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ESTIMATION OF MARGINAL ABATEMENT COSTS FOR THE TREATMENT OF BOD_5 IN INDUSTRIAL EFFLUENT IN REGION VII[1]

Department of Environment and Natural Resources

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ESTIMATION OF MARGINAL ABATEMENT COSTS FOR THE TREATMENT OF BOD_5 IN INDUSTRIAL EFFLUENT IN REGION VII[1]

ENRAP IV TECHNICAL PAPER

by

R. Virgino, N. Lasmarias [2]
and N. Zabala

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[2] The authors are Noela C. Lasmarias, ENRAP Consultant; Raymond Virgino, Development Management Officer, Nenita Zabala, Economist, PSD-PPSO, DENR. The authors are grateful for the assistance of the following PEENRA-ETWG members: Nicanor E. Mendoza, Chief, WQMS-EQD-EMB; Michico Navaluna, WQMS-EQD-EMB; Adele A. Casorla, ENRAP; Theresa Legaspi, RSD-PPSO and Bella Nunez, RSD-PPSO. The help of the technical staff of DENR-Region XI during the survey is also highly appreciated.

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BACKGROUND

Region VII or Central Visayas has a total land area of 1.4923 million hectares covering four (4) provinces. Negros Oriental accounts for 36% of the total land area, Cebu accounts for 34%. Bohol 28%. and Siquijor 2% (ENR Statistical Profile for Region VII).

The region has one of the fastest growing economies in the country. It is one of the top six (6) contributors to the nation's gross output (NSCB 1999). In 1998, it contributed 7% to the gross domestic product. In 1999, 3,923 new business establishments were registered with the Dept. of Trade and Industry (DTI), which was a 3% increase from the 1998 figure of new industries (NSCB 1999). In the industrial zones, 130 new firms were established in 1998 or a 27.45% increase from 1998. The region is, therefore, considered to have one of the highest potentials for economic growth despite the prevailing crisis during the period.

Local governments in the region are faced with increasing pressure to undertake physical planning due to three (3) major developments taking place in the region. First, the rapid economic growth. especially of Metro Cebu in the last couple of years, overtook traditional public planning and programming activities. Unless regional and local officials reconsider new assumptions and approaches to planning, highly urbanized and industrialized areas in the region will encounter the same problems as Metro Manila, such as traffic congestion, solid waste management, increase in blighted areas. and others (NEDA 1994). Second, the rapid rate of urbanization in some areas has resulted in the conversion of substantial agricultural lands to commercial and other uses. This generated concern over the region's ability to attain food sufficiency and security in the long run. Third. the problem of environmental degradation has reached alarming proportions at both national and regional levels. The 1992 environmental accounts for air and water pollution loads showed that Region VII accounted for 7.43% of the national PM_{10} load (ranking 7th among the 13 regions). 6.92% of the BOD load (ranking 6th), and 10.85% of the total suspended solid (TSS) load (ranking 4th) (IRG/Edgevale/REECS 1996). The manufacturing sector accounted for 4% of the total BOD load, of which approximately 88% came from sugar milling. The said ENRAP-III study also showed that the BOD load from food and beverage sector, although minimal. is concentrated in some regions, specifically the National Capital Region (NCR or Metro Manila). Regions III. VII and IV which accounted for 95% of the total load.

The recent water quality reports of DENR-Region 7 also revealed that the rivers within highly urbanized areas exceeded standards set for some water quality parameters. Monitoring data also showed that coastal areas are already adversely affected by pollution, e.g., the coastal waters of Talisay City in Cebu province (EMPAS-DENR Region 7 1998). It becomes incumbent for the Department to come up with effective strategies to address the rapid environmental deterioration while sustaining the economic growth of the region.

The present environmental management interventions. which are largely through direct regulation. have failed to curb rapid environmental deterioration. The existing policy framework has been shown to create more opportunities for non-compliance among industries. The DENR is therefore exploring other policy instruments that might be more effective in curbing the deteriorating environmental quality. One such policy instrument being studied is the wastewater discharge permitting system that follows the polluter pays principle. The system applies discharge fees per unit of BOD load discharged. This is similar to the concept of a pollution charge. The idea is for the fees to provide the right incentive for firms to reduce their wastewater discharges through means most affordable to them. The introduction of an economic instrument through a permitting system is envisioned to complement the existing policy framework. Target

firms are made to internalize environmental costs, which will lead to changes in behavior while stimulating the impetus for self-regulation.

