Photo: USAID

The Four Sides of Water Quality Degradation

The Hydrological Cost of Non-action

"The Ontario (Canada) government declared a state of emergency last night at a northern native reserve plagued with contaminated drinking water, paving the way for the removal of as many as 1,100 residents. The government will charter planes to airlift residents of the Kashechewan Reserve in need of medical attention to Timmins, Cochrane and other neighbouring communities."

This lead paragraph from an article dated October 26, 2005, comes from Canada – a country whose rivers discharge annually 105,000 m³/s, 7% of the world's renewable water supply. Canada is not alone; the most frequent sources of water pollution around the world are human waste (with 2 million tonnes a day discharged to watercourses), industrial and chemical wastes, and agricultural pesticides and fertilizers. Key forms of pollution include faecal coliforms, industrial organic substances, acidifying substances from mining aquifers and atmospheric emissions, heavy metals from industry, ammonia, nitrate and phosphate pollution and pesticide residues from agriculture, sediments from human-induced erosion to rivers, lakes and reservoirs.

Despite the growing attention to a chronic, pernicious crisis in the world's water resources, our ability to correctly assess and predict global water availability, water quality, use and balance is still quite limited. The first serious attempt in modelling global world water resources using the system dynamics approach integrated the water resources sector (quantity and quality) with five sectors that drive industrial growth: population, agriculture, economy, non-renewable resources and persistent pollution.

Projecting possible scenarios

The simulations of world water dynamics with the WorldWater modelling indicate that there is a strong relationship between world water resources and future global industrial growth. The total supply of the world's renewable water resources is estimated to be 42,650 km³/year. Production of wastewater was in excess of 1,400 km³/year in 1995. Estimating that each litre of wastewater pollutes at least 9 litres of freshwater, some 12,600 km³/year – approximately 30% of world's water resources – are not available for use due to pollution. The future outlooks are very alarming when this data is incorporated into WorldWater and linked to population growth, industrial development, agricultural production, use of non-renewable resources and persistent pollution.

WorldWater simulations also conclude: (a) the use of clean water for dilution and transport of wastewater, if not modified, imposes a major stress on the global world water balance; (b) despite conservative data on wastewater disposal and rate of dilution, the use of clean water for dilution exceeds the total water use by six times; (c) water use by different sectors creates an overshoot and collapse in world water dynamics which is quite different behaviour then predicted by classical forecasting tools and other water-models; and (d) sensitivity analysis conducted with WorldWater did not show any significant change in world water dynamics to the change in estimated

Photo: Mats Lannerstad

The poor suffer most from degradation of the water environment.

amount of freshwater polluted by one litre of wastewater (range from 7 to 13 litres has been investigated).

Potential solutions have been identified, however, by WorldWater. These include (a) continuation of "business as usual," with dire consequences; (b) water desalination; and (c) various conservation scenarios that combine use of desalination, water reuse and wastewater treatment.

Important conclusions from the numerous simulations are:

1. If not dealt with, the pollution of the world's water resources will have a dramatic impact on the world population in the 21st Century.
2. Alternative policy options can be used to address the main global water problem. Desalination can be used as a single

policy solution for providing clean water supply for dilution. The world economy is strong enough to absorb the cost of additional desalination capacity without difficulties. However, it needs to be stressed that this conclusion is valid only on the global scale. The implementation of such a unified world policy will be highly unlikely.
3. More realistic solutions to world water problems can be found on the regional scale. Integration of desalination, water reuse and wastewater treatment into more rational policy options is demonstrating that the main global water problem can be addressed at the regional scale, and that different combinations of measures will lead to global solutions.
4. Action is required now. The global water crisis exists, and the devastating consequences will be very hard to stop later. Mitigation policies at a later date would require policy solutions on the global level. Regional capital and capacity may not be sufficient for complete elimination of water quality related problems, and populations – particularly the poor – may suffer. Further, the gap between rich and poor countries may increase.

