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Major Chemical Accidents in Industrializing Countries: The Socio-Political Amplification of Risk

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Accidents in the chemical industry, such as those that took place in Seveso (1976) and Bhopal (1984), may kill or injure thousands of people, cause serious health hazards and irreversible environmental damage. The aim of this paper is to examine the ever-increasing risk of similar accidents becoming a frequent ocurrence in the so-called industrializing countries. Using figures from some of the worst chemical accidents in the last decades, data on the Bhopal disaster, and Brazil's social and institutional characteristics, we put forward the hypothesis that present social, political and economic structures in industrializing countries make these countries much more vulnerable to such accidents and create the type of setting where—if and when these accidents occur—they will have even more catastrophic consequences. The authors argue that only the transformation of local structures, and stronger technical cooperation between international organizations, industrialized and industrializing countries could reduce this vulnerability.

KEY WORDS: Major chemical accidents, socio-political amplification of risk, chemical industry; industrializing countries, industrialized countries

1. INTRODUCTION

Chemical accidents can result from emissions, fires, or explosion of chemicals during transportation, storage or industrial activities, leading to serious, immediate or delayed damage to human beings and/or the environment, and involve one or more chemical substances.[1-4] They are considered major chemical accidents—even if, as argued by Otway *et al.*,[5] the concept of "major accident" is a rather fuzzy one. This article deals only with accidents that have as source stationary activities, that is, storage and industrial production, and those that have occurred in the pipelines. It fails to consider those that take place while chemicals are being transported by road or sea.

Our main objective is to examine the increasing risk of industrial chemical accidents occurring in industrializing countries. It is possible that, in attempting to detect the causes for major chemical accidents, the overriding factor to be considered should be the characteristics of the context where such accidents take place, and this type of analysis could be even more important than considerations on the absolute magnitude of the accident. This certainly applies in the case of major chemical accidents in industrializing countries,[6] where the specificity of social, political, and economic characteristics should be the subject of further investigation and discussions in the risk analysis field.[7] As pointed out by Kasperson *et al.*[8] "... the practice of characterizing risk by probability and magnitude of harm has drawn fire for neglecting equity issues in relation to time (future generations), space (the so-called LULU or NIMBY issue), or social groups (the proletariat, the highly vulnerable, the export of hazard to developing countries)...." These discussions are of great importance to risk analysis and the notion of socio-political amplification can help us in the understanding of how present social and political structures in industrializing countries have contributed to aggravating risk situations and events.

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2. THE SOCIO-POLITICAL AMPLIFICATION OF RISK

Before embarking in the actual discussion, clarification about what we call socio-political amplification of risks is called for, since, the notion we use here differs in some aspects from the conceptual framework *social amplification of risk*, developed in the relevant literature.[8,9] By socio-political amplification of risk we mean the comparative powerlessness of certain societies to control risks. The notion is linked to a view of the contemporary global economy as a system characterized by the interdependence between countries, and where the production of goods for a world market is not just the main objective but also requires the development of financial and technological exchanges.[10–14] In this interdependent system, each and every country has its function in the international division of labor, and this leads to an international division of benefits and also of risks. About 80% of the global consumption of goods is restricted to a quarter of the world's population, most of it in the industrialized countries.[15,16] In India, for instance, the per capita consumption of goods resulting from chemical technology was estimated at 1 kg, while in industrialized countries, this figure is in the 30–40 kg bracket.[17] The positions are inverted when we consider risks. In industrializing countries, less elaborate measures for the protection of the environment, human health and safety, have been, although not always explicitly, an important item in global economic negotiations and these have often led to an unfair international division of risks.[16,18] How this has been accomplished will be explained below.