CONCEPTUAL FRAMEWORK

Water is a valuable commodity. It provides support for biological life, serves as a recreation facility and waste receptacle. It also possesses aesthetic value. However, society has overexploited the resource, leading to excessive extraction, wasteful usage and pollution. Water quality deteriorates when its capacity to assimilate wastes is exceeded. When this happens, damages occur. The objective of an economic instrument is for firms to internalize these costs. However, those who take the initiative to include these costs could find themselves uncompetitive because of higher production costs relative to their competitors. Thus, it is as well important that appropriate intervention measures enlist the participation of firms and elicit the right responses from them.

The basic concept behind the introduction of the wastewater discharge permitting system is the reduction of total abatement costs by giving firms options. Firms with higher abatement costs relative to the fees may opt to pay the permit fee. While those with lower abatement cost may opt to implement measures to reduce their discharge and consequently the lower the financial burden of the fee. Strategies to reduce pollution may include a) design and implementation of water conservation schemes, b) adoption of waste minimization strategies, c) installation of wastewater treatment facilities, and d) shift to cleaner technologies. While it can be argued that one possible constraint to these changes is the overall economic climate, it has been demonstrated that pollution abatement can be pursued using low cost-no cost strategies (IEMP 1996).

The choice of the fee rate per unit of BOD discharged into the environment can be determined by either efficiency or cost-effectiveness criteria. Economic efficiency requires that the rate should correspond to point where the marginal abatement cost (MAC) is equal to the marginal damages (MD) from pollution at P^*, as shown in Figure 1. However, this has been shown to be difficult because of the data requirement especially marginal damages caused by each pollutant. Baumol and Oates (1992) further stated that the difficulty is compounded since the optimal level of fees or pollution tax of an activity is not equal to the marginal net damages it generates *initially*. Rather, it is equal to the damage it would cause if the level of activity were adjusted to its optimal level. They suggest that a combination of environmental pricing and standards would be more practical and easier to implement. While this may not lead to Pareto-efficient levels, it nevertheless is a least-cost way of achieving environmental targets.

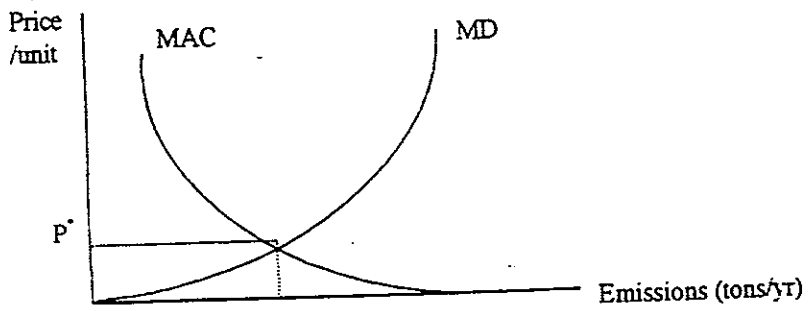

Fig. 1. Efficient Level of Pollution Fee

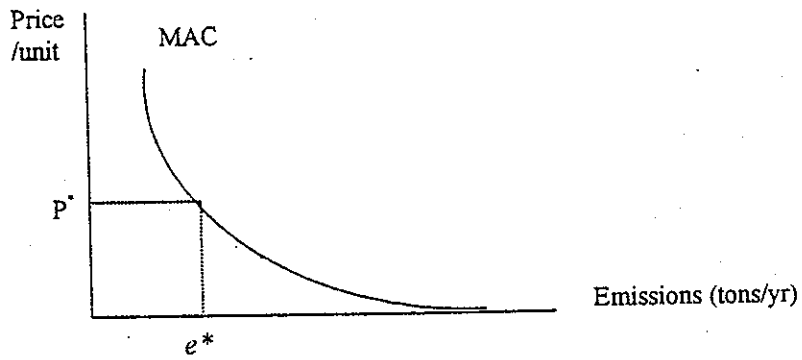

Fig. 2. Use of Standards and Prices in Setting a Pollution Fee

Figure 2 shows that if the standard or the level of environmental quality is set at e^*, the least-cost level of fees should be equal to P^*, i.e., the point equal to its marginal abatement cost.

