Water Pollution: Costs & Control

Insights from EEPSEA-Funded Studies

ECONOMY AND ENVIRONMENT
PROGRAM FOR SOUTHEAST ASIA

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Front cover photo: Wastewater management in the Thanh Long Industrial Park, by Chau Doan/UNIDO, sourced from flickr.com

This monograph was written and packaged by Julienne Bariuan-Elca.

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Economy and Environment Program for Southeast Asia (EEPSEA)
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Foreword

The Economy and Environment Program for Southeast Asia (EEPSEA) presents you with the fourth monograph in our *Practitioners Series*. This series provides natural resource managers and practitioners with quick, easy-to-use references on how to deal with environmental and natural resource management issues prevalent in the region. Each monograph of this series provides practical guidelines based on lessons distilled from environmental economics studies funded by EEPSEA.

Entitled *Water Pollution: Costs & Control*, this monograph explores ways by which natural resource managers can address wastewater pollution as a result of rapid industrialization and other economic activities. The ecosystem damages focused on in this monograph resulted mainly from the dumping of untreated wastewater from industries and intensive aquaculture.

While the studies reviewed for this monograph are mainly from Vietnam, they mirror issues and concerns prevalent in the region and are thus a rich source of both empirical and anecdotal information and experiences. The management strategies featured are general enough to transcend different socio-economic and political settings. These are presented so that users will build upon and adapt these strategies to better suit their unique situations.

It should be noted that the studies featured were conducted from 2006 to 2011, thus, their recommendations are based on the realities and experiences prevailing at the time they were conducted. The full text of the studies reviewed can be downloaded from the EEPSEA website (www.eepsea.org) as well as from the Economy & Environment Partnership for Southeast Asia (EEPSEA Partnership) website (www.eepseapartners.org).

This monograph is published as part of our continued commitment to improve natural resource management in the region through environmental and natural resource economics research.

Herminia A. Francisco
EEPSEA Program Director

Contents

Damages to water ecosystems resulting from economic activities will impede economic growth in the future.

Photo by Akhmad Solihin

The environmental cost of water pollution

In their bid to advance economic growth and attain poverty alleviation goals, many countries in Southeast Asia are becoming more industrialized. In the region, industrialization is largely driven by export markets (Rasiah and Yun 2009). This trend of rapid industrialization may increase even further in the coming years given the formation of the ASEAN Economic Community in 2015, which is putting additional pressure on local industries to become more competitive.

Such rapid industrialization comes at a cost. The results of the studies used in this booklet point to the fact that while export-oriented industries and other economic activities generally benefit the economy in terms of employment and income for local communities, the damage they cause to the environment, such as water resources, is a huge trade-off. In the long run, this damage to the environment will jeopardize economic gain and will contribute to poverty in natural resource-dependent communities.

Wastewater from industries and intensive aquaculture

Along with land and air, water ecosystems greatly suffer from the unregulated disposal of wastewater associated with rapid industrialization. Unless adequately treated, industrial wastewater threatens the surface and groundwater resources into which it is discharged as it contains chemicals and organic compounds that can cause significant damage (UN 2003). Pollution from industrial wastewater depreciates land values, increases municipal costs, and causes numerous adverse biological and human health effects, the cost of which are difficult to calculate (Corcoran *et al.* 2010).

In the developing countries of Southeast Asia, the dumping of industrial wastewater often goes undetected as monitoring is expensive. Even if detected, remediation most often does not occur as it is extremely difficult and expensive to address the source of pollution and carry out decontamination at the same time (Corcoran *et al.* 2010). Hence, there is a high incidence of untreated industrial wastewater being discharged intro sewers and

natural water bodies despite most countries in the region requiring treatment before discharge (UNEP 2004).

There is a high incidence of untreated industrial wastewater being discharged into natural water bodies in Southeast Asia.

This is confirmed by several studies conducted through the Economy and Environment Program for Southeast Asia (EEPSEA). Le (2011) found that most small-scale leather tanneries in Vietnam's Hanoi, Ho Chi Minh, and Quangnam regions dump their wastewater into external water bodies with no proper treatment. Likewise, most food processing firms in Hanoi and Ho Chi Minh were found to have no wastewater treatment facilities; those with one were mostly ineffective with treatment capacity lower than the volume of wastewater generated by the firm (Le 2009).

Both the leather tanning industry and the food processing industry (particularly seafood processing) of Vietnam are important export earners. The tanning industry produces the main material needed for leather and footwear products, which are among the country's top four major export items; it accounted for 9.1% of Vietnam's total export value in 2010 (Le 2011). Total export turnover from seafood products in 2005 was USD 2.7 billion or 8.4% of the total national export value and 5.7% of the GDP (Vietnam Economic Times 2006 as cited by Le 2009).