India, in Asia, and Brazil and Mexico in Latin America, are typical examples of countries where development models and the form of insertion in the global economy has contributed to increasing the number and the magnitude of major chemical accidents. The three countries had high rates of economic growth from the 1960s to 1980s only at the cost of developing a huge external debt—according to the World Bank[19] they are the world leaders in external debts—of increasing internalization of international corporations and strong State intervention in the economy. The search for rapid economic growth and accelerated insertion in the global economic system, led to an industrialization model that was further sustained by the absence or weakness of democratic political systems and by deep changes in the structure and organization of society.[10,13]

The adoption of this industrialization model brought in its tow a quick and disordered industrialization and an intense and uncontrolled urbanization process. The large migratory flow from rural and poor areas to the industrial-urban centers was not met by an equivalent number of openings in the job market, nor by the necessary expansion in basic infrastructure that could guarantee the newcomers minimum conditions in terms of housing, sanitation and health care.[13,20–24] One of the consequences of this process was that a large number of low-income and empoverished communities had no alternative but to settle in areas adjacent to potentially dangerous chemical plants, thus becoming, for social reasons, highly vulnerable to major chemical accidents.

Moreover, the elite's vested interests in rapid economic growth and industrialization encouraged its members to neglect or totally ignore the need for specific regulations to protect the environment and workers from industrial chemical risks.[25,26] Pressure groups and workers' organizations have been unable to counteract this trend and to press successfully for regulations such as the Seveso Directive in European Communities and the Emergency Planning and Right-to-Know in USA.[22,27] In Brazil, for example, the net result of this process is the absence or weakness of most institutional strategies for the prevention and control of accidents, such as the siting of hazardous facilities and land-use planning, risk analysis, obligatory accident notification, emergency planning, and the dissemination of information among community members and workers on risks and strategies for emergency situations. This absence or weakness of adequate strategies for the prevention and control of major chemical accidents seems to be a common feature also in other industrializing countries.

To build our notion of socio-political amplification of risk we use as reference notions and concepts developed by a series of authors. Some of these authors talk about the risk distribution both at the international level—for instance, the concepts of *export of hazards* and *double standards*[28–31]—an at the national level, where concepts such as *social inequalities* and *environmental inequalities*[32–34] are looked at. Others work with the concept of *vulnerability* in "man-made" and "natural" disasters. These particular studies introducing the significance of socioeconomic factors and economic development[35,36] attempt to explain how similar hazards can have different effects in different types of countries and populations. Yet another important group of authors make use of the concept of *coupling* to study mixed technological and societal systems, linking these systems to different types of uncertainty in the various phases of risk assessment and management.[37,38] A last group of authors compare the particular decision-making processes involving the acceptability and regulation of technological risks in different societies.[39,40]

In constructing the notion of socio-political amplification of risks, this literature has contributed to a greater understanding of why similar accidents have had a higher rate of fatalities, injuries, and more severe environmental destruction in industrializing countries due to the international division of risks. The countries we use in this article to exemplify the application of the socio-political amplification of risks notion—India, Brazil, and Mexico—have in common the adoption, in the 1960s and 1970s of similar development models and, in the 1980s, some of the worst major chemical accidents, either in multinational corporations (as in Bhopal, India) or in national corporations (as in São Paulo, Brazil, and San Juan Ixhuatepec, Mexico). The official death figures were respectively 2500 in Bhopal, 508 in Brazil, and 550 in Mexico.[41]

3. QUANTITATIVE ASPECTS OF MAJOR CHEMICAL ACCIDENTS IN DEVELOPING COUNTRIES

The magnitude and severity of a major chemical accident is usually measured by some of its consequences such as the number of fatalities, injuries, immediate or future and chronic health problems, ecological damage, economic losses, number of people evacuated, etc.[3–6,41,42] Among these consequences—or variables—figures about the number of fatalities seem to be the ones most commonly registered in most cases of major chemical accidents worldwide, and can therefore be used to compare the severity of the various accidents in different countries.