By definition, abatement costs are the "cost of reducing the quantity of residuals (discharges) being emitted into the environment" (Tietenberg 1997). Marginal abatement costs refer to the additional costs of controlling or removing an additional unit of pollutant or, conversely, the costs saved by increasing by one (1) unit of pollution. As illustrated in Figure 2, marginal abatement cost increases as additional units of emissions are controlled. Damages, on the other hand, are defined as "all negative impacts that users of the environment experience as a result of degradation" (Tietenberg 1997). While pollution abatement expenditures are costs, the reduction in damages reflects the benefits from a policy or pollution abatement.

METHODOLOGY

The study utilized both secondary and primary data. A survey of firms with wastewater was conducted to gather data on influent and effluent BOD concentration, type of wastewater treatment facility, capital cost and maintenance and operating expenses of the treatment facility, production volume, production inputs, and prices. Initially, survey questionnaires were mailed to 75 firms in Region 7 randomly chosen by the DENR Regional Office. This was followed by plant visits and interviews with the Pollution Control Officer (PCO) or the Plant Owner. Out of the 75 firms, 29 responded and provided adequate information requested in the questionnaire. DENR monitoring reports, self-monitoring reports and information from permit applications supplemented the survey data.

From the primary data, the firms' BOD loads, annualized capital cost for the wastewater treatment facility, maintenance and operating costs, and total abatement costs for 1998 were computed. A regression model was run for the total abatement cost as a function of the influent BOD load and BOD removal rate, which can be viewed as the treatment efficiency of the facility.

RESULTS AND ANALYSIS

The firms who responded to the survey were engaged in livestock production, manufacture of food products, beverages, and fabricated metal products. Most of these firms are located in Cebu and Negros Oriental.

The total BOD effluent load of the 29 firms surveyed is 146,617 kgs. (Table 1). Of this, approximately 46% come from seaweed processing, 13% from softdrinks manufacturing, and 10% from the manufacture of catsup and sauces. On a per firm basis, seaweed processing and the manufacture of catsup and sauces have the largest average contribution to the total BOD load. The average BOD removal rate is approximately 96 percent.

Using the linear form of the regression model $TAC = \alpha lnfBOD^{\beta_1} TXEFF^{\beta_2}$, the F-test shows that the model is highly significant with an adjusted R^2 of 48.8%. The t-statistics are also highly significant (Table 2). The coefficients indicate that for every one- percent increase in BOD, there is a corresponding 0.41% increase in TAC, with TXEFF held constant. The TXEFF variable is indicative of the type of pollution control technology being used. The regression coefficient indicates that the total abatement cost is highly responsive to the treatment efficiency so that for every 1% increase in treatment efficient, total abatement cost increases by 2.79%.

From the regression model, the resulting marginal abatement cost equation is

$$MAC = 5714.93 lnfBOD^{-0.58252} TXEFF^{2.785005}.$$

Table 3 shows that, on the average, the marginal abatement cost for the 29 firms surveyed is PhP23. The highest MAC value obtained is PhP198 per kg. BOD for the fruit processing industry and the lowest is PhP2 per kg BOD for the brewery and industrial estate. If the permit fee rate were set at PhP23 per kg BOD load, 13 out of the 29 firms or 45% will have lower marginal abatement costs and would therefore be likely to invest in further reducing their BOD loads. These firms would find it cheaper to reduce their BOD loads than pay the fees. If firms were required to achieve the allowable BOD effluent concentration of 50 mg/L, the appropriate level of permit fee should be PhP27 per kg BOD (Table 4). However, there would only be a minimal change in the number of firms that would likely invest in further BOD reduction, i.e., 14 compared to 13 out of 29 (or 48%) when the fee rate is at PhP23 per kg BOD.