Wastewater generated by intensive aquaculture is also a significant source of pollution. Many studies on intensive aquaculture and its impact on the environment cite untreated pond effluent discharged into external water bodies as a source of water pollution and a cause for concern (Dierberg and Kiattisimkul 1996; Pham *et al.* 2010; Phillips 1995; Primavera 1991; Boyd 2003; Cao *et al.* 2007).

This is confirmed in the study by Vo *et al.* (2009), which looked at Tra fish farming activities in Can Tho, Vietnam's Thotnot district. Tra fish (*Pangasius hypoththalamus*) is an important export item, as evidenced by its export volume increasing by about 40 times in a span of nine years—from 7,000 tonnes in 1997 to 286,000 tonnes in 2006 (Vo *et al.* 2009). Wastewater from Tra fish farming is also usually dumped untreated into external water bodies. This has considerably jeopardized the health of the fish being reared, the domestic water supply of the local people, and the sustainability of the industry itself.

Photo by Duy Khuong, from talkvietnam.com

A farmer harvests Tra fish in O Mon district, Can Tho, Vietnam.

Aquaculture ponds often have higher concentrations of nutrients, plankton, suspended solids, and oxygen demand than the water bodies into which they are discharged making pond effluents potential sources of pollution in receiving waters (Schwartz and Boyd 1994 as cited by Boyd 2003). Besides polluting the outside environment, pollution of culture areas by pond effluent is a recognized problem, especially in considering the sustainability of aquaculture ventures.

Wastewater pollution & damages

Clearly, the damages to water ecosystems caused by the discharge of untreated wastewater have associated costs. These are called "external costs" because the true social cost of the product or service produced by the polluting industries is not "internalized" in its price. Estimating the external costs of wastewater pollution demonstrates how destructive economic activities negate much of the economic gains that they provide society with.

To illustrate this fact, several EEPSEA studies determined the cost imposed by wastewater pollution on agriculture. Huynh (2011) found that rice production in Phuoc Thoi villages in Cantho, Vietnam suffered a yield reduction of 0.67 tons/ha per crop (12% yield reduction) and an increase in input costs of VND 0.97 million/ha (9% input cost increase) because of wastewater pollution. Phuoc Thoi is near six industrial parks, said to have released the biggest pollution loads in the country, putting Can Tho among the top ten most polluted provinces in Vietnam. Net profit loss is computed at VND 3.2 million/ha, or a 26% profit loss.

Focusing on the pollution created by one paper mill with no wastewater treatment system, Thathathep *et al.* (2009) estimated the annual attributable fish loss and annual reduction in rice output to be USD 148,210 and USD 42,480, respectively, for the whole of Ban Illai village in Vientiane, Lao PDR. This translates to a cost of USD 375 and USD 118 per household per year, respectively. Since 80% of Ban Illai households earned their living through rice growing and fisheries, the paper mill was found to be accountable for the total economic loss of USD 190,905/year for the whole village or about USD 408/ household per year.

Similarly, the results of the study by Pornpinatepong *et al.* (2010) on pollution control and sustainable fisheries management in Thailand's Southern Songkhla Lake indicates that the lake's water quality changes have a significant impact on natural shrimp production. It was found that a one-unit increase in the Water Quality Composite Index (WQCI) at U-Tapao River would lead to a shrimp productivity increase of 3.4% and a one-unit increase in the WQCI at Pak-ro Channel would lead to a shrimp productivity increase of 10%. U-Tapao and Pak-ro both flow into the lake and bring with them wastewater from factories, pig farms, and shrimp ponds.

Photo by Kunlayanee Pornpinatepong

Songkhla Lake, the largest natural lake in Thailand, has an area of 1,040 km$^{2.}$

Using 12 years of water quality data (1992–2004), Pornpinatepong *et al.* (2010) found that the amount of nitrogen and phosphate discharged into the lake has increased over time at every river mouth. Overall fish size in Songkhla Lake has become smaller and the catch of less economic value (Mabuntham 2002 as cited by Pornpinatepong *et al.* 2010). According to Thailand's Office of Nature and Environmental Policy and Planning (ONEP 2004 as cited by Pornpinatepong *et al.* 2010), the average amount of fish caught in 2003 (0.9 kg/day) was only a quarter of that in 1996 (3.6 kg/day).

Water ecosystems support life and livelihood. Hence, if left unmanaged, the damages to water ecosystems resulting from economic activities will impede economic growth in the future.

This doesn't have to be the case. The more emphasis is given to the role of industrialization in boosting the economy, the more effort should in turn be given to the protection of the environment.

Industrialization should come with effective mechanisms to protect the environment.

Given the complexities of environmental problems, they are usually addressed by employing a "policy mix" of: (a) command and control or regulatory instruments, which sets standards that are enforced through laws and regulations; (b) persuasive instruments, such as information campaigns and the use of eco labels, among others; and (c) economic instruments, which include environmental charges and other market-based instruments (UNEP n.d.). The constraints in the use of these instruments in controlling wastewater pollution in Southeast Asia are discussed in the next sections. Ways by which these constraints can be overcome are offered using the results of selected EEPSEA studies.

