs of pesticides.

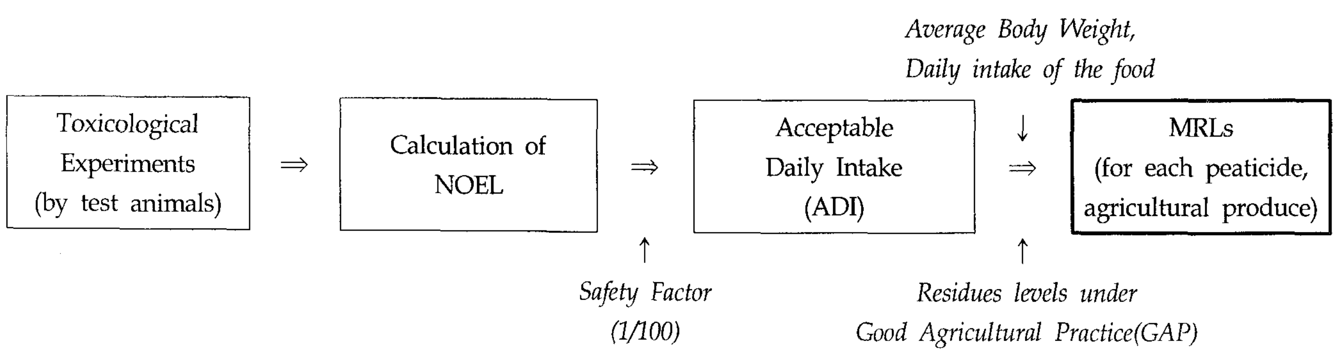

Fig. 1. Schematic flow to establish the MRLs of pesticides in food commodities.

Table 2. Comparison of carbaryl MRL in some food among selected countries

Country	Rice	Wheat	Apple	Grape	Lettuce	Strawberry
Codex	5	5	7	5	10	7
U. S. A.	5	3	10	10	10	10
Canada	2	2	10	5	10	7
Japan	1	-	1	1	-	-
Korea	1	3	5	0.5	1	0.5

No observed effective level (NOEL) of a pesticide is determined by output data on series of toxicological studies using test animals acutely and chronically, which is safe amounts in the tested animals ingested for their whole life span. ADIs are established by the WHO/FAO Expert Committee. MRLs are determined by taking into account the food intake, average body weight of human being, and pesticide residue levels under good agricultural practice in relevant national agency. Daily intake of each food commodity is quite different from countries due to the dietary customs..

In these contexts, MRLs set by Codex Alimentarius Commission are directed not referenced to the individual countries concerned. So many factors are involved to set national MRLs or tolerances (U.S.A refer the MRLs as tolerances.). As an example of carbary MRL in several food stuffs among several selected countries is given in Table 2.

In general, pesticide manufacturers are interested in their profit from the business; therefore, they have given special attention for the protective agents on major crops such as rice, apple, chinese cabbage, and etc. Meanwhile, recently the minor crops or the wild herbs such as leopard plant or perilla leaves are cultivated under greenhouse farming all the year round. These agricultural practices are frequently accompanied with pesticide application in order to ensure the product quantity as well as quality. On the other hand, the proper pesticides are unavailable on the market mainly because most pesticide companies do not want to register the promising pesticides for the crops with relatively small cropping area. Furthermore, Korean Food and Drug Administration (KFDA) adopts the lowest MRLs of a pesticide in/on which the crop is unregistered. In consequent, monitoring results of residue in/on minor crops done by KFDA manipulate the lowest value, which may result in unacceptable agricultural produces over MRLs. Even U. S. A., registration trials of reasonable pesticides for minor crops are being handled by Federal-State Project known as **Inter-regional Research Project No.** 4 or **IR-4**. Its charge is to conduct field trials and collect data needed for EPA approval of so-called minor-use pesticides during last three decades.