One of the concerns about the proposed permit fee or a pollution tax is its impact on competitiveness. The study by Medalla (1999) on the effect of various levels of environmental costs indicated that many Philippine industries are already uncompetitive and inefficient in their use of resources regardless of the level of cost. With zero environmental cost, for instance, only 65 out of 297manufacturing sectors have clear comparative advantage as indicated by their domestic resource cost (DRC) to shadow exchange rate (SER) ratios of less than or equal to one. Table 5 lists some of the sectors where the industries included in the Region 7 survey belong. The DRC/SER ratios of the manufacture of soaps, food products (n.e.c.), malt liquors, and preserved fruits and juices indicate clear comparative advantage up to 7% share of environmental cost to value of total output. The manufacture of softdrinks would be at the border at 5% to 7% environmental cost. All others are uncompetitive regardless of the level of environmental cost. Experience in the United States and other developed countries indicate that environmental cost is, on the average, about 2% to 3% of the total value of output.

RECOMMENDATIONS AND FUTURE DIRECTIONS

The following recommendations are made based on results presented above:

1. The fee rate should be high enough to achieve desired shifts in behavior among pollutive firms, such as the adoption of cleaner technologies, waste minimization strategies, and/or environmental management systems that reduce the financial burden from pollution fees.
2. Implementation of the proposed permitting system may be phased and initially target sectors with the least marginal abatement cost for BOD. Most likely, these sectors can still afford additional investments in pollution abatement.
3. The fast tracking of the classification of remaining unclassified rivers in Region VII is necessary to assist field personnel in implementing the proposed permitting system. It would also eliminate discretionary classification and computation of fees and minimize conflicts that could otherwise affect the effectiveness of the fee system.
4. Future studies could explore the applicability of the system to other parameters, such as heavy metals which may have more significant environmental impacts than BOD, and to other sources of BOD such as households and agriculture.
5. It is also important that the resource requirement of the proposed system be assessed, which would include the financial, technical, and human resource capability of the DENR.
6. The potential adverse financial impact of the system to small and medium sized enterprises (SMEs) also needs to be examined ex-ante.

REFERENCES

Baumol, W. J. and W. Oates. 1992."The Use of Standards and Prices for Protection of the Environment." In: Markandya, A. and J. Richardson (editors), *the Earthscan Reader in Environmental Economics.* London: Earthscan Publications Ltd.

EMPAS-DENR Region 7. 1998. *Water quality Report.*

Fields, B. C. 1997. *Environmental Economics: An Introduction.* Second edition. Massachusetts: Irwin/ McGraw Hill companies, Inc.

Industrial Environmental Management Project. 1996. *Success Stories.* Quezon City: IEMP.

IRG/Edgevale/REECS. 1996. ENRAP (Environmental and Natural Resources Accounting Project) III Main Report: Report prepared for the Department of Environment and Natural Resources and the United States Agency for International Development. International Resources Group, Ltd., Washington, DC, USA; Edgevale Associates. Virginia, USA; and Resources, Environment and Economics Center for Studies. Inc., Quezon City, Philippines.

Lasmarias, N. and N. Mendoza. 2000. "Proposed Wastewater Discharge Permit Fees." A paper presented at the ENRAP Conference on "Environmental and Natural Resource Accounting and Policy." Manila Hotel, Manila, Philippines. (February).

Medalla, E. M. 1999. "Impact of Environmental Regulation and Environmental Costs on Competitiveness." A paper prepared for ENRAP. Unpublished.

National Economic Development Authority. 1994. *Regional Physical Framework Plan for Region VII.*

National Statistical Coordination Board. 1999. *1999 Philippine Statistical Yearbook.* Makati: NSCB.

National Statistical Coordination Board – Region 7. Undated. "ENR Statistical Profile for Region VII." Unpublished.

Tietenberg, T. 1996. *Environmental and Natural Resources Economics.* 4th edition. New York: Harper-Collins College Publishers.

Table 1: BOD Loads by Industry Sector, Region 7, 1998.

