COST-BENEFIT ANALYSIS OF ENVIRONMENTAL SOUND MANAGEMENT PROJECT FOR OBSOLETE POPS STOCKPILE IN CHINA

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Abstract

A project titled environmentally sound management and disposal of obsolete POPs pesticides and other POPs wastes in China is just under preparation in the support of Global Environment Facility(GEF), which targets at 10,000 tons of obsolete POPs pesticides and associated wastes with a budget of US$ 42,000,000. The Damage-Function method is utilized in this study to assess the economic benefit of this project from the environmental quality changes on the reduction of PCDD/Fs and DDT emissions. It was found that the project could attain the reduction of population annual cancer risk rate to 2.20 and 0.65, respectively through PCDD/Fs and DDT elimination. The project net benefit value lies within the interval limits from US$-1.5 to 70.3 million. The project is feasible under most circumstances and the profit probability is higher than 98.4% according to monetary criteria of value of a statistic life(VSL) in USA.

1 Introduction

Environmental benefit analysis is regarded as one of the key criteria against which proposals are reviewed and accepted by Global Environmental Facility(GEF)-the interim financial mechanism of Stockholm Convention on Persistent Organic Pollutants (POPs) to help developing countries for convention implementation.[1] Qualitative analysis is preferred to identify the cheapest way, among competing alternatives, of achieving a stated objective and GEF outlines the related benefit analysis approaches in biodiversity and climate change projects in its technical documents. However, the approach in POPs projects is still missing. Environmental cost-benefit analysis (CBA), an effective way to identify the costs and benefits and express them in monetary terms associated with a determined project might be used as a tool for decision making in the GEF project identification, preparation and evaluation.

The Chinese government acceded to the Stockholm Convention on May 23, 2001. The Tenth National Peoples Congress Standing Committee ratified the Stockholm Convention on June 25, 2004. China is just implementing 7 full-sized projects in the POPs focal area with a budget US$ 73.29 million from GEF and US$ 100.36 million by co-finance,executed by UNIDO, IBRD and UNDP respectively. Apart from the direct environmental sampling and monitoring of POPs in the environmental medias to reveal the environmental change from convention implementation projects, the CBA method may be another effective way to evaluate the completion of pre-set goals from incremental cost, assess the improvement of human health situation from the environmental risk reduction and evaluate the achievements for the global environment improvement in a monetary form.

This study has been aimed at assessing the economic viability of an GEF funded project for the environmentally sound management and safe disposal of obsolete POPs pesticides and other POPs wastes in China(ESM Project), in order to supply a tool for decision making about disposal technology selection and budget plan evaluation in the project preparation. The Damage-Function method is used to assess the benefit of changes in environmental quality, and the economic viability from this project on the reduction of PCDD/Fs and DDT emissions. It has been developed with both world-wide and local monetary criteria: USA and Hong Kong (China).

2 Material and Methods

The damage-function or damage avoided method was adopted for CBA in this study, which is a step by step procedure linking a burden to an impact, and subsequently assessing physical measure of impact and, where possible, its monetary value.[2] The damage function method involves three steps: (1) estimate a physical change in yielding attribution to the environmental improvement; (2) assess the human health risk reduction resulting from the shift, e.g. carcinogenic case reduction; and (3) calculate the economic impacts of health benefit.[3] The damage-function based CBA is widely used in a number of air pollution controlling projects as a standard approach for assessing and incorporating economic aspects into public policy and environmental pro grammes.[4]

Intake fraction(iF) was used to help assessing the complex mixture effects of POPs considering both their environmental fate, exposure, and toxicity, which is the fraction of POPs emissions in the environment that are eventually taken up by all individuals(defined in equation 1). The iF can quantify the "exposure efficiency" of an emission source.

$$iF = \frac{\sum_{people,\,sum} mass\,intake\,of\,pollutant\,by\,an\,individual}{mass\,released\,into\,the\,environment} \tag{1}$$

Hirai et al. had studied the iFs of PCDD/Fs base in Japan.[5] Measurement-based iFs were calculated through dividing the congener-specific dioxin intakes by the dioxin emission inventory for 1 year period and 0.0014 was given under the consideration of total diet studies, which are quite close to the value 0.001139 for North America calculated by BETR model.[6] And 0.000154 was suggested for DDT on an open environmental system with landscape and climate parameters reflecting U.S. averages and population-based lifetime average exposure parameters (breathing rates, diet, activity patterns, etc.) with exposure occurring during the last 70 years of the release.

