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Mind your own business or Voltaire's cultivation of one's own garden does not exactly fit in the new tendency for interdisciplinary knowledge which is a hallmark of today's Science. This thought, which has been expressed at length in *Ciência e Cultura J Braz Assoc Adv Sci* and also by many scientists in this country, is now explicitly discussed by Michael S Gazzaniga in this Editorial to *Science* "How to change the University" (*Science* 282: 237, 1998). Says Gazzaniga: "Tired ideas, unworkable programs and rigid department structures all have a life of their own. They are deeply woven into the fabric of higher education even though they are strangling growth, creativity, and spontaneity. Self-interest and protectionism are now rampant".

The increasing interconnection of several scientific fields formerly regarded as independent specialities self-protected inside Departments makes the structure of the Universities incredibly obsolete. Reorganization on the basis of relevant programs, however, instead of crystallized institutions, is still regarded as stratospheric. Professors and researchers have the primitive urge to classify themselves within defined boundaries like in tribes. There is the tribe of the biochemists, the tribe of the pharmacologists and the tribe of the microbiologists. Cell biologists which constitute a relatively new tribe threatening to invade the fields of several other specialities are seen with suspicion. Apparently, to be classified in a tribe is more important than being associated with a scientific program, which can change and may not have a perennial existence because it depends on relevance, competent people and results. Programs require constant updating, constant incorporation of new knowledge and techniques. People within Departments are asked to be loyal to their corporation rather than to the ever changing scientific programs which can attract talented young people with new expertise and new ideas.

Gazzaniga proposes that large foundations should "form a consortium and offer four or five leading universities a one-time grant of $300 million to defray the transitional costs of intellectual renovation. Expenses include balancing teaching loads, renovating buildings, and funds to launch research and to provide scholarships". Such proposal has the merit of avoiding dispersion of resources and objectives, but implies a definition of priorities and private investment.

In Brazil private investment in research aiming at Universities is practically null and therefore a similar program can only be carried out by Federal and State Governments, which so far, did not act to the effect of demonstrating that Universities, Science and Technology are worth a direct and substantial investment. On the contrary, market fluctuations and monetary difficulties, always blamed on worldwide speculation and on the global economy, inevitably result in severe cuts in the budgets of Science, Technology and of Universities in general. Lack of positions for young PhDs and Post-Docs is now chronic, only to be followed by paucity of funds for research and development, the usual targets of so-called austerity measures. The State of São Paulo Foundation for Research Support is somewhat isolated in this scenario fulfilling its important role as a fundamental institution funding scientific projects. However, politicians, some with high aspirations, threaten to interfere in this program with uninhibited statements that "too much money is being destined to scientific research in detriment of more important social benefits".

Pesticide contamination in the South Cone: A review*

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Pesticide residues, especially of organochlorinated compounds, occur in all environmental compartments, from agricultural fields to the most remote areas of the earth. Information about the presence of pesticides in the South Cone is relatively limited and scattered, making it difficult to depict the state of our environment. This paper reviews the scientific literature on pesticide and residue contamination in the environment, food, feed and biologic matrices, and the exposure of rural workers and the general public to pesticides in the South Cone. Although pesticide contamination in the region seems to be similar to or smaller than that occurring in other areas of the globe, it is ubiquitous and problems of human exposure and intoxication are too common. The emergence of the South Cone as a commercial block fostered by the Mercosur provides an opportunity for the countries of the region to restate their position on matters of pesticide contamination, and to devise new policies with industry in order to minimize the environmental impacts of pesticides.

Resíduos de pesticidas, especialmente de compostos organoclorados, ocorrem em todos os compartimentos ambientais, desde campos agrícolas até as áreas mais remotas da Terra. As informações sobre a presença de pesticidas no Cone Sul são relativamente limitadas e dispersas, tornando difícil a composição de um quadro sobre o estado de nosso ambiente. Nesse artigo agrupa-se a literatura científica sobre contaminação por pesticidas e resíduos no ambiente, alimentos e matrizes biológicas, bem como sobre exposição do trabalhador rural e da população em geral no Cone Sul. Embora a contaminação na região pareça ser similar ou menor que a percebida em outras partes do mundo, ela é ubíqua e problemas de exposição humana e intoxicações são muito mais comuns que o desejável. O surgimento do Cone Sul como um bloco comercial proporcionado pelo Mercosul oferece uma oportunidade aos paises da região para que reafirmem suas posições em questões de contaminação por pesticidas, e delineiem novas políticas juntamente com as indústrias no sentido de minimizar os impactos dos pesticidas.

The encompassment of the environmental contamination issue in so vast and spatially differentiated a region such as the South Cone demands an approach in which each of the several facets of the problem are evaluated alone and combined to provide a picture of the state of our environment. Agriculture represents one such important facet, whose interest is pervaded by aspects of the varied physical environment and the diversity of economic activities and development levels within the region, coupled with the accelerated expansion in area and technological modernization of the last decades.

The most distressing aspect of agricultural pollution to the public, the press, and the international community is perhaps the pesticide issue. The concern is most likely due, firstly, to the latter-day character of the subject, for it was only during the 1970s that pesticides entered the regional market in significant amounts (1,2). Secondly, the concern stems from an ecological awareness born from the very problems brought up by the widespread use of these substances (3,4) that reach our tables every day despite their known toxicity.