Table I[43] shows some of this century's (up to 1984) major chemical accidents with more than 20 fatalities, that is, those that can be regarded as catastrophic accidents.[42] The data clearly demonstrates that, until the 1970s, major chemical accidents happened predominantly in industrialized countries, where there was a much higher concentration of industries. From the 1970s onward, however, even if a much greater number of industries was still to be found in the industrialized countries, the number of accidents in developing countries increased steadily, in spite of the incipient and recent industrialization of those countries at the time. And it was in fact in Asia and Latin America that some of this century's worst major chemical accidents actually happened

What we can conclude from the data in Table I, therefore, is that even if industrialized countries have had a greater number of accidents, the accidents that took place in industrializing countries—mainly in Asia and Latin America and in the 1980s—have had more fatalities, being therefore regarded as more severe The actual situation may be even more dramatic if we consider that data on major chemical accidents and their victims are more difficult to obtain in industrializing countries. In Table II, prepared by Glickman *et al.*,[47] the pattern outlined in Table I can be seen more clearly. Here, India, Brazil, and Mexico, countries where the worst accidents occurred in the 1980s, are, together with China, leader countries in major chemical accidents with five or more fatalities per accident between 1945 and 1991.

Out of the total 295 accidents in ten countries shown in Table II, 79% occurred in industrialized countries while only 21% happened in industrializing countries. In the case of fatalities, however, the situation changes: 65% happened in industrializing countries and 35% in industrialized countries. It is important to notice that Table II covers a long period (between 1945 and 1991), while major accidents became more frequent in industrializing countries after the 1970s

Table III uses data from the World Health Organization[41] to compare major chemical accidents—with more than 50 fatalities, or more than 100 people injured, or more than 2000 people evacuated—that took place in industrialized countries to those that occurred in the same period in industrializing countries Since it covers a shorter and more recent period (1974–1987) than that covered by Table II, it gives a better picture of how the number and severity of accidents increased in industrializing countries from the 1970s onward. In fact, after the 1970s and particularly in the 1980s—the latter period known in Latin America as the lost decade due to the prevailing social and economic crisis—accidents increased dramatically in developing countries.

It shows, for instance, that of the 59 major chemical accidents reported, 62% occurred in industrialized and 38% in industrializing countries, a clear increase in the number of accidents in industrializing countries and an equivalent reduction in the number of those in industrialized countries if compared with the respective percentages in Table II. Of the ten accidents with more than 50 fatalities, 90% happened in the industrializing countries, and of all accidents in the period, 92% of the fatalities were from accidents in the latter countries Moreover, in the case of accidents with more than 100 injuries, more than half (57%) took place in industrializing countries and of all these kinds of accidents, 96% of the injured were victims of accidents that happened in those countries

It is interesting to notice that in Table III, out of the 31 accidents with more than 2000 people evacuated, 65% occurred in industrialized and 35% in industrializing

Table I. Major Chemical Accidents with More than 20 Fatalities in This Century (up to 1984)[a]

Year	Country	Kind of accident	Chemical	Fatalities
1921	Germany	Explosion of anilin factory	Nitrate and ammonia sulfate	>500
1926	USA	Explosion of munition store	Trinitrotoluol	21
1926	USA	Release at a tankage	Chlorine	40
1930	Belgium	Toxic gases in the atmosphere	Hidrogen fluoride, sulphuric acid and sulphur dioxide	63
1933	Germany	Explosion in a foundry	Coke gas	65
1934	Hong Kong	Fire in a gasometer	Gas	42
1935	Germany	Explosion in an explosive factory	Dinitroluol, nitroglycerin, trinitrotoluol	82
1939	Roumania	Release at a chemical factory	Chlorine	60
1942	Belgium	Explosion	Ammonia nitrate	>100
1944	USA	Explosion of a gas cloud	LNG	130
1948	Germany	Tankcar explosion in a chemical factory	Dimetil eter	209
1948	East Germany	Explosion in a grinding plant	Coal-dust	50
1950	Mexico	Release at a factory	Hidrogen sulphide	22
1959	USA	Tankcar explosion on a highway	LGP	26
1966	France	Explosion in a refinery	Propane/butane	21
1968	East Germany	Explosion in a chemical factory	Vinylchloride	24
1968	Japan	Contamination of water from a foundry	Cadmium	100
1970	Japan	Explosion	Gas	92
1972	USA	Explosion from a coking plant	Propane	21
1972	Japan	Releases from six chemical factories	Unknown	76
1972	Brazil	Explosion of a refinery	Propane/butane	38
1973	USA	Fire in a liquified gastank	LNG	40
1974	England	Release and explosion in a chemical factory	Ciclohexane	28
1976	Finland	Explosion	Explosives	43
1977	Columbia	Release at a fertilizer factory	Ammonia, ammonia nitrate, and carbamide	30
1978	USA	Explosion of a tank wagon	LPG	25
1978	Mexico	Explosion	Butane	100
1978	Mexico	Pipeline explosion	Gas	58
1979	Soviet Union	Accident at a factory	Diverse products	300
1979	USA	Fire and explosion of a tanker	Crude oil	32
1979	Turkey	Fire and explosion of a oil tanker	Crude oil	55
1980	Iran	Explosion in an explosive storage space	Nitroglycerin	80
1980	India	Explosion at two factories	Explosives	40–80
1980	Spain	Explosion	Explosives	51
1980	Thailand	Armaments explosion	Explosives	54
1981	Venezuela	Explosion	Hidrocarburets	145
1984	Brazil	Pipeline explosion	Gasoline	508
1984	Mexico	Reservatory explosion	LPG	550
1984	India	Release at a chemical factory	Metil-isocianate	>2,500
1984	Pakistan	Pipeline explosion	Gas	60
1984	Indian	Release at a chemical factory	Mtilisocyanate	>2,500
1984	Pakistan	Pipeline explosion	Gas	60