By Slobodan P. Simonovic, Professor and Research Chair, The University of Western Ontario, London, Canada. ■

Better Estimates Are Needed of the Economic Costs of Not Controlling Hazardous Water Pollution

Estimating the costs of hazardous pollution in water bodies has received little attention. What makes the valuation complicated is that costs are likely to be "situation-dependent." In other words, the costs of hazardous pollution may be affected by the composition of water demand and information given to the public, which are dependent on both private and public actions. This is because private averting behaviour depends on the extent of information available concerning a contaminant's health risks, and whether reasonably priced, alternative, water supplies are available. Furthermore, studies have shown that the cost of abating toxic contamination can vary widely by type of industry and chemical. This means the net gain from abating a given pollutant would have an even wider variance.

Toxicity, persistence and source

To illustrate what information is needed, and why it is important, this article focuses on three quite different hazardous water pollutants in terms of toxicity, persistence and source – mercury, arsenic and atrazine. Arsenic primarily occurs naturally in groundwater, while atrazine is introduced commercially to control weeds. In contrast, mercury is a by-product of mining and coal burning and is one of 12, priority-persistent, bioaccumulative, and toxic (PBTs) chemicals that the international community has agreed to reduce or eliminate.

Since arsenic is primarily natural occurring, public agencies must focus their efforts on expanding, monitoring and helping families engage in actions to avert arsenic contamination through use of filters or other averting actions. Given the magnitude of the problem in China, India and Bangladesh, the monitoring of wells should take first priority, followed by assistance to avert contamination. Since Bangladesh may have over 2 million wells with arsenic levels above the World Health Organization's (WHO) standard, efforts to avert contamination need to focus on areas with the highest damages. What we need to know to set priorities is, what differences are there in health costs as the contamination levels climb from the WHO standard to levels more than 20 times above the standard, and what population groups are most susceptible to the contamination?

Mercury poses a different set of problems since it causes both air and water pollution. Estimates of the cost of mercury pollution are key to establishing tighter emission standards, both for coal burning plants and mining. For example, would the current U.S. administration have found it so easy to weaken the U.S. mercury emission standards if it was widely known that this would impose a cost on the U.S. population of between 2 and 4 billion dollars annually? In some countries, damage-cost studies would strengthen governments' abilities to control polluting firms. Such stud-

Many of the chemicals used in society, and which remain in the environment after use, have important economic functions. Pesticides and fertilisers help to increase agricultural production, for example. Is it possible to find more benign substitutes so that the economic benefits accrued from the use of the less-benign chemicals are not lost?

Photo: Jan Lundqvist

ies could help the Indonesian government in its court case against Newmont Mining, which has allegedly been dumping mercury and arsenic into Buyat Bay on Sulawesi.

Atrazine is the easiest of the three pollutants to control since it is commercially produced to use in agriculture. It also may have the best averting strategy, that of developing less toxic methods to control weeds. If recent U.S. Environmental Protection Agency studies are correct, and atrazine does not raise the risk of cancer among humans, then what we need are estimates of the costs atrazine imposes on different ecological systems. These costs can then be used to target our efforts to reduce atrazine use and encourage substitutes.

No time to wait

Sometimes we cannot wait for studies of the costs of not controlling hazardous pollutants, but when there is time, such studies help prioritise efforts and provide greater pollution control at lower costs. Controlling hazardous water pollution is not easy, particularly if the pollutants are naturally occurring, such as arsenic. Yet damage cost estimates may be what are needed to force greater cleanup efforts and set better priorities.

By Dr. K. William Easter, Dept. of Applied Economics, University of Minnesota, USA.