With the objective of compiling and evaluating the available scientific information about pesticide contamination in the South Cone, the main bibliographic databases (specially AGRIS, CAB ABSTRACTS, AGRICOLA, TOXLINE, E-CD)

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were carefully browsed and the papers and references related to the subject were obtained. Consideration of only indexed literature was an attempt to standardize the quality of information, and to distribute it among the different countries. Nevertheless, most of the articles refer to studies carried out in Brazil due to its greater volume of publications (5).

The literature review revealed a significant amount of data on pesticide contamination of air, waters and soils, food, animal feed and biologic matrices, as well as exposure of farm workers and the general public, and effects on public health. In addition, there are studies about past and present market trends, legislation, policy and popular awareness of pesticide risks and safety regulations. It is in this order of increasing complexity that the problems of environmental pesticide contamination are analyzed in this review.

Pesticides and environmental contamination

Pesticide residues, especially of organochlorinated compounds, are present in all environmental compartments of the globe, even the most remote areas. Traces of DDT, HCB, aldrin, heptachlor, among others, can be detected in the atmosphere over the South Atlantic and Antarctic Oceans (6), in samples of soil, water, ice and snow from Antarctica (7), and in the high altitudes of the Chilean Andes (8). The contamination extends to groundwaters tapped for human consumption (9), and in treated waters of city supplies (10) even if at levels considered safe. Although research on pesticide leaching from agricultural soils to groundwater was initiated forty years ago (11), the knowledge of the levels of contamination of aquifers and groundwaters is still very scarce or lacking in a large portion of the region (12). The contamination of a valuable resource such as groundwater requires redoubled attention (13).

Water contamination

Presently, there is a research effort being directed toward the characterization and evaluation of the risks of contamination in the recharge areas of the Botucatu (Guarany) mega-aquifer, which extends over all of Southern Brazil and vast areas of Paraguay and Argentina. In addition to the definition of the aquifer's geophysical attributes (14), the studies involve determination of pesticide residues that have been shown to be low (15); and the dynamics of vinasse (a residue of the ethanol distilling process) which is applied extensively to the sugar cane plantations that expand the aquifer recharge areas in São Paulo state (Brazil) (16).

In a more comprehensive study based on a set of methods for groundwater contamination risk analysis proposed by the Pan-American Health Organization (PAHO) (17,18), a map was developed showing the aquifer vulnerability and the contamination risk for São Paulo state (19). In general, the aquifers present moderate contamination risks, but sources and contamination loads were unevenly distributed, posing considerable risks at specific locations. A complementary study centering on nonpoint sources associated with agricultural activities pointed out that the main risks were related to herbicide use, especially in sugar cane plantations on vulnerable areas (20,21). In this study, the priority areas and compounds to be assessed were defined as a guide for future research.

Pioneering evaluations of surface water contamination were carried out in Paranoá lake, a reservoir formed at the time of construction of Brasília in the early 1960s. Aldrin and dieldrin residues in water resulted in up to 462 ppb in the fat of fish caught in the lake, indicating bioaccumulation through the food chain (22). One of the best studied water bodies in terms of pesticide contamination in the South Cone is the Lobo reservoir, in São Paulo state. Organochlorinated residues in sediments (23) and in the water column of the reservoir and its tributaries (24,25) were found to be very low (maximum of 5.3 ppb for HCB in sediments), but residues seemed to be concentrating in the reservoir because levels were higher than in the tributaries. The maximum level of organochlorinated residues found in 38 major reservoirs of seven different watersheds in São Paulo state was 1.4 ppb for DDT, a lower average concentration than normally reported for interior waters of northern hemisphere temperate regions. Watersheds with intense agriculture tended to show the highest contamination levels (26). Other assessments in agricultural areas such as the cocoa growing region of Bahia state (northeastern Brazil) resulted in residue levels below the tolerance limits established for drinking water (0.9 ppb for HCB in lakes) (27); whereas the levels detected in springs and wells in Paraná state (southern Brazil) were above these tolerance limits (28). Attention has been directed also toward the definition of adequate analytical practices for organic compounds and pesticide residues in fresh waters (29,30).

However not directly linked to one another, there is a series of studies that permits an evaluation of the contamination in one of the most important watersheds of the South Cone, the Paraná/Prata. Starting at Pardo river in the sugar cane growing area of São Paulo state, bioassays employing a bivalve suggested past exposure to several organochlorinated compounds (31). Only traces of residues were recovered from the water column of Baía river, a tributary of Paraná river in an area of intensive agriculture, but the sediments contained up to 0.5 ppm of HCB (32). About 600 km from its mouth the Paraná river in Argentine territory carried a very low load of organochlorinated residues (9 ppt for HCB), but the organophosphate parathion could be detected (at 22 ppt) (33). Monitoring performed in the Uruguay river seems to confirm these figures, with 10 ppt of HCH isomers, which is significantly lower than the levels found in the past, indicating a decreasing trend (34). As the Plata river reaches the sea, residue determinations in water, sediments, and organisms showed that contamination levels decrease from the industrialized areas toward the ocean. Lindane reached a maximum of 61 ppt in water, 12.2 ppb in sediments, and 1.5 ppm in fat of organisms, whereas total DDT reached 7.7 ppt, 91.4 ppb, and 25 ppm in water, sediments, and organisms, respectively (35).