[a] Source: Refs. 43, 44, 45, and 46

countries. However, if we compare the total number of people actually evacuated in these accidents, we see that a greater number (74%) of people were evacuated in industrializing countries. The table suggests that evacuations are not frequent in industrializing countries and only occurred in accidents of great magnitude—such as the one in Bhopal in 1984, which mobilized 200,000 people—or in situations of total panic—as it happened also in Bhopal in 1987, mobilizing another 200,000 people.[41]

4. RISK PREVENTION IN INDUSTRIALIZING COUNTRIES

The limitations of risk prevention in industrializing countries—and their relation to the recent globalization of the economy and the development model adopted in the last decades by these countries—may be better understood through the concepts of coupling[37,38] and vulnerability[25,36] insofar as the institutional weakness and

Table II. Nations with the Worst Record of Hazardous Materials Accidents (Five or More Deaths)[a]

Nations	Accidents		Deaths		Deaths per accident	
	n	Rank	*n*	Rank	*n*	Rank
USA	144	1	2241	2	15.6	8
Japan	30	2	526	5	17.5	6
India	18	3	4430	1	246.1	1
W. Germany	18	3	158	10	8.8	10
Mexico	17	4	848	3	49 9	3
France	15	5	236	8	15 7	7
Italy	14	6	260	7	18 6	5
Brazil	13	7	815	4	62 7	2
China	13	7	454	6	34 9	4
UK	13	7	170	9	13 1	9

[a] Source Ref 47

uncertainty in the control of risks, and the existence of those dangerous conditions that are a common feature in developing countries—that is, rapid urbanization, high poverty levels, poorly built and dangerously located housing, among others—can be easily correlated with an increase in the number and gravity of major chemical accidents. Using the three basic major phases in the prevention of hazardous industrial sites, the cases of India, Bhopal, and Latin America, in particular Brazil, will be used to give concrete examples of how these deficiencies operate in producing the socio-political amplification of major chemical accidents.

The *structural phase of prevention* represents investments on new plants or technologies and includes planning, siting, approval, construction, and licensing of new installations. In this phase, risk analysis can help in the decision-making process with four sequential steps: the identification of health and environmental hazards; the quantification of the extent of these hazards, decisions about the acceptability of risk; and risk reducing or controlling measures that can be used to maintain a situation of acceptable risk.

The second and third phases in prevention, involve the plant in operation before and after an accident and are the responsibility of risk management. The *operational prevention* includes safety measures to control potential sources of accidents such as maintenance procedures, work organization compatible with required safety levels, existence and adequate use of safety equipment, and continuous reviewing and evaluation of safety performance.