Economic instruments to control pollution

Environmental charges and other economic or market-based instruments are now common tools used to disincentivize environmentally harmful behavior. Taxing polluters is based on the polluter-pays-principle (PPP), which places the burden of pollution abatement on the polluter.

The costs of pollution, environmental degradation, and natural resource depletion form part of the true social cost of products or services produced by polluting industries. In most cases, these are not reflected in the products' or services' price and are therefore "external costs" borne by society. By imposing an environmental charge on polluters, these costs are internalized and this will encourage polluters to reduce the pollution they create to an "optimal" level (Jenkins and Lamech 1992).

In Southeast Asia, environmental fees are too low as they are rarely adjusted for inflation.

The price of the environmental charge would ideally depend on the monetary value of the environmental damage caused by the pollution (Jenkins and Lamech 1992). Furthermore, it should be adjusted regularly to reflect changing price levels. In Southeast Asia, environmental fees are too low as they are rarely adjusted for inflation (SEARCA and EEPSEA 2015). It has also been reported that the political process sometimes makes it impossible for environment agencies to set a price that creates a deterrent effect on polluters, particularly if the government can be easily swayed by various interest groups (SEARCA and EEPSEA, forthcoming).

A profit-maximizing firm will comply with an environmental regulation only as long as the expected penalty of violating exceeds compliance cost (Becker 1968). Hence, logic dictates that if complying with environmental regulations is more costly than paying the penalty, then firms will generally opt not to comply.

For instance, Le (2011) found that for Vietnam's small-scale leather tanneries the costs of installing a wastewater treatment system and paying wastewater charges were greater than the cost of non-compliance. Similarly, in exploring the cost-effectiveness of three possible wastewater treatment options for Thotnot district in Can Tho, Vietnam, Vo *et al.* (2009) found that the wastewater treatment cost per kilogram of COD[1] was much greater than the environmental protection fee imposed by the government on industrial and domestic wastewater.

If complying with environmental regulations is more costly than paying the penalty, then firms will generally opt not to comply.

This was also true in the study by Le (2009) wherein she found that food processing firms in Hanoi and Ho Chi Minh prefer to pay fines instead of the wastewater fee implemented by the Department of Natural Resources and Environment (DoNRE) since non-compliance with the law is less costly. Some firms surveyed also reported that they refused to pay wastewater fees because the environmental protection fees on industrial wastewater implemented by DoNRE overlaps with the wastewater fee being collected by water supply companies; firms see no reason to make a second payment. Le (2009) found that of the 119 firms surveyed, only 24 have installed wastewater treatment facilities, which were generally not very effective.

Clearly, the level at which the price of the environmental fee is set matters if it is expected to discourage pollution-creating behavior. The results of studies conducted through EEPSEA point to several recommendations on how to improve the effectiveness of environmental fees in incentivizing firms' investment in wastewater pollution abatement.

[1] Most applications of chemical oxygen demand (COD) determine the amount of organic pollutants found in surface water, making it a useful measure of water quality.

1. Reflect the value of pollution damages in the tax price.

The level at which environmental fees are set should capture the damages caused by pollution. The cost of pollution should be the basis for deciding whether to invest in pollution abatement technology or not. Unfortunately, in Southeast Asia, fines and penalties for non-compliance with environmental standards are often set without basis and are therefore ineffective in encouraging the adoption of abatement measures. This indicates the need to support research that estimates of the appropriate level of pollution tax.

It is important to analyze how much levies will have to be to induce firms to achieve the desired levels of pollution abatement.

This is what Muong (2006) did in his study on the implementation of effluent taxes for large-scale, highly polluting industry sectors in Cambodia. Using data from a survey of large-scale firms, Muong assessed the viability of setting effluent fee levies using four BOD[2] reduction targets, ranging from 25% to 85%. His analysis of marginal abatement costs (or estimates of how much local firms would spend on pollution reduction) and potential pollution levy charges allowed him to calculate the following: (a) how much the levies would have to be to induce firms to achieve the desired levels of pollution abatement; (b) the overall pollution abatement costs for each firm; and (c) the potential revenue that can be generated by the levies.

Based on the study results, it was found that fee levies from USD 104 to USD 521 per ton of BOD are the best option as these were shown to be sufficient to achieve at least a 40% BOD reduction target. Muong (2006) recommends that the levy be set at USD 104 per ton of BOD for an initial year of operation to minimize the impact of the fees on the competitiveness of the Cambodian industry.