The Korean Government, Rural Development Administration (RDA) is also being implemented a national coordinating project **Pesticide registration trials for minor crops** from 1998 together with National Agricultural Cooperative Federation and some domestic pesticide manufacturers. A total of 65 combinations of pesticide and crop were tested biological activities and residue trials. As an output of the trials, 20 pesticides for eight crops were registered in 1999 and 39 pesticides for 13 crops were registered in 2000. The reasonable MRLs for the registered pesticides in/on minor pesticides were also able to be set by discussing the crop residue data in the Joint Committee on Pesticide Residue under KFDA and RDA last August. In addition, KFDA recognized that so many different types of vegetables are available in domestic markets and adopts recommendation of RDA since October 1999: vegetable foods have to be sub-grouped into leafy, fruit, and root vegetables. Procymidone MRL in perilla leaves was changed to 5 mg/kg by adopting MRL in lettuce from 0.2 mg/kg in onion. Now, the MRL in perilla leaves is notified as 10 mg/kg.

Safety of exporting agricultural produces is an increasing issue in international trade. In basic, residue level in/on exporting agricultural produces should be compatible to the MRLs of the importing countries. However, some countries operate zero tolerance of the pesticide in the produce which is unregistered in their nation like U. S. A. Thus trace amount of residues in/on exported produces may cause to clearance rejection: Korean case; chlorthalonil in pear in 1989, procymidone in ginseng in 1995, dichlorvos in cucumber in 1995, and monocrotophos in citrus in 1996. In case a certain pesticide is substantial to prevent or protect from special pests in specified exporting crops and it is not registered in relevant country, an alternative pesticide has to be developed or import tolerance has to be established. Major pesticides causing residue problem moving in international trade of agricultural produces are one of the following reasons; post-harvest treatment, low (chlorpyrifos) or no Codex MRLs, or unregistered in major world market. They are chlorthalonil, vinclozolin, iprodion, captan/folpet, thiabendazole, dithiocarbamate, carbendazim, imazalil, procymidone, methamidophos, omethoate, diazinon, pyrimiphos-methyl, azinphos-methyl, permethrin, monocrotophos, parathion-methyl, mevinphos, phosmet, esfenvalerate, malathion, and methidathion.

According to the pesticide residue monitoring in/on fruits and vegetables in EU member countries revealed that regardless of nations and sample size, the unacceptable portion of agricultural produces over MRLs is around 1 % of the monitored samples as shown in Table 3.

Likewise, the pesticide residue monitoring data in/on Korean domestic agricultural produces on the market done by KFDA and their local agencies are showing that the percentage of samples over Korean MRLs is decreasing tendency during last few years as given in Table 4.

Food Quality Protection Act (FQPA) of U. S. A.

The 1996 Food Quality Protection Act (FQPA) in USA established a new standard of safety for pesticide residues in food, with an emphasis on protecting the health of infants and children. That is, US/EPA must conclude with reasonable certainty that no harm will come to infants and children or other sensitive individuals exposed to pesticides. All pesticide exposures food, drinking water, and home and garden use must be considered in determining allowable levels of pesticides in food. EPA has met an important deadline in the new law by issuing a schedule showing how the Agency will reassess the more than 9,700 existing tolerances or MRLs in foods by August 2006, considering the pesticides that appear to pose the greatest risks first. Many pesticides, even when they are applied legally, in accordance with label directions, may leave residues in or on treated fruits, vegetables, grains, and other commodities. Though pesticide residues often decrease over time as food crops are washed, stored, processed, and prepared, some residues may remain in both fresh produce (like apples or tomatoes) and processed foods (like applesauce or tomato catsup).

The FQPA requires EPA to review the more than 9,700 tolerances established before August 3, 1996 (the day the new law was enacted) within 10 years. EPA must meet the following timetable:

Review 33% by August 1999; 66% by August 2002; and 100% by August 2006.

EPA has issued a detailed schedule showing how the Agency will complete tolerance reassessment over a 10-year period, first through re-registration and later through the registration renewal program (The

Table 3. Number of fruit and vegetable samples analyzed for pesticide residues in Europe (EU, 1996) showing the sample numbers analyzed per capitum population

Country	Population (Million)	No. of samples Analyzed	% with residue	% above MRL
Belgium	10.2	932	52	1
Denmark	5.3	1,273	23	1
Germany	83.5	4,257	33	-
Italy	57.3	7,194	33	1
Netherlands	15.6	11,015	47	-
Spain	39.2	3,022	39	0.1
Sweden	8.9	8,908	39	2
U. K.	58.5	878	34	< 1

Table 4. Trend in unacceptable portion of agricultural produces over MRLs from 1998 to 2000