The third phase—*mitigant prevention*—occurs after an accident and is associated with the technical, medical, and institutional work that attenuates and/or repairs the negative impact of an accident. It includes, among others, the existence and effectiveness of on-site and off-site emergency plans, emergency and medical response, recovery of affected areas, social insurance procedures, and monetary compensation. All these factors are essential to cut down the number of victims and reduce other negative effects of an accident. Actions taken in this phase can influence other phases of prevention, for instance, through the so-called *feedback effect* of actual accidents. The analysis and the legal/monetary consequences of an accident may give the necessary feedback to help improving safety systems for potential similar accidents, for instance, by improving risk management in the operational phase and speeding up the development of safer technologies and plant design in the structural phase.

4.1. The Structural Phase

The *structural phase* in industrializing countries suffers from serious shortcomings. The legislation regulating the decision-making process for new installations is very precarious in practically all of these countries.[48,49] Hardly any country in Latin America has legislation equivalent to the European "Seveso Directive" or to the North American "Emergency Planning and Right-to-Know" In the cases where legislation exists, the technical and financial deficiencies of the regulatory institutions, added to the lack of efficient pressure groups in political systems that are not exactly democratic, strongly limits enforcement of the law.

In Brazil, the technical difficulties of controlling industrial risks by regulation have been aggravated by the financial crisis that assailed recent Governments. This means that many of the existing hazardous plants have been built without efficient government control, and safety becomes dependant almost exclusively on the self-regulation of industries in programs such as *responsible care*, which are very incipient in Brazil. Thus, an eventual decision about the unacceptability of a particular hazardous plant is delayed until later, when some catasthrophic effects would already have occurred, and when implementing new preventive measures or closing up the industry may no longer be so easily accomplished because the region around the plant has become economically dependent on its presence, or preventive measures too expensive to implement once the design and building phases have been completed.[50] The absence of competent technical fora where questions such

Table III. Total of Major Chemical Accidents Between 1974–1987 with More than 50 Fatalities, or 100 Injuries, or 2000 Evacuations in the World[a]

	Accidents		Accidents with more than 50 fatalities		Total of fatalities		Accidents with more than 100 injuries		Total of injuries		Accidents with more than 2000 people evacuated		Total of people mobilized in evacuations	
	n	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Industrialized Countries	38	62	1	10	349	8	16	57	2783	4	20	65	178,330	26
Industrializing Countries	21	38	9	90	3932	92	12	43	71,580	96	11	35	513,000	74
Total	59	100	10	100	4281	100	28	100	74,363	100	31	100	691,330	100

[a] Source: Ref. 41

as the choice of technology, technology transfer and plant design can be discussed and whose recommendations can provide the technical elements necessary for optimizing the result of the decision-making process, further reduces the possibility that the adopted technology will be the safest one.[51]

The decision-making process about the acceptability of risks is essentially a political process. The formulation of the problem, the right to participate in the decision process, the responsibilities specified by legislation and the ability to influence or constrain the actions of other actors can define the course of judgements. This social process can be viewed as a *social control of risks* and expresses the form in which a society accepts and influences the control of risks created by technological and industrial development. The construction of a technical risk analysis is, in most cases, and in all its phases, influenced by the prevailing interests in society. This happens also in industrialized countries, a fact that can be easily noticed by an examination of technical reports and results about the acceptability of liquefied energy gas terminals.[40] In industrializing countries, the decision-making process is normally restricted to commissions closed to representatives of workers' organizations, or of ecological and citizens' groups that in any case are usually not strong or organized enough to succeed in having their interests met. This obviously limits the efficiency of the social control of risks and increases the vulnerability of some social groups.

One of the main causes for the increase in the number of major chemical accidents in developing countries has to do with the siting of hazardous industries in highly populated or chaotically urbanized areas. As suggested above, in these countries, rapid and disordered industrialization—associated with the process of modernization in the countryside with a view to increasing the export of staples—led to also disordered migration from the countryside to urban centers. Jobless and homeless, these people settled in the peripheries or poorer sectors of cities. This, combined with local and regional governments' inability to—or lack of interest in—drawing and implementing feasible urban plans, gave origin to a series of slums or poor settlements that shared the space with hazardous industrial sites.