The technique of environmental risk assessment in this study is based on Dose-Response(D-R) function, which relates the quantity of a pollutant that affects a receptor (e.g. population) to the physical impact on this receptor (e.g. incremental number of hospitalizations). In the narrow sense of the term, it should be based on the dose actually absorbed by a receptor. However, the term D-R function is often used in a wider sense where it is formulated directly in terms of the intake content of a pollutant. There were a lot of studies and data published for specific D-R of POPs. At most of the time their carcinogenic D-R effects could be assumed linear and without threshold. As for as 2,3,7,8-TCDD, Farland et al. from US EPA suggested an interval of the potency cancer factor $5 \times 10^{-4} - 5 \times 10^{-3}\,day \cdot kgBW \cdot pg^{-1}$I-TEQ, which had been considered a log-normal distribution. And the value of $6 \times 10^{-4}\,day \cdot kgBW \cdot mg^{-1}$ was given by NYS for DDT cancer potency factor.

The concept of a statistically saved life(VSL) value was used to estimate the benefit derived from the carcinogenic risk reduction and human health improvement through POPs discharge elimination in the ESM project. VSL is not the value of a life, but a convention of how much are people willing to pay for a risk reduction, which can be defined in equation (2).

$$VSL = \frac{MWTP\,or\,MWTA(from\,hedonic\,wage\,or\,CV)}{Small\,Risk\,Change} \tag{2}$$

Recently, Kip et al. reviewed the market estimates of VSL throughout the world since the 1970s.[7] The author found that a VSL based on U.S. labor market data typically were just in the range of $4 million to $9 million, which are similar to those generated by U.S. product market and housing market studies. And EPA typically uses a VSL of $5.8 to $6.2 million in risk impact assessments. However, international estimates tended to be a bit lower than that in the United States, e.g. $4.2 million in UK,$3.9-$6.5 million in Australia, $1.2-$1.5 million in India and $1.7 million in Hong Kong(China).

3 Results and Discussion

3.1 POPs Emission reduction

China's large agricultural industry and heavy dependence on agro-chemicals resulted in about 574,000 tons of POPs pesticides production through the end of 2004. In the past, plant owners and end users have been responsible for managing their own POPs pesticides, which have resulted in stockpiles of obsolete pesticides and associated wastes, the distribution and scope of which has been unknown to central and local environmental protection agencies. Based on the research and surveys conducted in conjunction with preparation of obsolete POPs ESM project, obsolete POPs pesticide and associated wastes have been identified in 44 POPs pesticide manufacturing plants and a number of distribution and end user sites. Table 1 summarized the amount and major contents of the obsolete POPs pesticides. The ESM project will just provide for safe treatment for a minimum of 10,000 tons of identified targeted POPs pesticide wastes according to Stockholm Convention and Basel Convention guidelines.

Table 1: Identified Obsolete POPs Pesticides Sites

Area	DDT	Chlordane/Mirex	HCB	Sub-total
Pesticide manufactures	2,400-2,800	1,380-1,510	60-70	3,840-4,380
Agriculture distributor	4,164-5,640	-	-	4,164-5,640
Healthcare distributor	55-73	-	-	53-73
Total	6,619-8,513	1,380-1,510	60-70	8,059-10,093

Current practices for POPs waste disposal are dominated by incineration. According to the Chinese standard of pollution prevention for hazardous waste incineration (GB18484-2001), the required destruct and removal efficiency(DRE) is 99.99% for primary pollutants and dioxin emission limit is 0.5 ng TEQ/Nm^3. Based on the inventory of estimated dioxin releases identified in nation implementation plan(NIP), 79 enterprises in China for hazardous waste incineration in 2004, having an annual disposal volume of 271,000 tons, can be divided into three classes, for which emission factors for category 2 to category 4 in the Dioxin Toolkit were chosen. The estimated overall air and residual PCDD/PCDFs emission is about 57.27 g TEQ. With the support of obsolete POPs ESM project, a DRE of 99.9999% for primary pollutants and dioxin emission limit of 0.1 ng TEQ/Nm^3 should achieved at least.[8]It can be calculative that 8.97 g TEQ of PCDD/PCDFs emissions could be avoided to release into the atmosphere through novel non-incineration technologies or improved emissions control methods. Without the ESM project, it is supposed that a certain amount of DDT stockpile would release into the surrounding environment. And the values fit normal distribution in an interval of 5%-10%. Then the annualized DDT emission reduction could be estimated when the average concentration of DDT could be set as 10%.

3.2 Environmental Risk Assessment

The reduction of population annual risk from PCDD/Fs and DDT elimination, defined as the decrease of probable cancer cases over the whole population in a year, could be calculated by equation (3).

$$Population\,annual\,risk\,reduction = \frac{Dose\,reduction \times Cancer\,potency\,factor \times Population}{Year\,mean\,lifetime} \tag{3}$$

For a Chinese population, a mean weight of 60 kg, considered as an exact value, a number of inhabitant for China of 1,328 million in 2008, and a Chinese mean lifetime of 73 years, also considered as an exact value, the resulting probability distribution of the variable reduction of population annual risk rate from PCDD/Fs elimination is shown in Fig.1. The mean value is 2.20, the variance 1.21, and the interval limits

are 0.52 and 12.44. And Fig.2 shows the resulting probability distribution of the variable reduction of population annual risk rate from DDT reduction and pollutant prevention. The mean value is 0.65, the variance 0.01, and the interval limits are 0.40 and 0.95.