Other studied regions have included the basin of the Santa Lucia river in Uruguay (36) and Blanca Bay in Argentina, where maximum levels of 54.2 ppt for lindane, 61.8 ppt for aldrin, and 67 ppt for DDT were found, representing a contamination comparable to those observed in the Bay of Naples (Italy) or the St. Lawrence estuary in the USA (37). At the other extreme, the maximum detected levels of HCB in the estuarine system of Santos, considered the most heavily polluted of Brazil, reached 1.02 ppb in water and 103 ppb in sediments (38). Residues of other pesticides, however, were virtually absent in this area, except for endosulfan which also reached high levels. It is important to notice that this area comprises an important industrial and metallurgical park, and contamination may have origins other than agricultural. The levels of contamination by organochlorine pesticide residues on the coast of Rio de Janeiro state were similar to that observed on the shores of the North Sea in Europe (considered heavily polluted), remaining below 20 ppb for DDT, except in Sepetiba bay, where it reached 80 ppb. Pollutants typical of industrial effluents (PCBs and PAHs) were present at lower levels in Rio de Janeiro as compared with the North Sea (39).

Environmental contamination by organochlorinated compounds may have the immediate consequence of building up residues in organisms, because these compounds are lipophilic and tend to accumulate through the food chain. As an example, even though contamination of the water in the Lobo reservoir was not significant, total organochlorine residue content in fish fat reached up to 20 ppb, which although lower than levels observed elsewhere, and considered acceptable according to current standards, indicates the existence of a cumulative effect (40). The residue burden in living organisms may be considerably higher depending on the degree of environmental contamination. For instance, DDT residues reached 0.37 ppm in fish caught in the heavily polluted Tietê river, which flows through São Paulo city (41), and 41 ppb in fish caught along the Santos (SP) seashore, where an HCB concentration of 940 ppb was more alarming (42). On the other hand, along the coast and estuary of Cananéia (southernmost part of São Paulo state), a mostly pristine area, most samples showed no detectable residues, but some oyster samples were heavily contaminated, probably due to the accumulative capacity of these mollusks (43). On the occasion of a large fish kill that occurred in the Jaguari river (interior of São Paulo state), the water quality parameters indicated only traces of pesticide residues. The investigation pointed to parasites as causal agents (44).

In general, pesticide residue contamination of the aquatic environments of the South Cone may be regarded as moderate, with the exception of some restricted areas, and is less than observed in most of the northern hemisphere.

Soil contamination

Even considering this moderate contamination situation, water pollution is ubiquitous and results essentially from the runoff and leaching of pesticides applied to agricultural soils. Hence, a great deal of attention has been devoted to understanding pesticide dynamics in soils. Early studies began forty years ago, and attempted to describe through bioassays the fate of HCB applied to coffee plantations (45). The comparative persistence of organochlorine and organophosphate pesticides was the next stage of research, in an attempt to comprehend the long-term effects of the former (46), and the mechanisms involved in the movement of chemicals under tropical soil conditions (47,48). Later, refined radiometric techniques were introduced to elucidate the role of physicochemical properties of soils in determining pesticide environmental fate (49-53). Residues were found in 98% of 486 soil samples in a comprehensive assessment of the persistence of organochlorine and organophosphate pesticides in soils where the major crops of São Paulo state were grown. DDT in soils where sugar cane was cultivated reached the highest level (0.43 ppm), but organophosphates were not detected (54).

The interest in determining the persistence of bioactive compounds and residues in soils, both in terms of effectiveness for pest control and environmental safety and quality, has led to numerous bioassay studies. These studies showed that some herbicides (e.g., tebuthiuron, diuron and simazine) could remain active in soils for longer than ten months (55), while other compounds (oryzalin) would be deactivated in less than half that period (56). Bioassays carried out in orange groves corroborated these findings (57), offering an explanation for some cases of growth inhibition in crop rotations due to residual toxic effects of herbicides (58).

Residue persistence in soils is determined by the particular chemical characteristics of the compounds, interactions with soil particles and organic matter, and degradation by microorganisms (59). For instance, the number of microbial colonies was not influenced by pesticide application in a subtropical soil (59), and endosulfan degradation was slow in some soils of São Paulo state, but bound residue immobilization was much enhanced when microorganisms were present as compared to sterilized soils (60). Microorganisms appear to exert an important role in the bound residue release process in certain soils, making the residues available for degradation (61). This effect, however, is dependent on the length of the residue binding period (62,63) as well as residue characteristics, including product formulation and spraying method (64).

As this current analysis suggests, the vast majority of available information on environmental pesticide contamination in the South Cone regards organochlorine compounds and residues, which is due primarily to the long persistence of these compounds in the environment. Even after being banned from agricultural use in most countries during the 1970s, the residues were still present at the time that most of the literature in this review was written, and it is still valid today. Since the beginning of the 1980s, shortly after the establishment of use restrictions, organochlorine residue content in environmental samples has been steadily decreasing. Nevertheless, information on organochlorine residues is valid also for foodstuffs, because many of the studies were carried out when chlorinated compounds were in current use.