Year	M A F [a]			K F D A		
	No. of samples analyzed	No. of samples over MRL	% over MRL	No. of samples analyzed	No. of samples over MRL	% over MRL
1988	10,607	444	4.2	1,301	74	5.6
1999	26,319	464	1.8	3,765	98	2.6
2000. 8	18,805	153	0.8	3,200	31	1.4

[a] *MAF designates Ministry of Agriculture and Forestry(National Agricultural Product Inpection Office).*

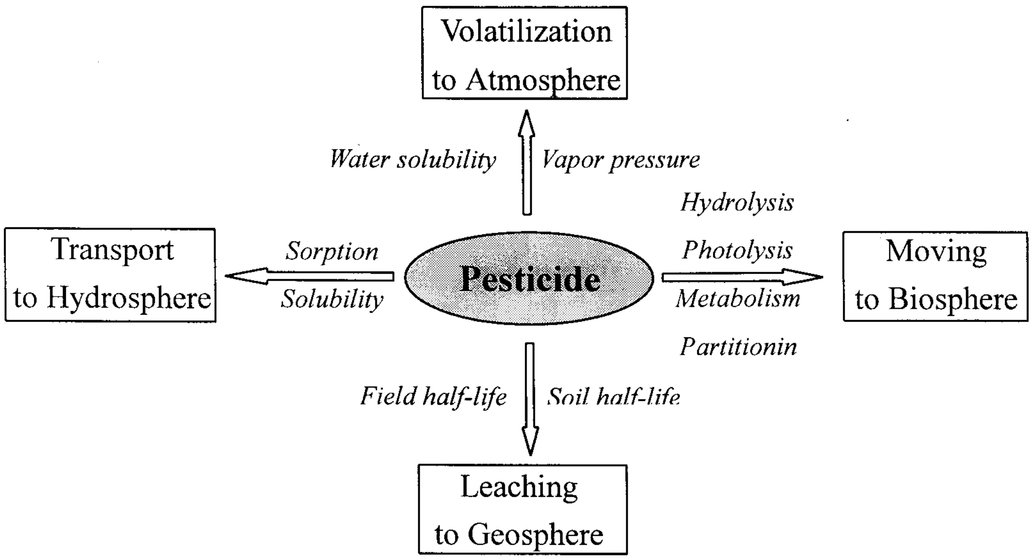

Fig. 2. Environmental fates and dissipation processes of applied pesticides.

re-registration program reviews older chemicals to ensure that the data used to evaluated them meet current scientific standards and includes a thorough review of risks to humans and the environment.). FQPA requires the Agency to give highest priority to those pesticides which appear to pose greatest risk. EPA has divided the 469 pesticides with tolerances into three priority groups, as described below.

Group 1 - Contains those pesticides that will be examined first in the tolerance reassessment program. It consists of 228 pesticides that appear to pose the greatest risk to public health. EPA will complete full risk assessments for these pesticides to see if actual human health concerns exist. Group 1 includes organophosphates, carbamates, and organochlorine classes of chemicals; probable and possible human carcinogens; high-hazard inert ingredients; and any pesticides that exceed their reference dose (RfD), the amount believed not to cause adverse effects if consumed daily over a 70-year lifetime. These pesticides are EPA's highest priority for tolerance assessment and re-registration. Protection of infants and children is a high priority for EPA. Of the approximately 1,800 organophosphate tolerances receiving priority review, over 300 are for residues on crops that are among the top 20 foods consumed by children.

Group 2 - Contains 93 pesticides that are possible human carcinogens not included in Group 1 and all remaining pesticides subject to re-registration. These are EPA's second-highest priority for review.

Group 3 - Contains 148 pesticides including most of the biological pesticides, inert ingredients, and more recently registered pesticides with tolerances that are not subject to re-registration (the post-1984 pesticide active ingredients).

Environment protection

A. Pesticide dissipation process and its associated parameters in the environment

Various kinds of parameters are involved in environmental fate of pesticides applied to the target. In principle, all the chemicals including pesticides introduced in the environment are cycling at low rates within and between bio-, geo-, atmo-, and hydrospheric systems as illustrated Fig. 2. Likewise, pesticide is also being moved and dissipated into the correspondent sphere and its degree and rate are closely related with physioco-chemical parameters of chemical itself and the surrounded environmental condition. Except phyisico-chemical parameters of pesticide, the concerned factors related with pesticide include application time and dose, land use patterns and target crops. The concerned factors with climate and weather may involves temperature, rainfall, evapo-transpiration rates and wind velocity. The parameters related with soil are run-off characteristics, organic carbon, texture, hydraulic characteristic and pH.