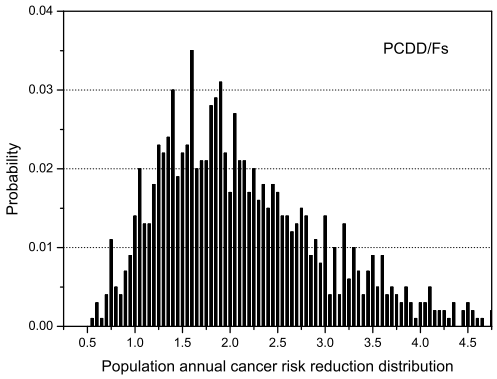

Figure 1: PCDD/Fs risk reduction distribution

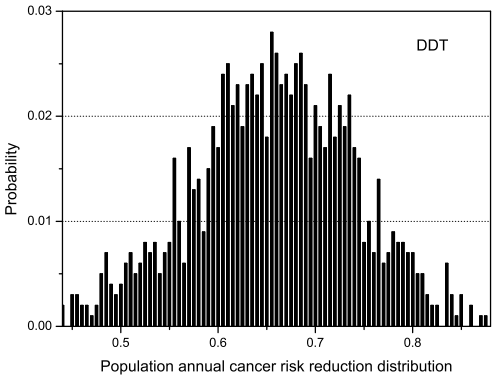

Figure 2: DDT risk reduction distribution

3.3 Cost-Benefit Analysis

The result of multiplying VSL by the sum of reduction of population annual risk rate of PCDD/Fs and DDT gives the economic value of benefits on the population health improvement from ESM project. The planed total budget for ESM project is about US$42,000,000 and annualized project cost is 8,400,000 diving by 5 years. And the net value could be achived by economic benefit value subtracting annualized project cost.

For the US case, VSL interval is US$5.8-6.2 million from US-EPA. Fig.3 displays the probability distribution of the annualized net value from the ESM project. Mean value and variance are US$8.78 million and 43.9, and the interval limits are -1.5 and 70.3 respectively. The ESM project is feasible at most of the time, since that the possibility of a positive benefit exceeds 98.4%.

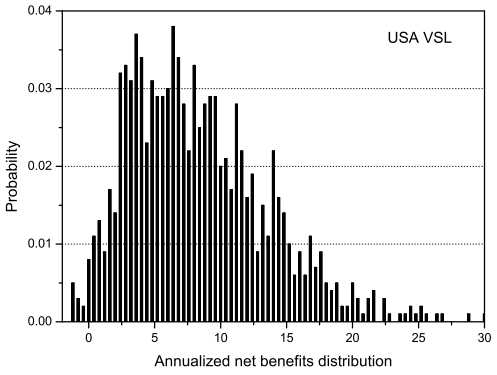

Figure 3: Annualized USA benefit distribution

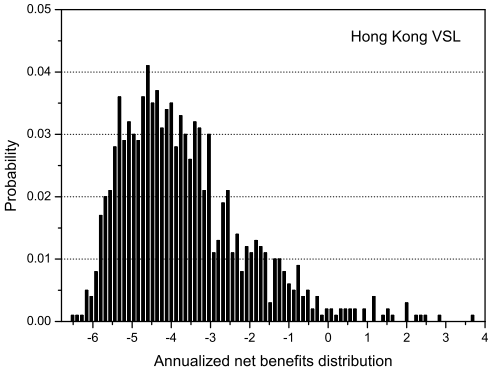

Figure 4: Annualized HK benefit distribution

For the Hong Kong case, however, the result is quite different from the one in USA. A value of cancer equal to US$1,700,000 could be used in Hong Kong. The probability distribution of annualized health

benefit from the ESM project, is shown in Fig.4. And the mean value is US$-3.55, the variance 3.52, and the interval limits are 6.41 and 13.91, where the possibility of a positive benefit is lower than 4.70%.

3.4 Sensitive analysis

The overall uncertainty in the results of net values from ESM project was implemented through sensitive analysis in this study . Eight input parameters: potency cancer factor of PCDD/Fs, potency cancer factor of DDT, concentration of DDT in stockpiles, intake fraction of PCDD/Fs, intake fraction of DDT, leakage rate of DDT stockpile, value of a static life for USA and Hong Kong China were analyzed with a 10% variation to identify what source of uncertainty weights more on the study's conclusions. And the sensibility analysis of net benefit value of ESM project calculated based on VSL of USA and Hong Kong were shown in fig.5 and fig.6, respectively.