Contamination of food

Pesticides applied to crops are destined to contaminate soils. Residues bound to soil particles may be slowly released through leaching, volatilization, and absorption, resulting in the contamination of waters, the atmosphere, and plants and their consumers. Meat contamination due to sanitary practices and consumption by livestock of organochlorine-treated pastures have been studied since the early 1970s, when HCB levels reached 1.69 ppm (average 0.39 ppm) in Brazil (65). Extensive monitoring conducted at that time pointed to an uneasy picture (66,67) - 17% of beef samples were contaminated above acceptable levels (established at 0.30 ppm for HCB in that particular study (68); as compared to 1.0 ppm proposed for Brazil since 1972 (69)). Spatial distribution of contamination matched the level of economic development, suggesting that regions applying more advanced technology would show higher residue contamination (70). Temporal trends, on the other hand, indicated that in the early 1980s residue levels began to decrease sharply, surpassing acceptable levels in just 3.2% of 2,959 beef samples analyzed in 1984 (71) and none in the 1984-87 period (72). In 1994 an extensive monitoring of organochlorine and organophosphorous compounds (acceptable limits then lowered to 0.01 and 0.02 ppm, respectively) was carried out for foodstuffs in São Paulo state. All 242 samples complied with established limits, but one sample of tomato had endosulfan residues, which is not permitted for that culture (73).

The decreasing tendency in organochlorine residue content was confirmed in evaluations of poultry meat in the 1988-91 period. Although a large proportion of samples showed traces of several compounds, the levels never exceeded tolerance limits (74). In another study (75), the highest residue levels detected in poultry flesh remained between one tenth and one hundredth of the maximum allowed. Even the manure produced in the poultry houses did not present any contamination problems (76). The absence of residues in poultry flesh is reflected in the quality of eggs, as shown in a survey carried out in the metropolitan area of Santiago (Chile). The prevalent residue (lindane) reached 8.3 ppb, a level well below acceptable limits (77).

Residue analyses of chlorinated pesticides performed in several foodstuffs in São Paulo in the early 1970s indicated a daily intake of 0.4 μg/kg (total residues) for an average adult, a large proportion of which originated from food of animal origin (69). These results showed that the contamination pattern observed in Brazil differed from that in the northern hemisphere, where DDT replaced HCB as the prevalent residue. The same pattern occurred also in Chile (77) and Argentina (78).

Legal restrictions and regulations on pesticide use in Argentina began as a result of trade constraints imposed by the USA because of organochlorine residue content in meat during the 1960s (78). As a consequence, and following the temporal trend that occurred in Brazil, recent monitoring programs of residues in meat and derivatives produced in Argentina showed only 0.7% of samples with residue levels above 50% of the acceptable levels established by North American legislation (79). Attention to the regulations established by trade partners has induced research for process development and product quality improvement. Experimental exposure of cattle to pesticide-treated feed allowed the establishment of safety interval and acceptable residue level (80). Similarly, herbicides applied to pastures have been evaluated with respect to the risk of meat contamination, which was found to be low when the dosage and safety interval were maintained (81). Concern with quality of food and feed prevails in all countries of the region, as in Chile (82,83) and Brazil (84). Results suggest that organochlorine contamination exists and results essentially from residues in pasturelands.

Contamination of pastures ends up causing residue in milk and milk products. As early as 1971, organochlorine detected in milk sold in São Paulo city reached up to 55 ppb for HCB, whereas some cheese samples contained up to 1,300 ppb, a level far above the maximum established by the WHO (4 ppb for milk and 100 ppb for derivatives) (85). In a follow-up study in 1979, residues were still detected in all samples. Even though contamination levels had decreased as compared to the previous assessment, 88.6% of the samples still exceeded acceptable limits (86). The decreasing trend in residue content in milk persisted in later evaluations (87), and in 1984 no samples collected in three cities of São Paulo state exceeded acceptable limits (88), with the highest average residue content being 0.020 ppm in milk fat.

A similar trend in residue content in milk products seems to have occurred in Argentina, where assessments are more recent. Milk (89) and butter (90) samples were evaluated for organochlorine residues and even though residues, especially of HCH and heptachlor, were present in most samples FAO/WHO limits were violated only sporadically. The maximum level detected in butter fat reached 0.64 ppm. In Chile, chlorinated residues were detected in raw and pasteurized milk, and in animal feed. Residue levels were high, with an average of 0.44 ppm of HCB in pasteurized milk, and 0.78 ppm in feed (91).

Chlorinated pesticide contamination of pastures, fields, and the environment in general also resulted in the presence of residues in honey (92,93). An assessment carried out in several Brazilian regions showed residues in 22% of the samples, at levels of HCH up to 0.044 ppm (94).

In addition to the occurrence of pesticide residues in processed and unprocessed foodstuffs of animal origin, there is also the problem of contamination of fruits and vegetables, most of which are consumed fresh or shortly after harvesting, thus increasing the risks to the public. The specific case of produce has been of special concern because organochlorine pesticide residues were not admitted legally, nevertheless were ubiquitous in analyzed samples. For instance, of 120 samples obtained in the Produce Distribution Center of São Paulo (CEAGESP) in 1980, eight showed unauthorized residues (one above limits) and 99 showed nondetectable levels (95). Similar results were reported in 1983 (96,97), and were confirmed in Paraná state (Brazil) in the period 1987-1992, when 30% of 523 samples had residues of organochlorine compounds (at low levels), and one sample of snap beans had pyrazophos above the tolerance limit (98). These residue monitoring programs for fruits, vegetables, and stored grains in several regions of Brazil (99,100), contributed to the documentation of the rapid trend toward lower levels of unauthorized residues, as well as residues in general in produce (101).