It is not a coincidence, therefore, that the victims of the three most serious major chemical accidents in the number of fatalities that happened in the second half of the twentieth century—namely in Mexico, Brazil, and India, all in 1984—were largely members of these marginalized communities. A comparison between the growing rates of the slum population and those for the population as a whole in the State of São Paulo—Latin America's main industrial metropolis and where the worst major chemical accident in Brazil took place—is revealing: between 1973 and 1987, the growing rate of the total population was approximately 63%, whereas the growing rate of the population in slums was 1145%.[52] The mushrooming of these poor and densely populated areas next to industrial plants is the origin for the social vulnerability of this contingent of the population. At the same time, the political weakness of these social groups limits their ability to press for the drawing and implementation of new social policies and regulatory practices

4.2. The Operational Phase

The social relations of work play an important role in the origin of industrial accidents at the *operational phase*. In industrializing countries the lack of qualification and formal education of the workforce should in theory lead to an extra effort by employers to provide extra training to make up for this, particularly in the case of technological transfer. This is largely not the case, how-

ever, because in these countries, effective labor legislation tends to be non-existent or is easily evaded by employers, and therefore, it becomes easier for employers to dismiss workers. The high turnover rates act both as a form of maintaining incomes at low levels and as a way to weaken workers' organizations. And weak workers' organizations mean less pressure for safety and risk control in the workplace. In Bhopal, previous to the accident, the number of blue-collar workers had been reduced from 850 to 642 over a 2 year period and qualified plant operators had been replaced by less qualified workers.[29] This dismissal of experienced workers was appointed as one of the many causes of the accident. In Brazil, high turnover rates and the replacement of experienced by non-experienced workers is a common occurrence in recent years. Also a strained and hierarchical mode of work relations, in making communication between the various work groups more difficult, limits the *feedback effect*—that is, reduces the possibilities of effectively implementing technical and organizational measures to avoid future accidents

The degeneration of equipment and the lack of safety precautions in industrializing countries during the *operational phase* can be associated with the transfer of technology and the firms' lack of sufficient investment, normally due to the constant financial crises. This also increases the potential for chemical disasters such as those in Bhopal, São Paulo, and San Juan de Ixuatepec.[29,30] Technical, organizational and economic difficulties discourage the maintenance of adequate operations and systems and this can affect the safety performance.[53–55] In Bhopal, demand for carbaryl pesticides had been lower than anticipated. This reduced the firm's profits and discouraged owners to make additional investments in safety measures, or equipment modernization. The closing up of the refrigeration system and the reduction of maintenance operators in Bhopal is an example of the type of economy measures that can lead to a major chemical accident.[51] Institutional weakness contributes to increasing the coupling of hazardous production systems in this context.

4.3. The Mitigant Phase

Another essential factor that must be considered in any attempt to explain the magnitude of major accidents in developing countries is the fact that off-site emergency preparedness plans are often not enforced by law in these countries, and therefore tend either not to exist at all or to be less than adequate. This limits an efficient *mitigant prevention*. Since no official information becomes widely available after an accident, when an accident does occur, the population living in the neighborhood of the hazardous site—usually densely populated slums as was the case in Bhopal, where density rates were on the range of 25,000 people per square kilometer—reacts instinctively. This leads to disordered spontaneous evacuation or situations of total panic that aggravate the impact of the accident, killing, injuring, or in any way affecting the health of a greater number of people.[56,57]

