Discussion paper for topic 2

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STRATEGIES FOR MINIMISING INDUSTRIAL POLLUTION OF WATER/WASTEWATER USED FOR AGRICULTURE

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Introduction

Both industrial wastes and wastes originating from city hospitals have hazardous components. When these waste streams get mixed with domestic sewage before discharge into watercourses, the health and environmental risks increase, since the polluted water may be used downstream as a source of drinking water (treated usually but sometimes untreated), for irrigation of crops, and for livestock uses. Most urban and peri-urban farmers in spite of the risks involved view the presence of domestic sewage in their water source as a benefit because it provides plant nutrients (findings from IWMI research with farmers in Mexico, Pakistan, Vietnam and Ghana).

Thus appropriate strategies for minimising industrial pollution of the domestic sewage and watercourses would contribute to the general well being of the farmers as well as the consumers of the farm products.

In developed countries, the trend is to segregate industrial wastes from domestic sewage and dispose of it separately (usually with treatment). Thus whilst some amount of illegal industrial waste disposal does take place, sewers receive mostly domestic sewage. Furthermore in an attempt to make treatment easier, most industrial wastes are separated at the factory level into hazardous and non-hazardous components that are dealt with separately. Solid wastes are either sent to landfills (municipal or special hazardous waste landfills), or incinerated (in municipal incinerators or in special hazardous waste incinerators), whilst the liquid wastes are sent for biological, chemical or physical treatment on site or off-site (hazardous and non-hazardous wastes handled separately), with "end-of-pipe" technologies, before being discharged to sewers and rivers.

In contrast, in developing countries current industrial waste disposal practices include the following (Tolentino et al. 1990):

- Direct discharge of untreated wastes to watercourses, drains and abandoned land. This practice may be illegal but overlooked by the authorities
- Discharge of untreated wastes to drains or sewers where infrastructure exists
- Collection and disposal with domestic waste in a solid waste dump site or
- Landfill or incineration on-site or off-site
- Storage and/or burial on-site

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Strategies that have an impact on minimising industrial pollution of water in the context of its end use for urban agriculture can be classified into:

1. End of pipe technologies – wastewater treatment at the point of discharge or centralised
2. Waste minimisation approaches - within the factory premises
3. Waste stream management between the factory outlet and the discharge point or end users (in the context of this paper, the agricultural producer), including segregation of industrial and domestic wastewater and controlled disposal.
4. Existence, application and monitoring of a set of adequate regulatory measures by the authorities (in combination with each of the above mentioned approaches)

The purpose of this paper is to provide an overview of current industrial waste management practices as a basis for an exchange of experiences, and reflection on the design of effective waste management policies aimed for improving the quality of water used for urban agriculture in developing countries. Many of the industrial waste management practices presented in this paper are more extensively applied in developed country contexts, but have relevance for developing country situations. The reasons for their limited application may range from a lack of financial resources to a lack of information and institutional mechanisms or simply a lack of interest and concern.

Industrial Waste Generation And Composition

The industrial waste stream is a heterogeneous waste stream. The industrial sector can be broken down into about 40 different industrial categories and each category will tend to differ in the amount and type of waste produced.

From a waste management perspective, size is more usefully defined by the amount of waste generated by an industrial firm. Waste generators are classified as being large, medium, small, or very small quantity generators. Small quantity (SQ) and very small quantity (VSQ) industries tend to dominate the industrial structure of developing countries and therefore represent an important focus of research. SQ and VSQ generators also tend to manage their wastes in a different manner from larger waste generators and may require modified policy initiatives adapted to their special needs (Deyle 1990, Schwartz et al. 1990).

"End-of-Pipe" Wastewater Treatment

Conventionally the emphasis of industrial waste management has been on *"end-of-pipe" approaches:* the on-factory or centralised treatment of liquid effluents found in wastewaters from industrial sources.

Water pollution control standards usually define the level of treatment that is required and, depending on the existence and strictness of the legislation, this level can range from none at all to extensive use of "end-of-pipe" technologies, which remove a wide variety of pollutants.

These technologies are widely applied in the developed world as well as in some mid-income countries like Jordan and Israel where the quality of the water is closely controlled, and is directly linked to the type of crops allowed to be grown. However, in most developing countries, municipalities lack the capacity to enforce regulations adequately for controlling factory discharges, even if they do exist; or to maintain sufficient centralised waste treatment capacity.

Introduction of industrial waste into the city sewerage systems creates serious difficulties since the existing city treatment systems have been designed for domestic sewage and design criteria for common treatment plants are more complex. Most municipalities in developing countries lack the capacity to establish and maintain sufficient common treatment facilities, mainly due to the high costs involved in establishment and maintenance of these facilities.

Moreover, end-of-pipe technologies tend to transform wastes from one form to another and do not contribute towards waste minimisation.