In the second or third year, the fee should be raised to USD 260 per ton of BOD to induce firms to further reduce their BOD emissions. This levy level would help reduce BOD emissions by 40% to 65% and would generate about USD 10,093 to USD 68,463 per year in revenue. Raising the levy further, to USD 400 or USD 521 per ton of BOD,

[2] Biochemical oxygen demand (BOD) is used as a measure of the degree of water pollution.

can then be done in the third or fourth year but only with caution and based on a better understanding of BOD emission levels and marginal abatement costs for the Cambodian industry.

Muong (2006) predicts that his proposed scheme will incentivize firms to reduce their pollution output; companies would make an average saving of 31% if they abate rather than forgo any abatement and pay the levy. He further suggests the establishment of an agency to manage the effluent levies. Initially, 80% of the revenue from the levies could be used to cover this new agency's staff development. This amount can be gradually reduced so that, eventually, most of the revenue could be used to subsidize pollution reduction efforts by firms.

Raising environmental taxes will also generate money to compensate farmers near industrial areas for the damage to their agricultural production and health (Huynh 2011). As discussed in the previous section, discharge of untreated wastewater has been found to increase agricultural input costs and lead to yield reduction. Determining the cost of damage or the net profit loss attributable to water pollution, as done by Huynh (2011) and Thathathep *et al.* (2009), can help in identifying the proper level of compensation that should be received by those whose livelihood has been negatively affected.

Photo by Mary Ann L. Macatigbac

Raising pollution taxes will generate money to compensate farmers for damages.

Also, because inflation slowly erodes the real value of a pollution fee, it is recommended that such fees be automatically linked on an annual basis to the value of the consumer price index in order to protect its real value (Le 2009; SEARCA and EEPSEA 2015).

2. Design the pollution fee structure to influence firms' behavior.

Levies are implemented to manage polluter behavior. As such, fees should be set up to encourage not only firms' compliance with environmental standards but also for them to continuously aim for better performance.

For instance, to incentivize firms who perform better than standards require, Catelo *et al.* (2007) recommended that the environmental user fee (EUF) imposed on polluting firms in the Philippines' Laguna Lake area be restructured so that the variable fee dominates the fixed fee. At the time of the study, the fixed fee dominated the variable fee in the EUF structure. The fixed fee, which covers the cost of program administration, is based on the number of wastewater samplings needed to monitor a firm's environmental performance. The larger the firm, the more sampling will be needed and the higher the fixed fee imposed. On the other hand, the variable fee is assessed based on the unit load of pollution and is computed as the product of the volumetric rate of discharge and the effluent concentration.

This fee structure does not encourage firms to perform better than standards require. For example, a firm with a wastewater discharge of above 150 m^3/day will have to pay a fixed fee of PhP 24,000 regardless of whether the firm abates further or not. Thus, there is a stronger incentive not to abate further because not only is it costly but it also does not reduce pollution charges.

Photo by Janus Mikael Escobin Balasoto

Laguna de Bay or Laguna Lake is the largest lake in the Philippines.

3. Support research to determine the cost-effective abatement option.

To encourage firms' investment on pollution abatement technology, some form of technical assistance in finding the appropriate technology options should be provided by regulating agencies to polluting industries (Thanthathep *et al.* 2009; Catelo *et al.* 2007; Vo *et al.* 2009).

Lack of information on the appropriate technology to adopt has compelled firms to take a trial-and-error approach, which is costly.

The lack of information on what abatement options are appropriate has been found to deter compliance with environmental regulations. In their study on the factors affecting the adoption of abatement measures by firms operating within the Philippines' Laguna Lake area, Catelo *et al.* (2007) found that some firms incurred significant losses during their search for an abatement technology. Their lack of information on the appropriate technology to adopt had compelled them to take a trial-and-error approach in finding the right technology option. This costly exercise has tended to discourage them from complying with environmental regulations.

Informing firms of appropriate and cost-efficient technology to adopt to reduce their wastewater pollution could lead to efficient compliance with environmental standards as it will reduce firms' compliance costs (Catelo *et al.* 2007). Governments can help promote appropriate wastewater abatement technologies by installing pilot projects, as was proposed by the Tra fish farmers in the study by Vo *et al.* (2009) in Thotnot district of Can Tho, Vietnam. The farmers suggested that the State install its suggested pollution abatement systems as a pilot project to demonstrate their performance and cost-efficiency. If such technologies prove effective, the farmers further suggested that a collective organization be set up to manage wastewater treatment in the area. They would be willing to pay for clean fishpond influent and for wastewater treatment through the said organization.

Supporting research that will look into the economics of available abatement technologies for wastewater treatment is also a practical course of action. There are two types of research that can

be done: a cost-benefit analysis (CBA) and a cost-effectiveness analysis (CEA) of available pollution abatement technologies. Such research can assist in determining the most cost-efficient pollution abatement option for a given situation.

Economic research can help determine the most cost-efficient pollution abatement option.