In addition, there has been a profusion of experimental evaluations of residue levels resulting from pesticide treatment for crop protection. Studies on aldicarb residues in potatoes under different treatment regimes showed that the 1.0 ppm limit would not be exceeded (102,103,104). The same kind of assessments was extensively carried out in oranges, an important export item for Brazil. When orange groves were treated with organophosphates (ethion and fenitrothion) there were nondetectable residues in fruit pulp (105); this was found also for a variety of systemic insecticides (106). On the other hand, the carbamate aldicarb resulted in residue levels of 0.12 ppm, below the 0.2 ppm tolerance (107). These results were confirmed in analyses performed in the US State of Connecticut, where none of the 15 orange juices listed as coming from Brazil contained unauthorized residues, nor levels above the established limits of that country (108). As fruits are a substantial Chilean export item, there is also a great interest in residue evaluations in Chile. Analyses of several compounds in kiwi fruit showed that residues were persistent on the peel (109).

The picture for contamination of vegetables by fungicide residues is a more serious problem (110). Studies with dithiocarbamate fungicides often show residues in harvested produce (111,112). A detailed assessment of fruits and vegetables ready for commercialization in Rio de Janeiro showed that of 466 samples, 63% had detectable residues, 24% exceeding the acceptable levels by up to 50% (113). Such results are troubling since these compounds (mancozeb, maneb, propineb, thiram and zineb) have as a major residue ethylenethiourea, a very stable carcinogen (114).

Argentina has a similar pattern of fungicide contamination as that observed in Brazil and residues increased during the period 1984-89, with 2.8% of samples exceeding the tolerance level and 4.5% showing unauthorized residues. The main problem, however, was biological contamination (18% with coliforms, 0.4% *Salmonella*). Concerning temporal trends, the proportion of samples exceeding the accepted limits grew from 1% in 1984 to 5.4% in 1989, with the prevalent residue being the organophosphate parathion (115).

Agricultural products less prone to spoilage, those stored normally under low humidity for long periods, as well as those employed mainly for oil extraction, present a number of contamination problems. Often these products need pesticide spraying before storage, adding to normal residues. Cocoa nuts analyzed for HCB residues following several spraying regimes had low (0.01 ppm) residue levels, but a safety interval for harvesting could be established at 60 days (116). Aldicarb residues in roasted coffee beans following periods of 15 to 90 days after treatment remained below detection limits (0.02 ppm), even with a dose as high as 32 kg/ha (117). Similarly, parathion-treated rice plants showed less than 2% the applied dose five weeks after treatment. Most residues remained bound to soil (22%), and the half-life was about two weeks (118).

Pesticides applied directly on grains before storage often result in diverse situations (119). An assessment of the recovery of pyrimiphos-methyl applied to harvested wheat grains showed that 94% of the dose applied remained 24 hours post-spray. The recovery decreased to 37% after 180 days in storage, and cooking did not alter this figure (120). Pesticide treatment for grain storage usually results in contamination of extracted vegetable oils. Analyses of oil and margarine produced from corn, soybean, sunflower and rice showed that organochlorine, but not organophosphate residues, would remain in the final products (121), and it occurred also with olive oil (122).

The case of heavy metals

Another important class of environmental contaminants are the heavy metals. Regardless of whether they originate from industrial wastewaters or mining activities, or from contamination of fertilizers and other soil amendments produced from urban solid wastes, sewage sludge, or other waste sources, or even from the once common pesticides based on metallic salts, heavy metals are contaminants of high risk to the environment and public health. Before the banning of mercurial fungicides in Brazil in the 1970s, the use of these compounds caused serious contamination problems. As one example, 25% of fish caught in some areas contained residues varying from 0.01 to 0.66 ppm, while the tolerance established by the WHO was 0.5 ppm (123). Presently, there is concern about the use of cupric pesticides, but in this case the risks are lower (124).

Phosphate fertilizers produced from Brazilian minerals have shown no problems of metal contamination, specially cadmium (125), but certain alkaline smelter residues may offer considerable risks (126). Exposure of rural workers to radionuclides present in certain phosphatic rocks had a small but significant increase to α-particle exposure (127). An epidemiological assessment of the general health status of populations living along polluted rivers in South America concluded that the occurrence of metals was at normal ranges, although lead levels in children from certain places were high enough to recommend closer surveillance (128). In some cases, however, rivers may get heavily polluted (129), contributing to oceanic and coastal contamination. Most commonly such high pollution levels are caused by industrial activities, and may attain contamination levels as high as those once observed in polluted areas of the northern hemisphere (130,131,132,133).

One particular problem of environmental contamination with mercury which is claiming much attention is related to gold mining in areas of the Brazilian Amazon and Pantanal regions (134). Atmospheric mercury at the mining site was similar to control areas, but concentrations in sediments, fish, and even hair of exposed miners indicated heavy pollution (135). Wastes from mining operations and heavy metals also pose important environmental problems in Chile (136) and Argentina where contamination by metals stems mainly from industrial activities (137). Heavy metal contamination is a global concern, and it is substantiated by the high levels of metals in marine mammals caught in the remote coastal areas of the South Atlantic (138).