Waste Minimisation Approaches

During the last decade the emphasis of waste managers has shifted towards *waste minimisation strategies* (Huisingh et al. 1986, Munroe et al. 1990, Sutter 1989, Piasecki and Davis 1987). Waste minimisation attempts to avoid the generation of waste in the first place and reuse of as much remaining industrial wastes as possible by source reduction (reduction of the volume, weight or hazardous nature of a waste prior to or during the production process), and on- and off-site reuse (for original or other purpose) and recycling (requiring some sort of processing)

By this means, the amounts of waste produced are reduced and the quality of the wastes generated is improved so that the waste will be less injurious if discharged into a common sewer system (as the waste is then more amenable to treatment), or into watercourses.

Source reduction

Source reduction of wastes is generally perceived as having the greatest potential for avoiding energy and raw material consumption as well as waste production. With respect to hazardous industrial waste, source reduction can refer not only to reduction of the volume or weight of waste but also to a reduction of toxicity.

Many different approaches have been identified in the literature for reducing industrial waste at source (Munroe et al. 1990, Ghassami 1989, Higgins 1989, Tay 1993, Hunt 1990). The two main types of source reduction are source control and product changes. A more detailed breakdown of these types of source reduction measures can be found in Table 1.

Table 1 Industrial Source Reduction Measures

TYPE OF SOURCE REDUCTION MEASURE	DESCRIPTION/EXAMPLE
Product Changes	Reduce waste/toxicity associated with a product's use
Product Substitution	Substitute water-based paints for solvent-based paints
Product Concentration	Concentrate powder detergents, thus requiring less packaging
Source Control	Reduce waste/toxicity associated with a product's manufacture
Input Material Changes	Reduce waste/toxicity of materials used in the production process

	Material Purification	Use a higher grade of crude oil during refining, thus reducing the amount of impurities that must be removed
	Material Substitution	Substitute water-based cleansers for solvent-based cleansers
Technology Changes		Reduce waste through process and equipment modifications
	Process Changes	Improve the efficiency of chemical reactions
	Equipment Changes	Use mechanical scraping systems for cleaning rather than solvents
	Process Automation	Automation can optimise product yields by automatically adjusting process parameters
(Good Housekeeping Practices		Reduce waste by means of procedural and administrative measures
	Management and Personnel Practices	Offer employee education programs, bonuses and awards to encourage employees to reduce waste
	Waste Stream Segregation	Facilitate recycling by preventing mixing of different waste types, particularly hazardous and non-hazardous wastes
	Inventory Control	Use input materials before expiry dates
	Loss Prevention	Check for spills and fix leaks from equipment
	Cost Accounting	Allocate waste treatment and disposal costs directly to the departments or groups that generate the waste

Source: United States Environmental Protection Agency (1988), Ghassemi (1989)

Recycling and reuse

Waste materials generated during the production process can be reused (either for its original purpose or in a new role) or recycled both on-site (either in the plant or on the plant property) and off-site. Recycling requires some form of significant physical, chemical or biological processing.

With recycling and re-use, the waste products finding their way to the discharge point from the factory outlet are reduced, thus contributing less towards pollution. The reuse of wastewater also means that the company's requirements for fresh water will decrease, as will its water bills.

An important difference between developing economies and developed ones is that the former tend to favour more extensive recycling and reuse of materials. The reason is that on the demand side, the value of raw material inputs tends to be higher and their availability scarcer, thus making recycled or reused materials more attractive. On the supply side, the labour costs associated with separating mixed wastes are also very low. Industrial waste material sorting for the purposes of reuse and recycling is an important income-generating source that can benefit a wide range of actors, including factory owners, factory employees, scavengers, junk buyers, and municipal waste collection employees. With a few exceptions (c.f. Wellings 1984, Maclaren et al. 1994), there has been very little empirical work conducted to date on recycling and reuse by industry in developing countries.

Waste Stream Management

Another approach to reduce industrial pollution of these watercourses, and hence the risks related to its use in agriculture, is to introduce appropriate interventions between the source (industries, households) and rivers and users.
At this point of the wastewater chain, which is essentially under the control of the local authorities/municipalities, one can postulate that there are interventions to be made that would not be too complicated or expensive which could greatly improve the waste characteristics and quality. However, the attention given and efforts taken, to adequately manage the wastewater stream in order to minimise the pollution of natural water bodies or to prevent further contamination of domestic waste streams by hazardous materials, is almost non-existent.

Preventing mixing of industrial and domestic wastes is possible only if the waste streams are segregated for which separate collection and disposal facilities are required. Waste disposal infrastructure in most developing cities, are common systems, possibly because many of these systems are old and the phenomenon of waste management as an approach is of recent origin. With cities expanding and absorbing the peri-urban fringe, city authorities now have to include siting and planning of industrial estates as part of their duties. Such planning allows for isolating and separating industrial waste streams over specific distances. In the case of industries scattered around cities, segregation would involve parallel drainage networks to isolate these wastes from domestic sewage – an expensive alternative.