In Southeast Asia, CEA is more commonly used. Huynh (2011), in his study of the costs of water pollution on rice production in Can Tho, Vietnam, recommended the use of CEA to decide whether water treatment facilities should be built in every factory in the industrial zones that discharge wastewater affecting nearby agricultural villages or if one should be built to accommodate the whole industrial park.

The CEA conducted by Pornpinatepong *et al.* (2010) in their study on how to control pollution in Thailand's Southern Songkhla Lake looked at several available technologies at each of the different stages of the wastewater treatment process. Their results indicate that it is more cost-effective for small-scale polluters (i.e., those that release less than 100 kg BOD per day) to share a common treatment plant and to pay for their discharge than to invest in individual treatment plants.

Thathathep *et al.* (2009) conducted a CEA of two wastewater treatment options for a paper mill in Ban Illai, Vientiane, Lao PDR. They found that a USD 1 investment in wastewater treatment can reduce 0.06 and 0.09 kg BOD using option A (biological treatment with activated sludge) and option B (biological treatment using stabilization ponds), respectively.

Vo *et al.* (2009) found through their CEA analysis of three technology options to reduce organic pollutants from wastewater discharged from Tra fish ponds that the COD treatment costs of all three options are much higher compared to the environmental protection fee imposed on polluters. The wastewater treatment cost per kilogram of COD was found to be VND 1.51 thousand, VND 0.83 thousand, and VND 2.27 thousand for the aeration, trickling filter, and constructed wetlands technologies, respectively, compared to the VND 0.3 thousand imposed by the government on industrial and domestic wastewater at the time of the study.

4. Explore the use of other economic instruments.

In Southeast Asia, most penalties for not complying with environmental regulations are fines (SEARCA and EEPSEA, forthcoming). Other forms of economic instruments may warrant further investigation.

In their study on pollution control in Thailand's Southern Songkhla Lake, Pornpinatepong *et al.* (2010) evaluated the use of the emission charge system (ECS) and the tradable discharge permit (TDP). Under the ECS approach, the emission charge to be paid by the polluting firm would be based on the amount of pollution it discharges. On the other hand, a TDP system offers industrial firms the option to avoid meeting stringent effluent standards by purchasing effluent credits or permits from other firms that can reduce their effluent at a lower cost.

Other forms of economic instruments to manage polluter behavior, other than fines, may warrant further investigation.

In evaluating the ECS and the TDP approaches, Pornpinatepong *et al.* (2010) used the following criteria: public acceptability, legal feasibility, implementation complexity, effectiveness, capital costs, operating costs, transaction costs, impacts, equity (i.e., polluter pays principle), and decentralization (measured by the number of firms which potentially set up plans for pollution reduction). The assessment criteria were set based on input from focus group discussions conducted with key stakeholders. These included major polluters, community leaders and representatives from related government agencies and external agencies such as NGOs and academic institutions. A person from each stakeholder group was then selected for small group discussion and in-depth interviews to rank the policy alternatives under evaluation.

Results of the study indicate that the TDP is best applied to large firms and farms given its high outcome effectiveness and its high capital costs. The ECS would better suit small to medium-scale firms and farms.

Regulatory measures for pollution control

Government monitoring, control, and enforcement of environmental regulations are either missing or inadequate in Southeast Asia (UNEP 2004). Developing countries in the region find it hard to enforce environmental laws and regulations governing wastewater discharge because of a host of regulatory constraints. Chief among these is the limited resources and capacity for monitoring and enforcement that regulatory agencies have to work with. This is compounded by firms' lack of technical know-how on what pollution abatement technology to adapt and their general unwillingness to accept this additional cost. This section offers strategies on how to overcome these regulatory constraints based on the results and recommendations of selected EEPSEA studies.

1. Enhance limited regulatory capacity.

Monitoring increases firms' rate of compliance with environmental regulations; but it has been observed that increased compliance leads to decreased monitoring. If monitoring remains reactive rather than proactive, then cycles of compliance and non-compliance among firms can be expected to continue (Catelo *et al.* 2007).

There are also reported cases when monitoring does not increase compliance. In Le's (2009) study on the environmental compliance of Vietnam's food processing industry, it was reported that inspections have very little effect on the behavior of firms. In fact, it appears that the more inspections firms receive, the worse the quality of their wastewater. It was reported that instead of improving their environmental performance, many firms bribe inspectors to turn a blind eye.

Clearly, strengthening and professionalizing a country's environmental regulatory capacity should be done if wastewater pollution is to be reduced. Enforcement activities need personnel with relevant experience and knowledge who can manage and conduct effective monitoring and inspection measures (Le 2011). Lack of trained staff requires that a plan for improved staffing and a staff development program be formulated (Le 2009). However,

this may take time, and so ways by which limitations on monitoring and enforcement capacity can be overcome need to be identified and performed. Several EEPSEA studies advanced the following recommendations on this matter, as discussed below.

a. Prioritize pollution control on top polluting industries.