PSIC	Industry Sector	No.of Estab.	BOD Load Influent (kg)	BOD Load Effluent (kg)	Sectoral Share to Total Effluent BOD Load (%)	BOD Removed Kg	BOD Removed %	Average Effluent BOD per firm (kg)	Firms Share to Total Effluent BOD Load (%)
371	Metal processing	1	841	8	0.01	833	99.11	8	0.01
2100	Piggery	2	72,631	6,158	4.20	66,474	91.52	3079	2.10
15110	Poultry	5	98,425	7,643	5.21	90,782	92.23	1529	1.04
15120	Food manufacturing (processed meats)	1	9,408	269	0.18	9,139	97.14	269	0.18
15135	Seaweeds processing	5	603,305	68,032	46.40	535,273	88.72	13606	9.28
15139	Seafood processing	1	68,642	21	0.01	68,621	99.97	21	0.01
15141	Fruit processing	3	8,227	7,197	4.91	1,030	12.52	2399	1.64
15143	Food manufacturing (catsup and sauces)	1	335,255	14,144	9.65	321,111	95.78	14144	9.65
15530	Brewery	1	832,728	5,260	3.59	827,468	99.37	5260	3.59
15541	Softdrinks manufacturing	3	83,854	19,406	13.24	64,448	76.86	6469	4.41
15640	Food Manufacturing (cornchips)	1	67,275	7,266	4.96	60,009	89.20	7266	4.96
15710	Sugar manufacturing	2	655,049	4,464	3.04	650,584	99.32	2232	1.52
24251	Soap manufacturing	1	470	83	0.06	388	82.39	83	0.06
33201	Manufacture of binoculars	1	17,031	1,408	0.96	15,623	91.73	1408	0.96
70120	Industrial estate	1	832,728	5,260	3.59	827,468	99.37	5260	3.59
TOTAL		29	3,685,868	146,617	100.00	3,539,251	96.02		
AVERAGE			127,099	5,056		122,043		5,056	

Table 2: Total Abatement Cost Function using Regression Analysis for Region 7 (Central Visayas), 1998.

LS // Dependent Variable is LNTAC
Included observations: 28
Excluded observations: 1
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.524356	1.658189	5.743829	0.00000
LNINFBOD	0.41748	0.147453	2.831268	0.00900
LNTXEFF	2.785005	0.947326	2.939858	0.00700

R-squared	0.525949	Mean dependent var	13.1896
Adjusted R-squared	0.488025	S.D. dependent var	2.435596
S.E. of regression	1.742727	Akaike info criterion	1.211859
Sum squared resid	75.92744	Schwarz criterion	1.354596
Log likelihood	-53.69631	F-statistic	13.8685
Durbin-Watson stat	1.017667	Prob(F-statistic)	0.000089

Notes:

1. lnTAC: natural log of the Total Abatement Cost =
   where: TAC = Annualized Capital Cost fo abatement + MOE
2. LNINFBOD: natural log of the Influent BOD5 load (Kgs)
3. LN TXEFF : natual log of the efficiency BOD5 removal of the wastewater treatment facility
3. Marginal Abatement Cost (MAC) = 5714.93 * (INFBOD^ -0.58252) * (TXEFF^2.785005)

Source: Lasmarias, N. and N. Mendoza, "Proposed Wastewater Discharge Permit Fees," 2000

Table 3: Total, Average and Marginal Abatement Costs by Industry Sector, Region 7, 1998.

(Costs are in constant 1994 prices.)

PSIC	No.of Estab.	BOD Removed (kg)	Total Abatement Cost (PhP)	Average Abatement Cost (PhP/kg BOD removed)	Marginal Abatement Cost (PhP/kg)
371 Metal processing	1	833	614,703	738	110
2100 Piggery	2	66,474	1,255,341	19	19
15110 Poultry	5	90,782	3,691,941	41	77
15120 Food manufacturing (processed meats)	1	9,139	841,480	92	25
15135 Seaweeds processing	5	535,273	11,914,722	22	76
15139 Seafood processing	1	68,621	103,349	2	9
15141 Fruit processing	3	1,030	244,582	237	198
15143 Food manufacturing (catsup and sauces)	1	321,111	282,501	1	3
15530 Brewery	1	827,468	9,300,774	11	2
15541 Softdrinks manufacturing	3	64,448	9,425,234	146	15
15640 Food Manufacturing (cornchips)	1	60,009	271,341	5	6
15710 Sugar manufacturing	2	650,584	15,502,890	24	7
24251 Soap manufacturing	1	388	410,219	1,058	91
33201 Manufacture of binoculars	1	15,623	115,440	7	16
70120 Industrial estate	1	827,468	1,407,699	2	2
TOTAL	**29**	**3,539,251**	**55,382,212**		**656**
AVERAGE		**122,043**	**1,909,731**	**16**	**23**