In Bhopal, it was found that whereas most of the people living in well-built houses escaped the worst effects of the accident, those living in the primitive conditions of the densely populated shanty towns were unable to protect themselves from the gas emitted by the accident. In Brazil, the worst major accident ever to happen (1984)—with 508 casualties—had its effects made worse by the fact that the surrounding population, in their poverty and ignorance, begun to store the spilt gasoline in the hope of being able to sell or use it later, thus creating an inflammable path between their own poorly built houses and the source of the accident and provoking further explosions and fires.[58] By comparing two similar accidents, one in Feyzin (France, 1966) and the other in San Juan Ixhuatepec (Mexico, 1984) it becomes clear how the proximity of densely populated and poorly built houses to hazardous sites can more than double the number of victims of an accident. The explosions in Feyzin in a tank with 6,400 m^3 of LPG resulted in 17 fatalities and about 80 injuries whereas the accident in San Juan Ixhuatepec, with 12,000 m^3 of LPG, killed 500 people and injured 7,000. The greatest difference here was the presence of adequate urban planning in Feyzin where the distance of the nearest house to the storage perimeter was in the range of 1,000 meters, while in Mexico city this distance was only 100 meters.[59] This proximity of houses to chemical plants is, nowadays, a common feature in Brazil.[58]

One of the essential items of emergency planning is the availability of adequate medical facilities. This just does not happen in industrializing countries. The medical response in Bhopal, for instance, was totally inadequate, inspite of the heroic efforts of the untrained and uninformed local health staff.[60] In general, in developing countries, the hospitals serving the densely populated and low-income areas that surround chemical plants, due to the so-called diseases of poverty, are permanently overcrowded with patients. They are also understaffed and lacking equipment, drugs,and dressings. When a chemical accident occurs, they are simply unable to respond adequately Here again, social causes such as the lack of public investment in health, contribute to an increase in the number of victims of chemical accidents in these countries.[61]

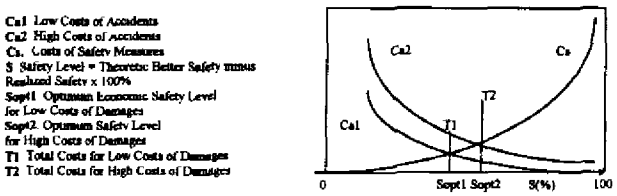

Fig. 1. Safety investments, danger costs, and economical optimum safety standard See Refs 62 and 63

5. ECONOMIC RATIONALITY VS. SOCIAL CONTROL OF RISKS

The lack of adequate legislation on industrial chemical risks in developing countries, and the fragility of existing decision-making processes involving technological risks limit the *social control of risks* and allows firms—the risk creators themselves—to do their own regulation with restricted legal enforcement and hardly any government control. Companies' self-regulation in industrializing countries, tend to be based on cost-benefit calculations and a strict economic rationality and therefore their investments in safety precautions are relatively much lower than the ones in industrialized countries where government regulations and public pressure are much stronger.

Also one important instrument of prevention is the incorporation of environmental and occupational costs resulting from industrial hazards. These potential costs to the firms may be lower in industrializing countries depending on whether they are or not incorporated by the firms, thus encouraging or discouraging investments in safety measures

A chemical accident is a costly affair with destroyed equipment and installations, repair expenses, interruption of production, first aid, and medical equipment and treatment, emergency response facilities, decontamination activities, payment of indemnities and eventual pension to victims, loss of image and market, and so on. Here there are two important questions: the actual cost of an accident and how these costs are distributed between firms—or insurance companies—and society as a whole. In a strict economic analysis of safety investments the optimum value is the one which maximizes the relationship between investments and costs, as we can see in Fig. 1,[62,63] in a theoretical approach to the optimum value The optimum economic safety standard leaves a residual risk that may be economically acceptable. This does not mean, however, that this risk is morally acceptable.

There are some indications that the costs of major accidents, particularly its human costs, are not as expensive in industrializing as they are in industrialized countries. The initial compensation payment requested by the Indian authorities from the Union Carbide was $3 billion, but, in the end, they were satisfied with $470 million. Parents of the fatal victims received between $4500 and $12,500, invalids between $1000 and $8000, and a provisional pension of less than $10 a month was offered to the victims by the government. If a similar accident had occurred in an industrialized country, costs would have been much higher than these.[64]