Some industrial sectors simply generate more pollution than others and a significant reduction in discharges of industrial pollution could be achieved by targeting a limited number of industrial sectors (Le 2009). This is a logical strategy, especially if considering limited environmental management capacity and resources.

Both Pham *et al.* (2008) and Le (2009) recommended this strategy. Pham *et al.* (2008) recommends that priority should be given to controlling pollution caused by top polluting industries. Le (2009) adds that big firms within these top polluting industrial sectors should be the target of environmental protection fees on industrial wastewater.

Such a strategy would of course require that the targeted group of industries must first be clarified. Hence, conducting a study that identifies industrial sectors with high pollution intensity is a must (Pham *et al.* 2008; Le 2009).

b. Share the work.

With the limited resources and manpower of environment regulating agencies, ways by which their work can be shared with other relevant service providers can be explored.

For instance, in a study on the adoption of abatement measures by firms within the Philippines' Laguna Lake area, firms suggested that the Laguna Lake Development Authority (LLDA), as the regulating agency, accredit other third-party laboratories in handling and analyzing industrial wastewater samples (Catelo *et al.* 2007). This suggestion stems from firms' reports that the LLDA has been slow in responding to requests for wastewater resampling.

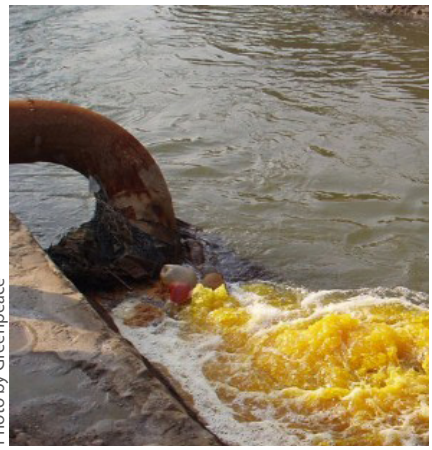

Photo by Greenpeace

A list of laboratories that are accredited to handle industrial wastewater analysis should be widely disseminated to the business sector.

LLDA usually requires wastewater resampling when their own laboratory test results do not agree with those submitted by firms using results from other laboratories. When this happens, LLDA requires firms to make the necessary pollution abatement improvements then resamples the wastewater to ensure that it passes the set standards.

In essence, the LLDA does not honor results from other laboratories, including those accredited by the Philippine Environmental Management Bureau, when it comes to the issuance of wastewater discharge permits and clearances (Catelo *et al.* 2007). However, their delayed response to firms' resampling requests has associated costs; firms are required to pay a daily non-compliance fee while waiting for their wastewater to pass the set standards.

Standardizing the procedures for the handling and analysis of industrial wastewater samples paves the way for the accreditation of third-party laboratories. This answers the firms' complaint regarding LLDA's delayed response time as well as prevents the need for LLDA to use its limited resources to expand its laboratory services to better accommodate resampling requests.

Le (2009) makes a similar recommendation indicating the need for Vietnam to establish a system of high quality and standardized testing/analysis centers/laboratories and accrediting agencies with sufficient staff and measuring equipment. She adds that a list of such laboratories should be widely disseminated to the business sector.

c. Find innovative ways to monitor wastewater discharge from small-scale enterprises.

Monitoring the wastewater discharge from thousands of small-scale, household-based enterprises can be a daunting task. In Vietnam, there is only 2–4 environmental staff for every one million persons as compared to China's 20, Thailand's 30, and Cambodia's 100 (Le 2009). Given this, monitoring activities have been minimal enough for small-scale, household-based tanneries to escape detection for not complying with any environmental regulations.

The difficulty of monitoring small-scale enterprises is also mentioned by Vo *et al.* (2009) in their study on the wastewater discharge of pond Tra fish farmers in Thotnot district of Can Tho, Vietnam. Compared to factories, controlling the wastewater discharge of thousands of fish farmers was found to be a big challenge. Such a situation points to the need to find innovative ways by which to approximate wastewater discharge from such small-scale firms using available data.

For instance, in studying wastewater pollution in Duong Lieu agro-product processing village, Nguyen and Tran (2009) found that it is possible to calculate household wastewater volume through the household monthly electricity use. Based on survey results, processing one tonne of fresh cassava required around 6.5kW and discharged 5.5 to 6.5 m^3 of wastewater. This shows that wastewater discharge volume can be approximated from the available electricity consumption data.

d. Establish industrial zones.

Establishing industrial zones can pave the way for concentrated wastewater treatment systems to be set up. This may be especially useful in managing wastewater from thousands of small-scale, household-based industries.