Several schemes have also been proposed foe the assessment of the degradability of pesticides in soil. The IUPAC commission on agrochemicals proposed half-lives in soils be used for assessing degradability if pesticides (Table 5). Half-lives, DT-50 and DT-90 values have also been introduced by some regulatory authorities (US EPA, 1982; DK AEP, 1988; BBA, 1990) as triggers in tiered persistence testing systems (Table 6). In addition to DT-50 and DT-90 values, the

Table 5. Ranking of pesticide persistence in soil

Range of DT-50	Pesticide	Persistence class
< 1 month	Dicrotophos, dimethoste, diazinon, methidathion	Readily degradable(non-persistent)
> 1 month	Atrazine, ametryne, bromacil, diuron, monuron, prometon, propazine,	Moderately degradable (moderately persistent)
< 6 months	Smazine, terbacil, trifluralin	
> months	Aldrin, DDT, dieldrin, lindane, methoxychlor	Slowly degradable(persistent)

Table 6. Regulatory triggers for soil degradation testing

Testing step[a)]	USA (Korea)	Germany	Denmark
1 → 2	None (field testing is always required	DT-50 >30 days and DT-90 > 100days	Half-life > 80months for herbicides, > 3months For other products
2 → 3	< 50% degradation until next application in the filed or total extracted residue in lab studies > 50% of initial amount at next application	Residue plateau after several application 5x as high as after single application	Exceeding above triggers in field testing

[a)]1:lab test, 2:short-term field test(1yr), 3:long-term field yest(accumulation study, 3yrs).

evaluation criteria used by the BBA of Germany include the percentage of active ingredient or metabolite left in the soil before next application, percent of bound residues formed and rate of application.

Since the 1980s, a large number of mathematical models that attempt to simulate pesticide fate in the soil have been developed with a range of applications and levels of detail. Research into the interplay of factors affecting pesticide fate and mobility in soils has developed at a rapid pace in the last 15 years. The development of simulation models has proved useful, both in guiding experimentation and in integrating, testing and improving our understanding of the dynamic and complex nature of the soil-plant-pesticide system. Pesticide leaching models are also now being used for management purpose, by both industry and public authorities, within the registration process. The use of models for management purposes implies a different set of needs and priorities. Most important of these are ease of parameterization and predictive reliability. To some extent, these requirements are conflicting, since reliability implies the need for mechanistic models which minimize 'model error', but at the cost of increasing demands.

Despite many differences of detail, the most commonly used models of pesticide mobility have much in common in their general approach since they are all attempting to represent the same phenomena. Table 7 are summarized some pesticide leaching models in unsaturated soil zone.

Protection of the water sources is one of the most effective ways of reducing the potential for introducing toxicants into the water supply. Among the many chemicals encountered in drinking water, pesticides occupy a unique position, since they are deliberately used to control the growing problem of pests. WHO (World Health Organization) has derived drinking water guidelines for some 40 pesticides. Tolerable daily intake (TDI) was derived in the traditional manner by dividing the no-observed-adverse-effect level (NOAEL) or the lowest-observed-effect level (LOAEL) for the critical effect by an uncertainty factor accounting for interspecies and intraspecies variation. The guideline value (GV) was derived from the TDI by multiplication with body weight (bw; 60 kg for adults, 10 kg for children, 5 kg for infants) and the proportion of total intake accounted for by drinking water (P; 10 % by default if no data exist), and divided by the daily drinking water consumption (C; 2 liters for adults, 1 liter for children, 0.75 liter for infants): **GV = TDI x bw x P / C**. The toxicological basis of the guideline values and exposure assumption made, as reflected in the percentage allocation of the TDI to drinking water is