Waste stream segregation as a strategy has its greatest impact in situations typical of developing countries where industries do not apply either of the strategies outlined earlier.

Motivations and Barriers

This section and the following section of the paper discuss some of the incentives and barriers to the implementation of the strategies discussed. We will focus first on barriers and incentives relevant for 3R practices, which apply equally well to "end-of-pipe" practices. We then focus on the barriers to waste stream segregation likely to be faced by municipalities and how these might be overcome.

There are a number of *factors that can motivate industry* to reduce, reuse and recycle its wastes (Munroe et al. 1990, Ghassemi 1989, United States Environmental Protection Agency 1988). Implementing a waste minimization program has been shown to help reduce production costs (reduction in energy and raw material inputs used) and waste disposal costs and it can reduce the pollution on-site. It may also improve a company's corporate image or facilitate compliance with existing or future pollution regulations.

There are also a number of *important barriers* that can hinder the implementation of waste minimization programs (Resource Integration Systems et al. 1984, United States Environmental Protection Agency 1988, Batstone et al. 1989). The general types of barriers can be classified into six categories: economic, information, technological, regulatory, attitudinal and physical. The first four barriers are more relevant to developing countries than to developed countries, and are easily understood. The last two however are encountered as frequently in developing countries as they are in developed countries and may need some explanation.

An attitudinal barrier can exist if management is reluctant to take risks and is unwilling to consider changes in existing manufacturing processes or procedures for fear of affecting product quality. Another reason why firms may be reluctant to undertake a waste minimization program is simply because of organizational inertia.

There are three types of physical barriers to the implementation of waste minimization programs. The first one is the problem of having insufficient quantities of waste to justify internal use or external collection. The second is a lack of sufficient storage space to accumulate wastes for collection. A third frequently is lack of sufficient land for on-site treatment. All these problems tend to be more significant for small and very small firms.

All of the barriers discussed above apply equally well to wastewater treatment

In the case of segregation of waste streams, motivation for such a strategy has to be at the level of the municipality. Apriori there are no direct economic gains to be had, and any motivation would be purely an ethical one with the intention of protecting human health and the environment.

In recognising the barriers that may impede progress, technology is not a major limitation but having the economic resources at the city level, for implementation, is. Attitudinal barriers will include the inertia of municipalities/city planners to make changes. But it is felt that the main barrier is the lack of regulatory and control mechanisms with pursuit of offenders, to prevent discharge of industrial wastes into the city drainage/sewerage systems.

Incentives to Internalise Strategies that Minimise Industrial Pollution

There are several ways in which government can attempt to overcome the above-mentioned barriers that prevent execution of the waste minimisation strategies discussed. These include the provision of technical assistance programs, the creation and enforcement of pollution control regulations, the dissemination of information, the establishment of financial incentives, and the foundation of award programs (specially for waste minimisation) (National Research Council 1985, Tay 1993, Sherry 1990, Schecter 1990). In developing countries, the implementation of many of these suggestions can only be made possible with substantial outside resources.

An information dissemination program for waste minimisation, includes education and training, the creation of a waste exchange, and the distribution of technical information bulletins. Employee support at all levels is essential for the success of these programs (Ford et al. 1992, Higgins 1989, Hunt 1990, National Research Council 1985).

Financial support for capital expenditures on waste minimisation equipment can include matching grants, subsidies, low or no-interest loans, tax deductions, or tax credits.

Regulatory approaches for minimizing waste are most effective if the sanctions (e.g. jail terms, fines) associated with contravening those regulations are sufficient to counter industry's perceived avoided cost of continuing with its current, wasteful practices.

Many countries have established *award programmes* that give public recognition to outstanding waste minimization efforts by individual companies. The award programmes may be sponsored by government, business associations or by non-government organizations and they may or may not have a monetary reward associated with them.

Eco-labelling programmes such as those found in Germany, Canada, Japan, Austria, France, Indonesia and other countries, may also be useful in encouraging industries to manufacture products and use production processes which generate less waste (Organization for Economic Cooperation and Development 1991). Such programs alert the consumer about whether the products that they are purchasing are more environmentally friendly than similar, competitive products.

Off-site recycling and reuse have been aided in recent years by the emergence of *industrial waste exchanges* that facilitate the transfer of wastes between a waste-producing company and a company that can use that waste as a material input to its production process. There are numerous examples of successful waste exchanges already in operation in such countries as Canada (Geiser et al. 1986, Pollution Probe 1990), the United Kingdom (Tron et al. 1981), the United States (Banning 1985, Sloan 1985), the Federal Republic of Germany (Geiser et al. 1986), Japan (Geiser et al. 1986) and the Philippines (Tolentino et al. 1990).