For instance, the establishment of Tra fish industrial zones in Can Tho was recommended by Vo *et al.* (2009) given that this industry is made up of thousands of small-scale Tra fish farming enterprises. Based on the results of the cost-effectiveness analysis they conducted, it was found that COD treatment costs can range from VND 0.83 thousand to VND 2.27 thousand (USD 0.04 to USD 0.12) per kilogram of COD. Given this high cost, a concentrated wastewater

system that can serve multiple small-scale fish farms may be the more prudent option so that more fish farms can share the cost of installing and maintaining such a system.

Similarly, in the analysis conducted by Nguyen and Tran (2009) for Duong Lieu's cassava starch-processing households, they identified that a wastewater treatment system for the whole village is the most cost-effective option. This is as opposed to the installation of either a small treatment system for each processing household or a treatment system per group of 10–15 households. Not only does such a system require less space but it is also more feasible to finance since the whole processing village will contribute towards maintaining it. Moreover, in the treatment system options that target either individual or groups of households, there is still the risk of other households staying as non-adopters. Thus, wastewater pollution abatement will not be as encompassing as a village-wide treatment system.

In addition, it is recommended that, in establishing industrial zones, governments should refrain from allowing new industrial parks to be constructed in or near high-yield agricultural land unless such parks include the latest pollution treatment technologies (Huynh 2011).

Photo by Neil Palmer/CIAT, from flickr.com

Cassava starch processing in Vietnam is a household-based industry.

2. Provide small firms with financial support to invest in abatement technology.

Small industries contribute significantly to the manufacturing sector of Southeast Asia by creating jobs for large numbers of workers. They are concentrated in labor-intensive industries where their traditional technique of production has a competitive edge (Tan and Tan 1990).

For instance, Vietnam's handicraft villages play a significant role in the rural economy of its Red River Delta, especially in terms of job generation, household income augmentation, and poverty alleviation. However, as such villages are generally made up of individual households operating at a small scale, attempts to control the wastewater they produce have been largely ineffective. This is because small-scale industries are generally wary of the additional costs associated with environmental compliance because of their limited financial resources.

Small-scale firms are generally wary of the additional costs associated with environmental compliance because of their limited financial resources.

During their study on the wastewater pollution generated by the agro-product processing handicraft village of Duong Lieu in Vietnam, Nguyen and Tran (2009) found that financial constraints and lack of space were the main reasons why many small and medium-sized enterprises did not invest in wastewater treatment systems. Likewise, during the survey of tanning firms in Vietnam's Hanoi, Ho Chi Minh, and Quangnam regions, Le (2011) found that no small-scale tanneries complied with environmental regulations in terms of wastewater fee payment and installation of wastewater treatment systems, among others. Small and medium-sized leather tanning firms reasoned that the high cost of compliance with environmental regulations will reduce the competitiveness of their products.

While small-scale industries do have efforts to curb their wastewater pollution, such efforts have mainly been reactive, short-term countermeasures that have little contribution towards a long-term solution. For example, in response to the wastewater pollution generated by its processing households, the village of Duong Lieu invests VND 20 million each year for the upkeep of its drainage

system. The village also disseminates environmental protection information through a village meeting once or twice a year. However, the speakers are usually commune staff who are not specialized in environmental management and cannot provide much information on pollution abatement measures (Nguyen and Tran 2009). Clearly, there is a lack of sound technical advice on cost-effective pollution abatement measures, which is crucial to the long-term effectiveness of such efforts.

The same can be said of the building of settling ponds to store wastewater from Tra fish farming in Thotnot district, Can Tho, Vietnam. Based on local practice, wastewater is stored in such ponds before it is released into external water bodies. This has not been effective because the wastewater is not kept long enough for the pollutants (i.e., uneaten feed, excrement, chemicals to treat fish disease) to decompose, mainly due to the fish farmers' frequent replacement of the pond water to avoid self-pollution (Vo *et al.* 2009).

The frequent flushing of pond water with water from external sources to dilute the fishponds' pollutant concentration is done based on advice from technical agencies such as the Can Tho Fisheries Department. The guidelines given by these agencies regarding the use of settling ponds do not indicate the length of time wastewater had to stay in such ponds before being safely released into external water bodies (Vo *et al.* 2009).

Photo by Helen Clark/IPS, from flickr.com

Houseboat on the polluted Red River near central Hanoi, Vietnam.

Ways by which cleaner production can be achieved during the production process of industries should be encouraged by governments as agreed through Agenda 21, which has several references to cleaner production (UNEP and UNIDO n.d.). Resource efficiency as pollution prevention, as in the case of recycling water to achieve zero discharge, is an example of a cleaner production action (World Bank 2012). For example, in cassava processing, Nguyen and Tran (2009) noted that cleaner production is possible by replacing old processing machines with modern ones, reusing the wastewater from filtering to clean cassava roots, and using cassava residues to produce bio-fertilizers or materials for mushroom cultivation.