Table 7. List of current unsaturated zone leaching models for pesticides

Model	Authors, Country developed	Computational Requirement	Extent of use, Where used
CALI	Walker and Barnes, U. K.	Low	Low, Europe
PESTLA	Van der Linden & Boesten, Netherlands	Moderate	Low, Netherlands
SESOIL-FHG	US/EPA, Germany	Moderate	Low, Germany
PRZM-1	Carsel *et al.*, USA	Moderat	Most widely used, Europe and USA
GLEAMS	Leonard *et al.*, USA	Moderate	Moderate, USA
LEACHMP	Wagenet & Huton, USA	High	Moderate, Europe, USA

Table 8. Risk assessment of some selected pesticides with potentially high exposure from food

Pesticide	NOAEL (mg/kg bw/day)	UF	TDI (%)	GV μg/liter
Atrazine	0.5	1000	10	10
Bentazone	10	100	10	300
Carbofuran	0.22	100	10	7
2,4-D	1	100	10	30
Glyphosate	175	100	10	U[a)]
Metolachlor	3.5	1000	10	10
Molinate	0.2	100	10	6
Pendimethalin	5	1000	10	20
Propanil	5	1000	10	20
Pyridate	3.5	100	10	100
Simazine	0.52	1000	10	20
Trifluralin	0.75	100	10	2

[a)] *U = unnecessary to recommend a health-based GV since the calculated value (5 mg/liter) is orders of magnitude higher than glyphosate concentrations normally found in drinking water.*

summarized in Table 8.

One of the biggest problems faced by water supplies is the short-term presence of a high concentration of a pesticide in drinking water. If , for example, an individual pesticide is found in drinking water at a level higher than the standard, a decision has to be made as to whether the greater risk is the presence of the pesticide in the water supply of turning off the water supply. And despite current concerns about endocrine disrupting chemicals (EDs), it is not clear that drinking water is likely to be a major source. Many EDs are hydrophobic and therefore, if present in raw water, can be relatively easily removed by treatment.

B. Persistent organic pollutants (POPs)

Persistent organic pollutants (POPs) are organic compounds that, to a varying degree, resist photolytic, biological and chemical degradation. POPs are often halogenated and characterized by low water solubility, and high lipid solubility, leading to their bioaccumulation in fatty tissues. They are also semi-volatile, enabling them to move long distances in the atmosphere before deposition occurs. These properties of unusual persistence and semi-volatility, couples with other characteristics, have resulted in the presence of compounds such as PCBs all over the world, even in regions where they have never been used. They have been measured on every continent, at sites representing as the open oceans, the deserts, the Arctic and the Antarctic, where no significant local sources exist and the reasonable explanation for their presence is long-range transport from other parts of the globe.

Halogenated carbons are major group of POPs and, of these, the organochlorines are by far the most important group. Included in this class of organohalogens are dioxins and furans, PCBs, aldrin, endrin, dieldrin, hexachlorobenzene, mirex, toxaphene, heptachlor, chlordane, and DDT. Halogenated, and particularly chlorinated organic compounds have entrenched in contemporary society, being utilized by the chemical industry in the production of a broad array of products ranging from polyvinyl chloride (millions of tonnes per year) to solvents (several hundreds of thousands of tonnes), to pesticides (tens of thousands of tonnes) and specialty chemicals and phamaceuticals (thousand of tonnes down to kilogram quantities). In addition, both anthropogenic and non-anthropogenic sources also lead to production of undesirable by-products and emissions often characterized by their persistence and resistance to breakdown such as chlorinated dioxins.

Immunotoxicity in association with exposure to different POPs has been reported by several authors. Investigators have demonstrated immune dysfunction as a plausible cause for increased mortality among marine mammals and have also demonstrated that consumption of persistent organic pollutant contaminated diets in seals may lead to vitamin and thyroid deficiencies and concomitant susceptibility to microbial infections and reproductive disorders. Exposure to POPs has been correlated with population declines in a number of marine mammals including the common seal the harbor porpoise, bottle-nosed dolphins and beluga whales from the St. Lawrence River. The scientific literature has demonstrated a direct cause and effect relationship in mink and ferrets between PCB exposure and immune dysfunction, reproductive failure, increased kit mortality, deformation and adult mortality.