Human Diseases Induced by Chemical Pollution: The Paris Appeal

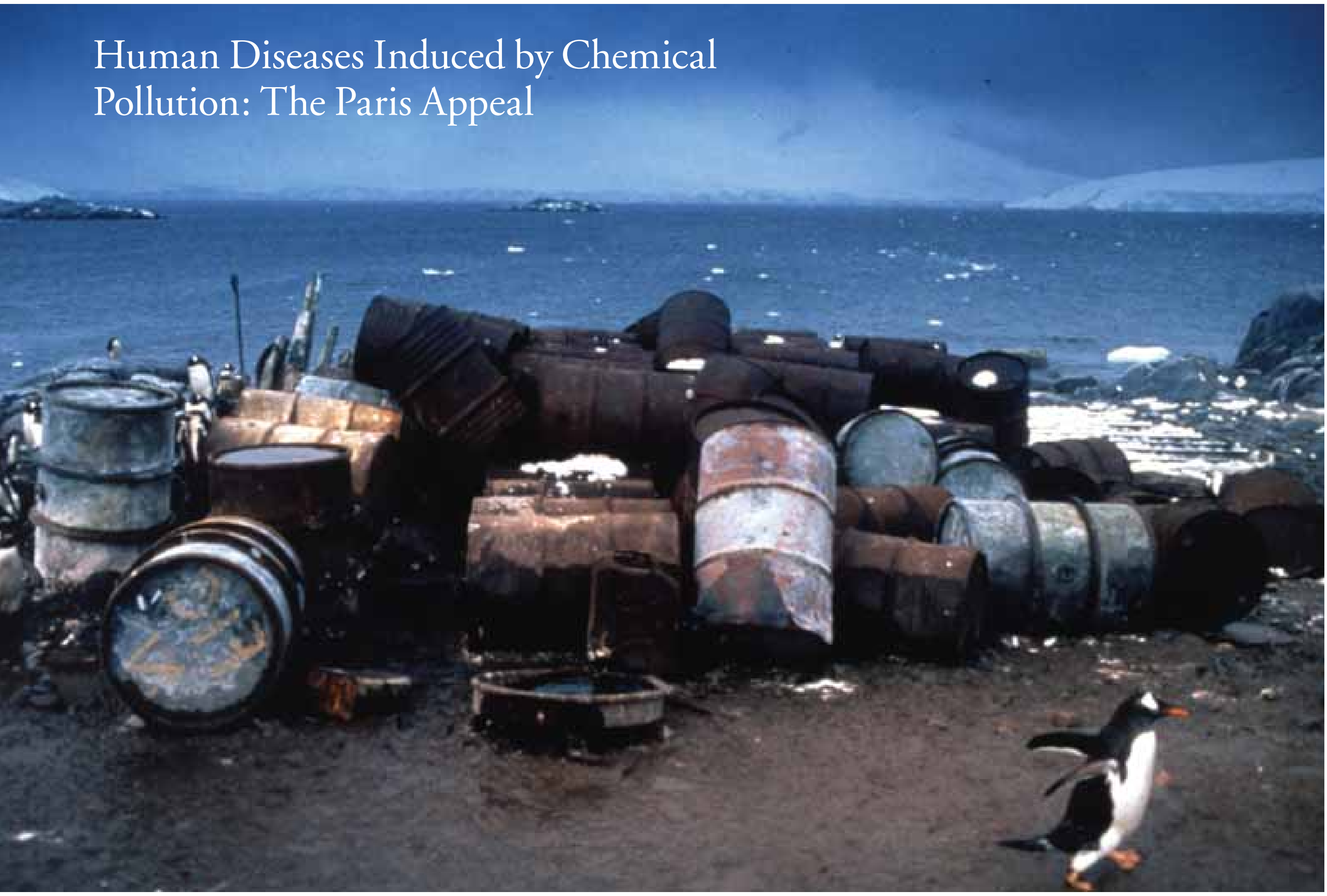

Photo: EU Audiovisual Library

Among the 100,000 chemical substances on the European market since the second world war, fewer than 5,000 were tested for their health toxicity, and among them, only a few hundred for their carcinogenicity.

Waste and dust are the main vectors of human contamination by micro-organisms or chemicals. Water pollution in air and soil contaminates drinking water as well as food. Water pollution by chemicals can be due to well-designated sources such as a factory or a waste discharge, or to more diffuse sources related to household or outside atmospheric air pollution, or to agricultural or industrial activities. Pollutants can migrate from disposal sites, underground injection wells or underground storage systems and contaminate ground and surface water sources.