A lending scheme with preferential interest rates can be set up to enable small industries to invest in pollution abatement.

Clearly, besides needing assistance in identifying the right abatement options to invest in, small-scale industries also need financial assistance in investing in pollution abatement. Installing and maintaining wastewater treatment systems are an added financial burden on small-scale enterprises. Hence, Le (2011) and Vo *et al.* (2009) recommend that their investment in abatement costs be financially supported.

Based on her study of Vietnam's leather tanning industry, Le (2011) suggests that a low interest rate lending scheme be provided, with consulting services, to help small tanneries install and manage waste treatment systems. Vo *et al.* (2009) made a similar recommendation to reduce untreated wastewater dumping by Tra fish farmers in Thotnot, Vietnam. They suggested that an environmental fund be set up to provide fish farmers with long-term loans with preferential interest rates to enable them to install treatment systems and reduce their unwillingness to invest in such systems because of the high initial investment cost.

3. Ensure social acceptability.

Identifying the right abatement option should not stop at economic analysis. The study by Nguyen and Tran (2009) highlighted the importance of determining a technology option's cultural acceptability as well.

Their study looked into three possible wastewater pollution abatement options for Duong Lieu, an agro-product processing village in Vietnam. The options were the installation of: (a) a small treatment system for each processing household; (b) a treatment system for a group of 10–15 households; and (c) a village-wide treatment system.

As mentioned earlier, the third option was chosen during the voting game done in the study, in which representatives from the commune staff and the processing households participated. Despite the first option being the most cost-effective based on the results of the cost-effectiveness analysis conducted as part of the study, the third option was chosen because of several advantages over the first two options.

Policies and practices lacking social approval will ultimately fail, even if they are supported by sound science and are economically feasible.

One such advantage is that it does not involve underground tanks and deep ditches to be established near homes. Many participants of the voting game pointed out that it would be difficult to persuade processing households to establish an underground 45 m^3 tank in their backyards for wastewater treatment, a requirement in the first abatement option. This is because many local people believed that the establishment of a wide and deep ditch very close to their homes (and their altars) would bring them bad luck in their life and business. Therefore, the first option was not really suitable for households with a small area.

For the second option, participants also thought that the establishment of 15 or so small wastewater treatment plants in the village was not culturally acceptable. It would also be impractical given the space that this would require.

4. Raise public awareness to increase community pressure on polluting firms.

Anecdotal evidence has repeatedly proven that community pressure can significantly motivate polluting firms to follow environmental standards and/or invest in technology to lessen their pollution (Shao 2009; Blackman and Bannister 1998). Le (2011) reports that leather tanning enterprises that are under much public pressure, as well as those inspected more frequently, tended to exhibit better environmental compliance. Catelo *et al.* (2007) also report that clients and community environmental groups are among firms' top three sources of pressure to improve their environmental performance.

Photo by Reuters, from straitstimes.com

Improved environmental awareness allows the larger public to put pressure on polluters to perform better.

To motivate firms to perform better, Huynh (2011) recommends that a public disclosure system for the environmental performance of polluters be considered as one of the best ways to increase efficiency in the implementation of existing laws regarding the handling of firms that cause serious environmental pollution. Public disclosure increases environmental awareness and allows the larger public to put pressure on polluters to solve current environmental problems (Wang *et al.* 2002; Anbumozhi *et al.* 2011).

Conclusion

Water resources in Southeast Asia are under strain from rapid industrialization. Given the vital role of water ecosystems towards attaining the region's economic development and poverty alleviation goals, the need to prioritize the control of water pollution is crucial.

Economic development cannot be sustained if the water resources that make it possible are degraded beyond use.

Much of firms' abuse of water resources as well as governments' inadequate enforcement and monitoring of environmental regulations in the region stems from a general unawareness as to just how high a price is being paid to boost the region's economies through rapid industrialization. The EEPSEA studies reviewed therefore highlight the essential role of research in better understanding the true cost of water pollution and in informing environmental policy and decision making to curb the negative effects of industrialization on water ecosystems.

It is with research through which the true cost of water pollution damages can be determined. This, in turn, can be used to determine the appropriate level of environmental charges to discourage pollution-creating behavior among firms. Research can also be used to identify the most cost-efficient and culturally acceptable pollution abatement option. This will then facilitate better environmental compliance among polluting firms as it will lessen their costs in searching for the right technology option to adopt. Exploring the use of other economic instruments to manage polluter behavior, other than fines, is also best done through research.

Science-based environmental management and decision making is necessary in light of Southeast Asia's rapid industrialization. And showing the costs and damages avoided by reducing the amount of untreated wastewater discharged into the environment through research will help policy and decision makers appreciate the value of investing more resources into environmental management. After all, economic development cannot be sustained if the water resources needed that make it possible are degraded beyond use.

Photo by Mary Grace S. Isidro

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