In general, however, and as discussed earlier for pesticides and persistent industrial contaminants such as PCBs and PAHs, the environment of the South Cone seems relatively less contaminated by heavy metals than the industrialized countries of the North. This is corroborated by an elegant study in which feathers of predatory migratory birds were analyzed for metals. Mercury was significantly more concentrated in the feathers grown while the birds stayed on North American summering grounds, as compared with feathers grown in the southern hemisphere nesting grounds (139).

Rural worker exposure and public health

In order for pesticides to occur as environmental contaminants and residues in food, they must first be sprayed on fields, which always results in some drift and exposure of both the worker spraying and the population living close to treated areas. Concern about rural worker occupational exposure (140) and related public health aspects in the South Cone are long-standing (141), and together with the risks associated with contaminated food (142,143) have been the most common circumstances linking pesticides to morbidity and mortality (144,145). Improper spraying equipment and protective gear, as well as prolonged periods of uninterrupted exposure, often result in acute intoxication and profound physiologic alterations in workers (146,147).

The South Cone appears as a region with relatively low pesticide usage per unit area, but the amount applied per rural worker may be considerable. In São Paulo state, where pesticide use per rural worker is higher, each worker sprays an average of 32.2 kg/year of pesticides (148), a quantity representing a dangerous exposure if not properly handled (149,150). Indeed, levels of dieldrin in the blood of workers exposed to aldrin could reach values as elevated as those found in cases of acute intoxication (0.49 ppm) (151). In addition, there is the typical exposure to residents, related to food and environmental contamination characteristic of areas adjacent to treated fields (152,153,154), and areas treated in health campaigns against disease vectors (average blood contamination of 100 ppb for HCH (155)). Nonetheless, in most cases the residue levels in blood samples, even of those occupationally exposed, remained within limits deemed safe (average between 10.5 and 16.5 ppb for DDE (155,156)).

Apparently, human contamination was once much greater in Argentina, especially by HCH residues (157). Adult Argentines not occupationally exposed had an average of 23 ppb of HCH, as compared to rural workers with an average of 237.7 ppb. For DDT and its metabolites, the values were similar or a little less than those observed in the USA, around 15 ppb (158). The recent literature describes many incidents caused by improper pesticide handling, indicating that in Argentina as well, this is the origin of most problems. Nevertheless, DDT levels in blood have decreased since the 1970s, to a 6 ppm average in Argentina as compared to 11 and 19 ppm in the USA and Israel, respectively (159).

The observable effects caused by chronic contamination by pesticide residues are controversial. One study of chromosomal aberrations in human lymphocytes did not detect any increase in damage to workers exposed to methyl parathion as compared with nonexposed control subjects (160). Similarly, an assessment of the frequency of carcinomas in the rural population of the city of Londrina, in Paraná state (southern Brazil), did not indicate a different degree of incidence relative to the national average, but a research program was proposed to check the possible association between the high pesticide usage of the region and this aspect of public health (161). On the other hand, pesticides were involved in the etiology of at least five of 31 cases of aplastic anaemia in one group of patients (162). Pesticides were also epidemiologically linked to the increased incidence of a type of infantile abdominal tumor (Wilm´s disease) in Brazil (163). The toxicity resulting from residues in the circulatory system may be the immediate cause of death, as described in a report that shows how unjustifiable can be the exposure to pesticides (164).

One way of inspecting the prevalence of acute intoxication by pesticides is through the information deposited in "Toxicity Surveillance" Centers (165). The general register of the University Centers of Toxicological Information on four macroregions of Brazil showed that pesticides were related to 11.5% of the 15,024 attended patients in 1994. The majority of injuries were due to animal toxins (30%) and medicines (30%), 52% of events being accidental, 24.5% suicide attempts, and 13% occupational. Industrial activities comprised 8.5% of the cases, agricultural activities 6.4%, and urban activities 67.3% (166). Because these numbers reflect the routine of the Toxicity Surveillance Centers they blur the real picture of the pesticide intoxication situation. In addition to exposure in handling and in the rural workplace, there are reports of collective intoxication caused by treatment of garden playgrounds (167), or by agricultural chemicals being illegally substituted for rodenticide, resulting in contamination of houses (168), and by improper and unlawful disposal of empty containers (169). Usually, these instances of illicit use involve banned substances, as recently denounced in an investigation of their availability in Brazil (170).

Due to all of these problems, many research programs on the epidemiology of intoxication have been initiated in the South Cone and elsewhere (171,172). An outcome of these programs is that much improvement is being felt in public and worker awareness and, consequentially, in legislation in Argentina (173), Brazil (174,175), Chile (176) and Uruguay (177). Certainly there is much left to do for the small landholders (4).

Programs and initiatives, however commendable, contribute little to minimize the crucial problem of the slow but inescapable poisoning of our children. Only with a strict observation of the law and the effective discontinuation of organochlorinated pesticide use, and the passing of time, will this abate. The vulnerability of children rests first in their extravagant dietary habits, which are virtually ignored in the establishment of residue tolerance limits for food (178), and second in the contamination of maternal milk.