Persistent toxic pollutants (PTPs) include heavy metals (arsenic, mercury, chromium, nickel, lead, cadmium, etc.) and persistent organic pollutants (POPs): nitrates, pesticides, hormones from intensive farming, and polycyclic aromatic hydrocarbons (PAHs), dioxins, furans, polychlorinated biphenyls (PCBs) from diverse industrial activities, food additives and pharmaceutical products, etc.

Although water is the main pathway for these pollutants, a major property is their low water solubility and high lipid solubility. Thus they tend to accumulate in lipid structures in plants and animals. Therefore, as all these pollutants are bioaccumulable, their concentration in fish and other aquatic organisms are not only a biological monitor of environmental pollution, but also as a sentinel human health indicator and monitor of potential human health hazard. Indeed all these pollutants impact on ecosystems, including the food chain, and therefore can be found at very high concentrations in human fat tissue.

Health – a fundamental value

Health is a fundamental value. According to the World Health Organization (WHO), health is "a state of complete, physical, mental and social well-being and not merely the absence of disease or infirmity." Due to risk to human health of polluted water, a major public health concern is to define acceptable quality parameters for drinking water. The European Space Agency (ESA) has described 72 water quality parameters for manned space vehicles among which 26, such as nitrates, are substances which are undesirable in excess amounts, and 13 toxic substances, such as heavy metals, pesticides (and their related products) and PAHs.

Because many of these toxic substances are carcinogenic, mutagenic and reprotoxic (CMR), and some of them allergenic, they must be monitored in water and multiple drastic measures must be taken to avoid contamination.

Human diseases are no longer only secondary to microbial or parasitic pollution (infections), but first and foremost, to chemical pollution (mainly chronic toxicity) induced by human activities. From such pollution originate many diseases with a growing incidence that we, at the Association for Research and Treatments Against Cancer (ARTAC), are investigating for their toxicological origin and epidemiological features. They include cancers (50% could be related to chemical pollution), congenital malformations (fetus' vulnerability), infertility (in Europe, 15% of couples are infertile), food-related allergies (in France, 20% of the population is allergic), certain degenerative diseases of the central nervous system (CNS) such as Parkinson's disease in young individuals, and even possibly forms of obesity.

The child is most vulnerable

Within the population, the child is the most vulnerable. After storage in the mother's body, POPs are released from the adipose tissue and during pregnancy, penetrate the placenta and contaminate the fetus. Indeed, recent data indicates that many newborns are contaminated at birth by many chemicals. Due to their affinity for lipids, such molecules can concentrate in the CNS of the fetus and induce CNS abnormalities, while other molecules, due to their immunosuppressive properties can worsen in newborns the physiological immune deficit, which itself can favour bacterial or viral infections.

Furthermore, as many of these molecules are of the CMR type, they may very well induce CMR-related diseases during infancy or later on. This is happening in Europe. There has been a 1% yearly increase of incidence of childhood cancers, over 20–30 years. Cancer is therefore the second cause of mortality in children today. Although much medical progress occurred for the treatment of childhood leukaemia, it is worthy of note that childhood leukaemia doubled during the last 50 years. Likewise, compared to about 20 to 30 years ago, congenital malformations tripled in some agricultural areas polluted by pesticides, and as reported by several studies, including a Danish metaanalysis, infertility due to azoospermia drastically increased in young adults. The data says clearly that children are in danger.

The Paris Appeal

This is what is explained in the Paris Appeal, an international declaration on the sanitary dangers of chemical pollution. This appeal was presented at the WHO-organised European conference of June 2004 in Budapest, and at the European Parliament in January 2005 in Brussels. It has now been signed by the standing committees of European doctors, all the Medical Associations Boards in the 25 EU member states (they represent 2 million European medical doctors) by over 500 scientists, including several Nobel Prize recipients, by approximately 1,000 non-governmental organisations and by more than 150,000 European citizens.