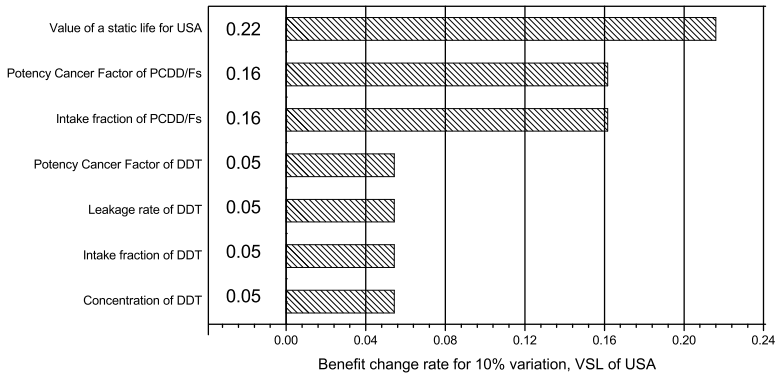

Figure 5: Sensitive analysis of net benefit value, VSL of USA

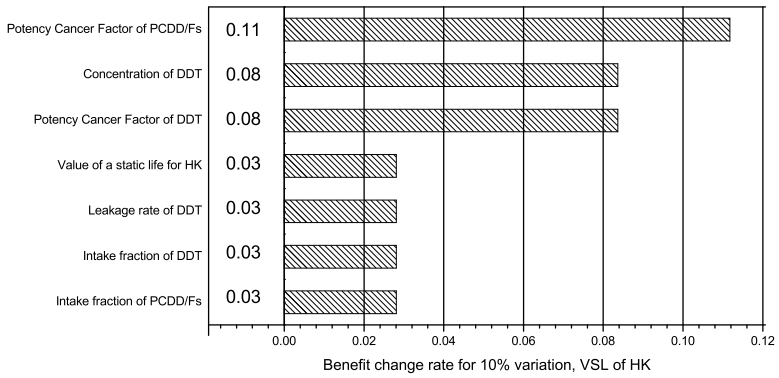

Figure 6: Sensitive analysis of net benefit, VSL of Hong Kong

It could be found that those parameters show different effects on the net benefit value of ESM calculated by USA and Hong Kong VSL criteria. As for the USA case, value of a static life for USA, potency Cancer

Factor and intake fraction of PCDD/Fs shows more important effects than other parameters, which might be from the big value of USA VSL and the high cancer risk from PCDD/Fs. While, potency cancer factor of PCDD/Fs, potency cancer factor of DDTs and concentration of DDT in stockpiles are listed in the first 3 important factors, which might be from the big amount of the DDT in the stockpiles.

4 Conclusion and Recommendation

The above CBA results basing on the VSL of USA demonstrated the economic viability of this ESM project under most circumstance from the reduction of POPs emissions. However, it can also be seen, the kind of VSL adopted in CBA study affects largely the result of cost benefit analysis. A widely accepted international standard for VSL selection is very helpful to reduce uncertainty of the CBA results in assessing the economic benefit value of an GEF environmental project.

5 Acknowledgments

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References

[1] GEF Secretariat, *Cost Effctiveness Analysis in GEF Projects*, http://gefweb.org/ Documents/Council_ Documents/GEF_ C25/C.25.11_ Cost_Effectiveness.pdf 2005

[2] Gerard F. Cost-Benefit Analysis as a Tool for Decision Making in Environmental Project, *Environ Sci & Pollut Res* 2004, 11:307

[3] Thanh BD, Lefevre T. Assessing health benefits of controlling air pollution from power generation: the case of a lignite-fired power plant in Thailand. *Environ Manage* 2001,27:303

[4] Atkinson G, Mourato S. Environmental Cost-Benefit Analysis, *Annu Rev Environ Resour* 2008,33:317

[5] Hirai, Y, Sakai SI, Watanabe N, et al. Congener-specific intake fractions for PCDDs/DFs and Co-PCBs: modeling and validation, *Chemosphere* 2004,54:1383

[6] Macleod M, Bennett DH, Perem M. Dependence of intake fraction on release location in a multimedia framework: A case study of four contaminants in North America, *J Indus Ecol* 2004,8:89

[7] Kip W, Aldy J, The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World, *J Risk Uncertainty* 2003,27:5

[8] Secretariat of the Basel Convention, *General Technical Guidelines for the Environmentally Sound Management of Wastes Consisting of, Containing or Contamined with Persistent Organic Pollutants (POPs)*, 2005:13