By the end of the 1970s, organochlorine residues in maternal milk collected in a milk bank in São Paulo reached very high values (1-66 ppb of lindane, 15-1,752 ppb of a DDE metabolite), even if the average (13 ppb) was lower than that observed in Europe and North America (179). More recent assessments in the interior of São Paulo state have pointed to stable average levels (180), but showed that mothers previously exposed to organochlorinated pesticides could present extreme values (0.149 ppm), enough to cause a daily ingestion of DDT by newborns threefold that recommended by FAO/WHO. Even for nonexposed mothers, such ingestion would be 60% of the acceptable value (181). Studies carried out in other Brazilian states such as Paraná (total DDT average 0.142 ppm (182)) and Rio Grande do Sul (DDT_{total} 1 to 35 ppb (183)), as well as data from Argentina (DDT_{total} 0.14 ppm in 1971, 0.61 ppm in 1981 (159)) and from Chile (DDT 3 to 190 ppb, lindane 1 to 29 ppb (184)) confirm the ubiquitous presence of residues in maternal milk in the region. Acknowledging the vital value of maternal milk to the healthy development of the child, society must not spare efforts to attain a rapid and drastic reduction of this contamination.

Pesticides and environmental degradation

The direct exposure to pesticide residues through the diet (185) does not convey all impacts associated with the current usage of these substances. The deterioration of the agricultural environment is explained in part by the fact that agricultural management is based upon chemicals as the fundamental technologic pillar (186). Despite evidence of the counterproductive effects of pesticides, e.g., resistant pests and weeds, negative impact on symbiotic microflora and beneficial organisms (187-190); and despite all the renewed attention devoted to the development of a sustainable agriculture (191-197), the adoption of technology by farmers and the viability of adequately altering current management practices depend on very complex variables (198). A "cult" based upon pesticide usage still pervades the region (199,200,201). There is a certain institutionalization of the pressure toward the use of banned substances on fragile environments, even when alternatives are available (202), as commonly has occurred in mosquito control initiatives under the aegis of public health programs (203).

The consequence of this utilitarian perspective on pesticide usage is the widespread pollution problems detected in all Latin America (5,204-209). One must still face the current trend of expansion in agrochemical usage in the region, due to resumed economic growth and integration in the Mercosul (210-214).

Pesticide market and pertinent legislation

The intensification in pesticide usage in the South Cone followed the entrance of the transnational chemical corporations in the regional agribusiness in the early 1960s, with full concurrence of governments. There are differences within the region related to the size of the markets and the pace of their growth. Brazil stands out both in variety of products available and in volume consumed (1,879 trade marks and a largest volume of 105 million kilograms reached in 1983 (215)). This position ensues not only from the size of the agricultural sector in this country, but also from an explicit subvention policy set in 1975 with the National Plan of Agricultural Defensives (PNDA), which offered incentives for the installation of an industrial park directed to providing inputs to the sector (2,216,217,218). The PNDA caused a boom in the domestic production of pesticides, turning Brazil into a net exporter in 1981 (219).

There are those who argue in favor of the savings brought about by such a policy to the country that spent US$ 37 million in pesticides in 1970 and US$ 281 million in 1981, a figure that could mount to US$ 534 million if the productive infrastructure had not been built (220). This account, however, is clearly biased, for it assumes a steady consuming market against a hypothetically diverse production structure. In all cases, one must ask: Which factors induced such expansion? In reality the Brazilian government was a generous facilitator for the industries. Credit was offered to farmers with a share strictly directed to investment in pesticide purchases (221). The industry was allowed to keep an enormous degree of foreign control on production (in 1982 the transnational corporations held 77% of the Brazilian market (222)) and was called upon to exert technical assistance in the field, as the government dismantled the official extension programs, opening the market from production to prescription to sales. This liberal legislation permitted the industries to deal with compounds banned in the countries of their origin (which still persists) extending the commercial life of the compounds and making the local market even more attractive (222).

In Argentina the evolution of the market was diverse. During the 1960s domestically produced organochlorine pesticides predominated. Beginning in 1970 the market grew rapidly, reaching 30 million kilograms. Imported substances increased their share from 30 to 80% (1).

Regarding legislation, the modernization process was, or has been, extremely slow (223,224,225,226). The bill of 1934 (previous to the introduction of the organochlorine pesticides) prevailed in Brazil until 1986 (227), and quality standards for waters and tolerance levels for residues in food were also late to arrive (228,229,230). In a review of the pertinent Brazilian legislation in 1986, the author declared the need for a new code (231). A bill passed in Rio Grande do Sul state in 1977 was then introduced nationwide, under the strong objection from industry (232). The bill established the *agronomic prescription* (a compulsory receipt filed by a certified technician and required for any pesticide purchase), banned the organochlorinated pesticides (except for special uses which, unfortunately, were too many), and demanded the renewal of pesticide registration with the Ministry. More importantly, the bill allowed civil organizations to solicit cancellation of pesticide registration for reasons of public interest (233). A good law code, however, does not warrant easement for such complex problems as those related to pesticide use, whether for agricultural use (234) or environmental impacts (235).