This appeal comprises 3 articles:

- The development of many current diseases is caused by environmental degradation.
- Chemical pollution constitutes a serious threat for the child and for the survival of mankind.
- As our health, that of our children and future generations are under threat, the human race itself is in danger.

This Appeal offers 7 categories of measures, among which are the reinforcement of the European program REACH (Registration, Evaluation and Authorisation of Chemicals), the adaptation of regulatory toxicological standards to suit children, and following the ratification of the Kyoto Protocol, the need to implement quickly measures to fight climatic warming.

Of the 100,000 chemical substances on the European market since 1945, fewer than 5,000 were tested for their health toxicity, and among them, only a few hundred for their carcinogenicity.

The REACH European program wants to inverse the situation. It aims (1) at regulating the marketing of new chemical by reinforcing the registration report, (2) at verifying the authorisation procedure and (3) reinvestigating presumed CMR molecules (the estimated number is 30,000) through the creation of a central European agency of chemical product.

Substituting where possible

The substitution principle is a fundamental way to concretise the precautionary principle. According to measure 1 and 2 of the Paris Appeal, substitution is mandatory for chemicals which can cancer. It is what was demanded, during an ARTAC-organised press conference on REACH in November 2005, in the European Parliament. Substitution should be the first option if a safer substance exists. This should stimulate R&D innovation and encourage green chemistry with responsible industries. Indeed, due to potential cocktail effects of substances, the risk for the environment and health cannot be adequately controlled by industries.

The European Commission calculates the avoidance of chemically-induced diseases in the first ten years of REACH to be Euro 0.66–6.2bn, with a midpoint estimate at around Euro 3.5bn. Over a longer, 30-year period, it puts the benefits at Euro 21–161bn, with a midpoint of around Euro 90bn.

It is urgent to reduce and eliminate release of POPs in the environment. Water pollution is clearly devastating for people and for animals, including fish and birds. Coping will require some type of realistic "European Marshall Plan," linking health to environment, protecting flora and fauna and deciding concrete measures to minimise the greenhouse effect. This is what stipulates the Paris Appeal, and what will be discussed during the next international ARTAC-colloquium in May 2006 at UNESCO-Paris.

By Dr. D. Belpomme, Professor in Medical Oncology, Paris V. University. ■

Photo: Olli Varis

The Paris Appeal has been calling attention to the role of environmental contaminants in cancer.