Table 4: Marginal Abatement Costs Computed at Target BOD Concentration of 50 mg/L, Region 7, 1998.

PSIC	Industry Sector	No. of Firms	Influent BOD Concentration (mg/L)	Effluent BOD Concentration (mg/L)	MAC per Firm at BOD = 50 mg/L (PhP/kg)
371	Metal processing	1	1121	10	100
02100	Piggery	2	1737	106	10
15110	Poultry processing	5	8110	2226	30
15120	Food manufacturing (processed meat)	1	700	20	23
15135	Seaweeds processing	5	4382	270	12
15139	Seafood processing	1	45761	14	9
15141	Fruit processing	3	1717	100	70
15143	Food manufacturing (Catsup and sauces)	1	155210	6548	3
15530	Brewery	1	1884	12	2
15541	Softdrinks manufacturing	3	795	277	11
15640	Food manufacturing (corn chips)	1	6870	742	9
15710	Sugar manufacturing	2	551	63	2
24251	Soap manufacturing	1	1484	261	144
33201	Manufacture of binoculars	1	1270	105	18
70120	Industrial estate	1	54795	30000	0.04
	Total	**29**	**286,387**	**40,753**	
	Average		**9,875**	**1,405**	**27**

Note: Target BOD concentration of 50 mg/L is the allowable limit or standard for industrial effluents under DENR Department Administrative Order No. 95-35.

Table 5: Domestic Resource Cost (DRC) and Effective Protection Rate (EPR) Estimates for Selected Industry Sectors at Varying Levels of Environmental Cost.

PSIC	DESCRIPTION	DRC/SER Ratio at assumed levels of Environmental Cost				EPR at assumed Levels of Environmental Cost			
		0%	3%	5%	7%	0%	3%	5%	7%
35231	Soaps and synthetic detergents	0.79	0.84	0.87	0.9	52.9	60.8	66.1	71.4
31299	Food products, n.e.c.	0.85	0.89	0.92	0.94	32.1	38.7	43.1	47.5
31330	Malt liquors and malt	0.86	0.92	0.95	0.99	53.3	60.1	64.7	69.3
31141	Canning & preserved of fruits & juices	0.91	0.94	0.96	0.98	-1.4	3.2	6.2	9.2
31340	Softdrinks & carbonated water	0.95	0.99	1.02	1.05	35.3	42.1	46.7	51.2
31231	Milled sugarcane	1.33	1.37	1.4	1.43	95.8	112.1	123	133.8
31143	Fruits and vegetable sauces	1.38	1.42	1.44	1.47	15.8	26.5	33.7	40.9
31232	Sugar refineries	1.79	1.84	1.88	1.91	175.5	202.5	220.5	238.4
31114	Meat processing, preserving and canning	2.23	2.3	2.34	2.39	162	197.8	221.6	245.5

Notes:
1. Assumed levels of environmental costs (0% - 7%) are percentages of total value of production.
2. DRC/SER <= 0.9 — Huge comparative advantage
   0.9 < DRC/SER <= 1.0 — Comparative advantage
   1.0 < DRC/SER <= 1.2 — Borderline
   1.2 < DRC/SER <= 1.5 — Slight comparative disadvantage
   1.5 < DRC/SER <= 2.0 — Comparative disadvantage
   DRC/SER > 2.0 — Huge comparative disadvantage

Source: Medalla, E. "Impact of Environmental Regulation and Environmental Costs on Competitiveness," 1999.