Public disclosure programs have been found to be quite effective for encouraging waste reduction. Under these programs, companies are required to provide annual reports to government on their emissions and effluents. When the government publishes these reports, there is often strong public pressure for the highly polluting companies to improve their waste management practices. Sometimes governments do not publish the full reports, but rather simply publicize the names of the worst polluting companies in a "top 10" list, or something similar.

As with barriers and motivations, the incentive policies that are useful for encouraging waste minimization are equally relevant for encouraging wastewater treatment. These would include provision of technical assistance, the creation and enforcement of pollution control regulations, the dissemination of technological information, and the foundation of award programmes.

For waste stream segregation, of all the incentives mentioned above, those with the likelihood of having the most impact include the provision of technical assistance programmes and the creation and enforcement of pollution control regulations.

Many municipalities and city planning authorities will require assistance to come up with innovative and inexpensive changes in the design of existing systems and new systems, to segregate wastes.
Enforcement of pollution control regulations will force industries to take action and discourage them from discharging into domestic sewer systems.

Towards Effective Waste Management Strategies

From the perspective of this paper effective waste management will have as objective, the minimisation of industrial pollution of water and wastewater used for agriculture.

Table 2 summarises the characteristics of industrial waste management systems in developing countries and provides us with pointers as to how to set up effective waste management strategies.

Table 2: Characteristics of Industrial Waste Management Systems in Developing Countries

DEVELOPING COUNTRIES HAVE:	IMPLICATIONS
A high proportion of small and very small quantity generators	More difficult to control waste movements arising from such generators and more difficult for such generators to initiate waste reduction measures
Low waste disposal costs	Less incentive to reduce wastes
A high level of off site waste reuse and recycling	Higher health risks associated with disposal of hazardous industrial wastes, mixing with domestic wastes and discharge to rivers and sewers; Lower solid waste disposal.
Little or no information available on waste quantities and types generated	Difficult to identify the types and number of disposal facilities needed
No facilities or limited facilities for hazardous waste disposal (landfill and incineration)	Hazardous waste dumped in watercourses, on land, or mixed with municipal waste in landfills or dumps
Solid and liquid waste streams are frequently combined	More difficult to manage mixed wastes
Few or no award schemes in existence for encouraging waste reduction or treatment	Less incentive to reduce wastes or seek public recognition as "clean industries"
Low awareness among generators about the hazardous nature of their wastes	Improper disposal of hazardous wastes
Low awareness by the general public about the health impacts of improper waste disposal	General public puts less pressure on government and industry to take action
Stockpiles of waste awaiting proper treatment or disposal	Risk of leaks from storage containers and, when storage space runs out, potential for illegal disposal
Limited technical resources	Hinders the implementation of technological solutions
Limited financial resources	Industry cannot afford to invest in waste minimization or treatment facilities; government cannot afford to provide industry with economic assistance for such investments or provide secure disposal sites
Few or no regulations on industrial waste	Less incentive for industry to reduce or treat their wastes or transport to proper disposal sites

Key Questions for Exchange and Discussion

We'd like to conclude this paper by asking a few questions that have been brought up in the course of this review:

- Will the industrial discharge of polluted wastewater to rivers and sewers **increase or decrease** during the next decade in the country/city you are reporting on? Why?
- Do the local authorities in the city you report on, have **the capacity to detect and monitor** the sources of industrially polluted wastewater, its disposal, the concentration of hazardous chemicals in domestic sewage and the levels of contamination in rivers? What can be done to improve this capacity?
- What are the **main barriers** for industries to accept strategies to reduce the generation of wastes and to enhance the recycling of industrial wastewater? What are -in your experience- the most effective strategies to overcome these barriers?
- Is the provision of **information and technical assistance** (on waste minimization and recycling strategies and technologies) an effective instrument to reduce the discharge of industrial wastes in rivers and sewers and to encourage waste reduction and waste reuse and recycling? Why yes or no? Under what circumstances?
- To what extent does the **creation and enforcement of regulations** on the generation and discharge of wastes constitute an effective control and regulation instrument? Why yes or no? What are important pre-conditions? How effective are the actual regulations and what limits their enforcement?
- Is -in your experience- the **provision of economic incentives** an effective strategy to encourage waste reduction and waste reuse and recycling? Why yes or no? When to apply?
- In what ways can the **separate disposal of industrial wastewater and domestic wastewater** be enforced? Under what conditions?
- What are the strategies for improvement recommended by **local industries** themselves? What are the differences between "big" and "small" polluters?
- What **other strategies** may be applied effectively? What are their pros and cons?
- What can be the role and contributions of local **NGO's and farmer organizations**?

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