As noted for environmental effects, it is also most difficult to establish cause and effect relationships for human exposure of POPs and incident disease. As with wildlife species, humans encounter a broad range of environmental exposures and frequently to a mixture of chemicals at any one time. Much work remains to be done on the study of the human health impact of exposure to POPs, particularly in vies of the broad range of concomitant exposing experienced by humans. Studies of carcinogenesis associated with occupational exposure to2,3,7,8-TCDD also seem to indicate that extremely high-level exposures of human populations do elevate overall cancer incidence. More recently, literature has been accumulating in which some researchers have suggested a possible relationship between exposure to some POPs and human disease and reproductive dysfunction.

Information on criteria for identifying POPs is recommended by the Intergovernmental Negotiation Committee (INC) and Intergovernmental Forum on Chemical Safety (IFCS). The following parameters have been identified to be considered additional POPs. A) **Persistence**: the ability to resist degradation in various media such as soil, water and sediment, measured as half-life of the substance in the medium; b) **Bioaccumulation**: the ability of a chemical to accumulation living tissues to levels higher than those in the surrounding environment, expressed as the quotient between the concentration in the target tissue and the environmental concentration; c) **Toxicity**: the ability of a chemical to cause injury to humans or the environment; d) **Volatility**: the ability of a chemical to vaporize into air; e) **Measurements of the chemical in remote regions**: considered by some to be critical for identifying a chemical as a persistent organic pollutant of global concern; f) **Bioavailability**: this, based on field data or expert judgement, has also been proposed as a criterion for identifying POPs.

Funding the global negotiations to establish a global treaty on POPs is a challenging task, and the international community is responding to the need for resources by contributing through an innovative financial mechanism known as the POP's Club. Donation and pledge have been received from; Australia, Austria, Canada, Denmark, Finland, Germany, Madagascar, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, the United States, and the International POPs Elimination Network.

Fig. 3 shows the schematic procedure for identifying POPs by assessing the physico-chemical parameters and in-field surveyed data globally of the candidate chemicals.

C. Endocrine disrupting chemicals (EDs)

During the 1990s, increasing concerns on the reproductive abnormalities in wildlife, the increasing breast cancer in women, the decreasing sperm counts in men have lead to many scientists and politicians think and point to pesticides and other chemicals that disrupt the endocrine system as the underlying thread. Because of the endocrine system's critical roles in normal growth and development and in reproduction, even small disturbances in endocrine function have the potential to exert profound and lasting effects.

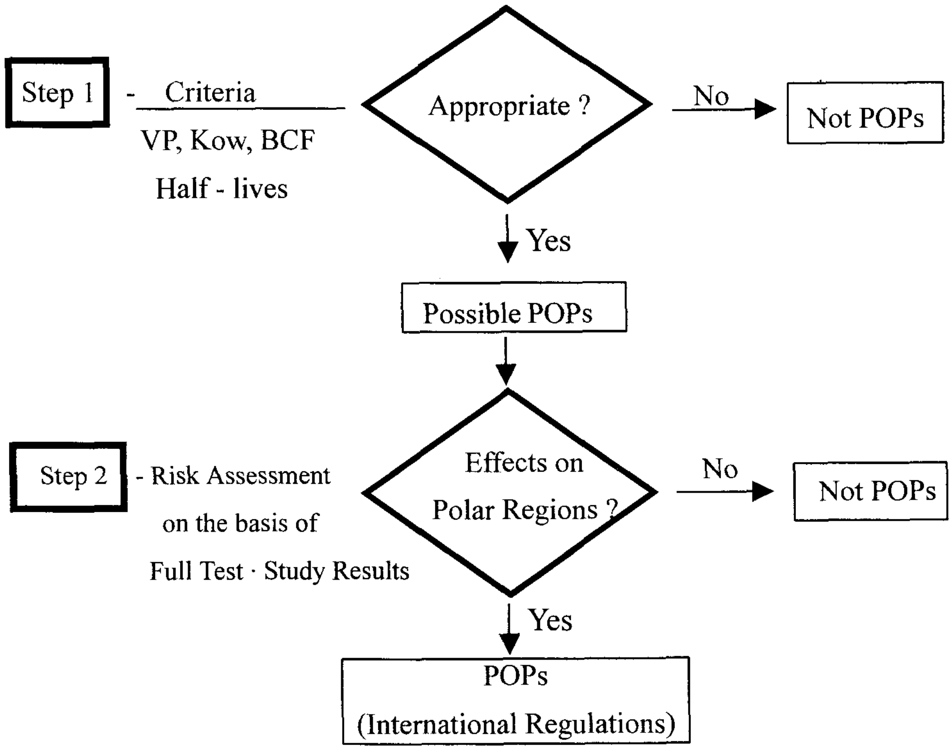

Fig. 3. Flow chart of POPs identification procedure.