Public awareness and the will to change

A simple modification in sprayer design can reduce from 1,864.7 ml/h to 166.8 ml/h the worker's dermal exposure to pesticides being applied (236). Nonetheless, rural workers fall victim to pesticide poisoning with a frequency much higher than is admissible (164), not only accidentally but also by chronic exposure, legally virtually unavoidable. As much as 40% of the growers in the town of Nova Friburgo in Rio de Janeiro, and 12% of 1,493 farmers of ten counties in Santa Catarina state (southern Brazil) that were studied showed organophosphate contamination of blood (221). These numbers are contrary to the assertion of the pesticide industry that poisonings and deaths stem from careless handling, thus making it a problem of the user - these numbers indicate that the use itself is inadequate (221). It is only with an effective participation of a conscious public, combined with the strong support of committed social agents - with special reference to the National Institutes of Agricultural Research (INIAs) - that society will achieve an improvement in the existing situation of environmental impact by pesticides in the South Cone (237).

The release of dubious information by unqualified agents tends to distort the problem, and is definitely misleading for the education of the public and for the definition of official programs (238). Another important aspect relates to the manner by which tolerance levels are established (178,239). Normally, toxicity parameters determined in the laboratory are compared with food consumption patterns of the average population, and the residue concentration limits are established to match an acceptable daily intake for millions of people. How can one acquiesce to such a procedure when many pesticides banned elsewhere are legally used among us? (240). This contradiction could be worked out through a cost/benefit analysis but there is always the likelihood that the best organized interest group will prevail - benefit to industry, cost to society (227). There are those who maintain that the costs are already too high, that the presence of pesticides in food and the environment is inadmissible (241,242,243).

It is imperative to think ahead, develop and stimulate a sustainable agriculture, more advanced than the conventional management of the green revolution, dependent on toxic inputs and voracious for natural resources (244). Setting forth the sustainable alternative, however, clashes with the present-day policy once called "conservative modernization" (221), which places emphasis on export crops, managed intensively in extensive monocrops directed solely for introduction into a market avid only for competitive prices. The rural worker and the families of small farmers are driven out to shantytowns, and those who stay are captive of a circle of poison and poverty (3). Intoxication is credited to ignorance, illiteracy, inadequate training, lack of protective gear, and disregard about the explicit warnings of the hazards and toxicity of pesticides. The true causes of pesticide impacts, however, pertain to a higher sphere and must be attributed to the preponderance of economic policy and interest (instead of public interest) that orients production, sales, and use of pesticides (245). We are, after all, dealing with a problem that involves as many as 375,000 cases of poisoning, and 10,000 deaths a year worldwide! (237).

The prevention and abatement of poisonings mean a shifting of practices and engaging society in an agreement that simultaneously: *a)* Promotes strict enforcement of regulation and demands the issuance of the agronomic prescription without exception; *b)* instructs the population in general, and farmers in particular, about the hazards of pesticides, and makes them protagonists of the regulation enforcement programs; *c)* instructs specialized personnel in chemical safety, including toxicology and safe handling of pesticides; *d)* promotes integrated pest management programs, crop rotation, biological control, and emergency systems to allow early prevention of emergent outbreaks; and *e)* implements sustainable agriculture (3).

It is important to take into account that we have focused our attention in this review on aspects of pesticide contamination, but the pesticide issue and the environmental implications that derive from them span a much broader subject (246). There are those who vehemently argue in favor of the withdrawal of pesticides from common use for three main reasons: *a)* Pesticides are not an effective or definite way of controlling pests, for they induce resistance and secondary pest outbreaks, establishing a cycle of dependence; *b)* pesticides cause ecological imbalances, deteriorating soil and water, eliminating species, and bringing about all kinds of environmental degradation; and *c)* pesticides poison people both in the countryside as well as in cities (246).

As extremist as it may sound, such a solution does not seem viable in the short run, faced with the established agricultural model on which depends mankind's food supply. Considering these factors, could any effort dedicated toward educating the public be successful? (247). Should we educate or ban? (248).

An alliance for health and the environment

Even if the South Cone comprises a market of vital interest to the transnational chemical corporations, the countries in the region alone have not been capable of preventing the abuses and misuses of pesticides. Pressures from the global market for quality and competitiveness, and the present-day movement to enter this market determine how nations set priorities. When worse social and environmental practices of a *commercial competitor* afford trade advantages and are accepted in international negotiations, they are difficult to avoid. However, an alliance of power can be formed if, as *commercial partners*, the rules of conduct are defined in favor of social and environmentally sound practices, i.e., power to call for a new order of conduct from other partners, even transnational ones.

The alliance being now celebrated by the peoples of the South Cone - named the Mercosul - and the global expression reached by the subcontinent offer an opportunity for a novel balance of power. Inferring that there is consensus of will, changes may be possible, and based upon what appears in this review, change is needed, and change we must. As an allied society we must embrace the agenda of sustainability. Once established we may act to modify the changes to our particular needs.

When we learn that official credit was the mechanism of choice for favoring corporations, we notice that similar mechanisms might be used to forward the currently needed technologic shift. If partnership for the future is the motto, we must unite all partners engaged in agribusiness for an exercise in co-responsibility. We must incorporate in the toxic substances agenda, more justifiably than in any other, the concept of product life cycle. Containers and unused products should close the cycle of production-sale-use-return (from cradle to grave) safely handled by industry. We must invite industry to an exercise in equity for the availability of compounds, in such a way that only those deemed safe in all parts of the world are made available to us. Many more changes such as these, some easy, some difficult, must occur.

It is imperative that our empowered representatives establish a dialogue and set a joint policy for dealing with the impact of pesticides on our environment and our health. The issue necessitates to be changed, the moment is ripe. ■

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