This is not to say that Union Carbide management knew of the possibility of such a severe accident happening and accepted it because of an economic investment analysis, although, it is clear that the American management knew that the Indian company was not a good example of safety performance.[65] However, as in all industrializing countries, there was neither strong legal requirements nor enough pressure from workers' groups and communities, and therefore, the firm's own economic rationality—rather than a balance between economics and the more desirable social/institutional control of risks—guided its policies on safety. The result was that many of the essential safety measures were inexistent in Bhopal. To name a few: (a) the vent scrubber was designed to neutralize only 7 tons of MIC, whereas a tank contained 40 tons; (b) whereas an European factory will work with a process that has a maximum inventory of 10 kg of MIC, the Union Carbide factory in Bhopal was designed to provide storage to up to 120 tons of MIC—one of the most toxic chemicals on an industrial scale—probably obeying economies of scale of chemical plants and not taking into consideration the potential danger of such high inventory; (c) technical reliability was reduced by the non-existence of redundant safety systems for flaring the MIC and for the pressure monitoring systems; (d) the prime protection system was not in operation—the refrigeration system had been closed down 6 months before the accident simply in order to reduce running costs in the factory; (e) the number of operating personnel in the MIC plant had been reduced from 11 to six operators.[29,51,66]

6. CONCLUSION: POSSIBILITIES OF CHANGE

The contemporary organization of the global economy, with its international division of labour, benefits and risks, has been contributing to the socio-political amplification of industrial chemical accidents in industrializing countries, a tendency that also applies to other

industrial risks In Brazil, for instance, the official number of accidents at work between 1980 and 1989 was 10,500,000 (ten and a half million) resulting in 260,000 permanent injuries and 46,000 fatalities. This number may be in fact greater, since accidents at work are not always reported in this country.[67] Similar figures for accidents have been reported in other industrializing countries, where the International Labour Office estimates that rates of fatalities and injuries at work are about sixfold those in industrialized countries.[68]

Reversing the socio-political amplification of risks in industrializing countries involves initiatives of different nature and degrees of complexity, both at national and international level This recognition, however, should not encourage immobility nor imply that change is not possible. The Bhopal accident in India and Mexico's participation in NAFTA have, in different ways, been contributing to the development of some institutional strategies for prevention and control of major chemical accidents. If compared to the existing policies in industrialized countries, however, these strategies are still incipient and in most developing countries, just starting, in spite of the efforts of international organizations such as the United Nations Environmental Programme, the World Health Organization, and the International Labour Office.

In a global world, intensification of international cooperation between international organizations, and between industrialized and industrializing countries is an important step toward the reduction of prevailing differences in standards of prevention and of the severity of major chemical accidents in the latter countries The OECD guide for chemical accidents goes in this direction when it proposes the same safety standards for multinational corporations even when the latter are located in developing countries. How this proposal may be implemented, however, is still unclear, and all our efforts must be directed to finding the necessary instruments to do this. As suggested by Inhaber[7] the Society for Risk Analysis may also play an important role in this process, by dedicating attention how to make trade-offs between risk and economic, social, and political concerns, putting forward proposals for the control and prevention of major chemical accidents through discussions and the development of joint projects between institutions and researchers of industrialized and industrializing countries.

A global approach reveals that the social vulnerability within hazardous sites in industrializing countries will not be reduced without the drawing and implementation of major social policies. In those countries, a large part of the obstacles to the regulation of industrial risks can only be overcome by changing the socio-political structures that amplify the frequency and effects of chemical and other industrial risks. For this to happen, however, we must strive for two things: first, and at the international level, a deep transformation of the social and environmental inequalities that characterize the present global economic system is needed; and second, and at the national level, a more intensive participation of the involved actors—and this means an effective redistribution of wealth and the consolidation of civil rights for all—to guarantee the modernization and enforcement of appropriate legislation and the elimination of other obstacles.

Perhaps safety standards in the case of chemical accidents even in industrialized countries are not yet perfect. However, in order to achieve global ecological change it should be necessary for all spaceship Earth's passengers to have similar sets of basic protection measures and to be able to discuss directions together. The fact that there are different classes of passengers in this ship may jeopardize the development of a common alternative solution for the present impasse. Thus unfortunate concepts such "Third" and "First" Worlds should be forgotten if we genuinely believe that both major industrial accidents and future ecological disasters must be prevented

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