Meanwhile, at present, scientific knowledge is inadequate to fully inform public policy. Even in USA, EDSTAC (Endocrine Disrupter Screening and Testing Advisory Committee) has prepared final report on the schemes on testing the chemicals for endocrine disrupting activities last year. US/EPA estimates that there are approximately 87,000 chemicals to be sorted for the screening program. Chemicals to be sorted include about 900 pesticide active ingredients; 2,500 other ingredients used to formulate pesticide products; 75,500 industrial chemicals; and 8,000 cosmetics, food additives and nutritional supplements. Initial sorting stage will separate chemicals into four categories based upon a review of all existing relevant scientific information as shown in Fig. 4.

Category 1 : No testing necessary now Hold. Category one includes those chemicals, like strong mineral acids and bases, amino acids, sugars, certain polymers (approximately 3,000 polymers), etc., that are unlikely to exhibit endocrine activity and need not be screened. For example, polymers with a number average molecular weight greater than 1,000 daltons are unlikely to be able to cross biological membranes and barriers and would, therefore, not be biologically available to cause endocrine-mediated effects.

Category 2 : Insufficient data Tier 1 screening. Category two consists of chemicals with insufficient data to determine their potential for endocrine activity. Chemicals with insufficient data will undergo priority setting for Tier 1 Screening which may include High Throughput Pre-screening (HTPS). HPTS is presently being examined by EPA to determine if suitable technologies can be developed for routine application in regulatory priority setting for Tier 1 Screening. Priority is necessary because it is estimated that up to 62,000 chemicals may be sorted into this category.

Category 3 : Direct move to Tier 2 testing. Category three includes those chemicals that have sufficient data to bypass screening, but need testing. Chemicals with sufficient data to bypass Tier 1 Screening will go directly Tier 2 Testing. EPA estimates the total number of chemicals in this category and the next (Hazard Assessment) to be more than 1,000 for each.

Category 4 : Direct move to hazard assessment. Finally, category four consists of substances with adequate data, which will be referred to the appropriate office or agency for hazard assessment.

In consequent, at present, none of chemicals are designated as endocrine disrupting chemicals by any other agencies or authorities over the world; but being suspected as a candidate. Moreover, the list of the candidate is also quite different from the organizations; thus National Environment Research