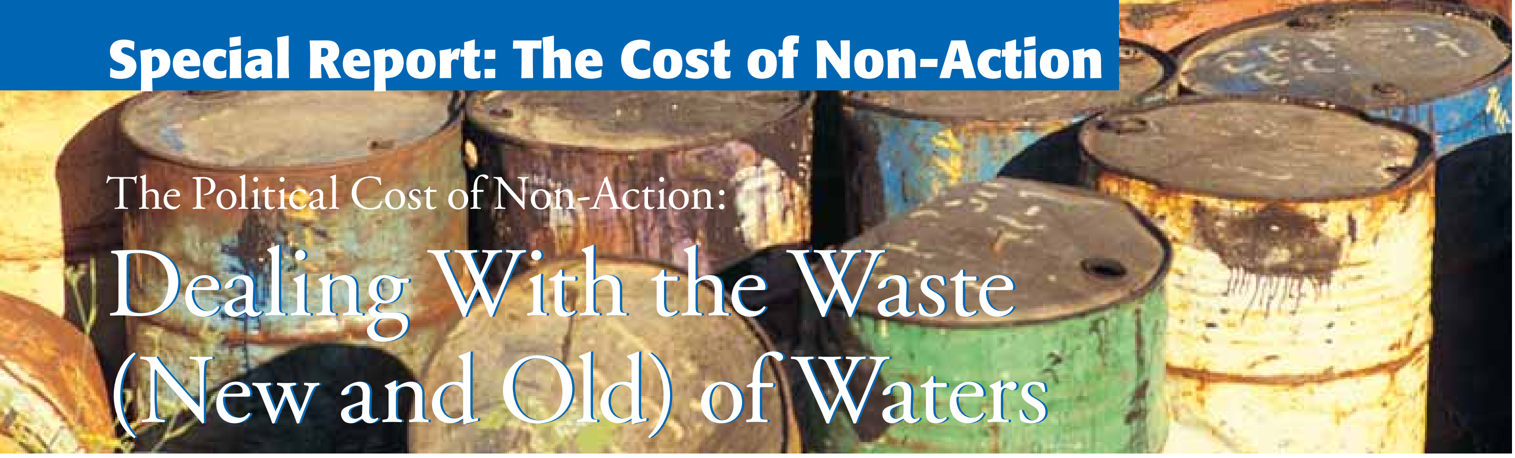

Photo: SIWI

The Political Cost of Non-Action:

Dealing With the Waste (New and Old) of Waters

The characteristics of wastewater are an important measure of Society's progress to modernity. If the water has biological contaminants it can be presumed that society is still water-traditional and poor, as it does not have the ability to treat its human sewage and other organic wastes. If the water is full of chemical toxins then society is progressing towards the next phase of water-industrial use but is still poor as it cannot clean the water before discharge. If the water has cocktails of trace toxic pollutants – from arsenic and mercury to hormones and pesticides to even more deadly dioxins and furans – then the society is truly industrialised and rich. It uses huge amounts of products, which contain these chemicals, it also spends huge amounts to treat its effluents, but it is finding that traces – deadly and toxic traces – escape its best efforts. It needs to continuously upgrade its treatment plants and effluent standards to track and treat the new characteristics of its wastewater.

What then would one say of waters, where all three characteristics of waste are found – biological, crude chemical and modern chemical? This wastewater is clearly reflective of a society in various stages of economic growth. But it is also a society, which as it grows is finding itself incapable and unable to treat its waste. It is accumulating all waste and all costs of treatment as it progresses towards higher levels of industrialisation. In simple terms, it is society in deep trouble. It has a double-burden of pollution to treat – traditional and modern.

It therefore, also has a double-burden of diseases to treat – the traditional water-borne diseases, which still result in unacceptable human morbidity and mortality – and the modern chemicals, which result in expensive diseases like cancers and other genetic disorders. It is this double-burden of pollution and disease that large parts of the industrialising South is confronted with today.

The political costs of this inaction are difficult to predict. The fact is that life is unfortunately cheap in the South. The fact also is that modern science has found it difficult to prove cause and effect of large numbers of chemicals we use and their ability to trigger diseases in the human bodies. It is this combination of apathy and ignorance that may just ensure that we continue to pollute our waterways with a heady mixture of the old with the new.

It is also a fact that modern technologies for cleaning waste are out of reach from this waste-accumulated society. They are too expensive to install and even more expensive to run. The problem is that even as industry has universalised the use of its chemicals and other pollutants, it has not worked hard to universalise the answers needed to mitigate its deadly discharge. The reason is that industry has treated waste as a business – it must be profitable to treat. This principle works when society has money to pollute and also to treat. But in large parts of this poor and polluted South, there is little money to treat on its human excreta, let alone its modern chemical waste.

It is here the challenge lies: To reinvent the paradigm of waste treatment by reinventing the paradigm of waste generation itself.

But to do this we must discuss not just the cost of inaction. But we must understand the cost of political action, which will force this technological and societal change. I believe it can be done. The fact is that the environmental movement of the North came at a time, when the society had already created wealth and was generating waste. The political action was driven by waste managers. But in the industrialising South, the movement for change is growing at a time when it is generation waste in the midst of poverty. Its political managers will need to be much more than drain inspectors and cleaners. They will have to change the nature of the drain itself. That indeed is the political challenge of change in our world.

By Ms. Sunita Narain, Executive Director, Centre for Science and Environment in New Delhi, India, the 2005 Stockholm Water Prize Laureate ■

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