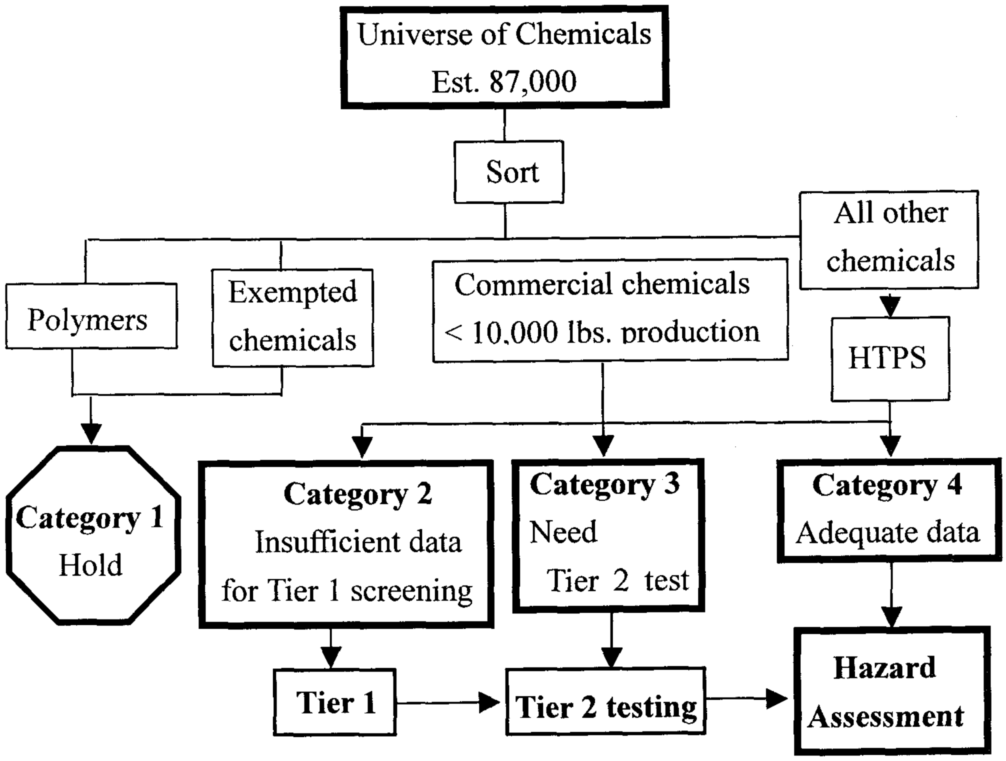

Fig. 4. Endocrine disrupter screening program in USA. overviewed by US/EPA. HTPS : Highly Throughput Pre-screening.

Institute as national executing agency for monitoring endocrine disrupting chemicals in Korea determined to follow the list announced by WWF, which involves 67 chemicals. Of which, 44 pesticides are included in the list, in which 17 pesticides are still valid and on the market.

Multi-disciplinary studies mainly focused on monitoring the chemicals in agricultural and environmental compartments are being executed among relevant institutions. National Environmental Research Institute is responsible for water, sediments, air, and dioxins from waste incinerators. Korean FDA is responsible for disposable vessels of ramen, cans, etc. Whereas, NIAST is responsible for agricultural produces, cropping soil and irrigated water.

Conclusion

The regulatory arena in pesticide management in recent is characterized by noticeable trends: a demand for ever more safety data, coupled with increased international harmonization efforts. The big challenge in the regulatory environment is the costly re-registration program, designed to ensure that older generation, but still widely used, products meets today's qualified environmental and safety standards. The social, political and regulatory environment that have an impact on the crop protection industry have become much more complex in th e last decade. People living in modern society play a role of consumer. They are concerned about the safety, price, availability, and quality of their food. All these factors affect the demand for food to a greater or lesser extent, depending on individual culture and social standing. These demands must be reconciled by farmers, regulators, policy makers, and farm input industry including the crop protection sector. The evolution of crop protection technology over next decade will most likely be relied upon chemical control remaining the backbone of crop protection.

In these contexts, the crop protection agents for the future have to be fulfilled the following requisites: working and active with low dose less than 5 g /ha; degrading rapidly and completely after their jobs are done; doesn't leaving residues in/on food or environmental compartment; immobile from the target location; compatible with manufacturing, formulations, packaging, and application methods that minimize waste and exposure; and doesn't disturbing the treated ecosystem in any undesirable way.

In order to ensure the safety of our food and keep our environment healthy and clean, efforts getting information from advanced nations or international bodies have continuously to be given under the national regulatory agencies for relevant chemicals. Likewise, a nation-wide regular survey of the residues has also to be operated to monitor the trends of the toxicant level in/on foods, feeds and environmental segments as well. In final, the scientifically assessed data are open to the public to provide and satisfy the right-to-know.

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식품 안전성과 환경보존을 위한 농약 잔류성 평가

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요약 : 지난 반세기 이상 작물보호제의 수단으로 사용되어 왔던 화학농약은 사용 후 식물과 환경구성 요소 중에 남게 되는 잔류성 문제로 일반사회의 지대한 관심거리로 부상하고 있다. 세계 각국이 국가차원의 규제로써 등록시 안전성 요구자료를 강화하고 있고 일단 등록된 농약이라 할지라도 주기적으로 안전성은 다시 평가하는 재등록제를 도입하고 있다. 특히 최근 지구환경보호 차원에서 국제기구를 중심으로 잔류성 유기 오염물질 (POPs), 내분비계 장애물질 (EDs)에 대한 관심이 집중됨에 따라 국가차원에서도 우리 먹거리의 안전성을 확보하고 환경보전을 위하여 다양한 조사사업과 정책 등이 수립 시행되고 있다. 이들 조사결과에 대하여 과학적인 평가와 진단 그리고 대책들은 소비자의 알 권리를 충족하기 위하여 일반 대중에게 공개되어야 할 것이다.

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