INDEPENDENT EVALUATION DIVISION
OFFICE OF EVALUATION AND INTERNAL OVERSIGHT

Independent Terminal Evaluation

Environmentally sound management and disposal of obsolete POPs pesticides and other POPs in China

UNIDO Project No.: GF/CPR/09/006 - 104147
GEF Project ID.: 2926

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List of acronyms and abbreviations

ADB	Asian Development Bank
APCD	Air pollution control device
APCS	Air pollution control system
APR	Annual Project Report
BAT BBMG	Best available techniques Beijing Building Material Group
BEP	Best environmental practices
BOT	Build-Operate-Transfer
CAS	Chinese Academy of Sciences
CCCEPI	China Certification Centre of Environmental Protection Industry
CEMS	Continuous Emission Monitoring System
CICG	Convention Implementation Coordinating Group
CIO	Convention Implementation Office
COP	Conference of Parties
CSC	China Standard Certification Centre
CTA	Chief Technical Advisor
DEHP	Diethylhexylphthalate
EMS	Environmental Management System
EPA	US Environmental Protection Agency
EIA	Environmental Impact Assessment
ESM	Environmental Sound Management
FECO	Foreign Economic Cooperation Office
GEF	Global Environment Facility
HWDC	Hazardous Waste Disposal Centre
MW	Medical Waste
IHB	Institute of Hydrobiology
IR	Inception Report
MIS	Management Information System
MOA	Ministry of Agriculture

MEP	Ministry of Environmental Protection
MOHURD	Ministry of Housing and Urban-Rural Development
MOF	Ministry of Finance
MOFA	Ministry of Foreign Affairs
MOFCOM	Ministry of Commerce
MOH	Ministry of Health
MOST MSW	Ministry of Science and Technology Municipal Solid Waste
NCG	National Coordination Group
NDRC	National Development and Reform Commission
Ng	Nanogram
NGOs	Non-governmental Organizations
NIP	National Implementation Plan
NHMWP	National Hazardous and Medical Waste Disposal Facility Construction Program
NTA	National Technical Advisor
OP	Operational Program
OPP	Obsolete POPs pesticides
PW	POPs waste
PPW	POPs pesticide waste
PCDD/PCDFs	Polychlorinated dibenzo-para-dioxins and dibenzofurans
PPP	Public-private partnership
PIR	Annual Project Implementation Review
PM	Particulate matter
PMO	Project Management Office
POPs	Persistent Organic Pollutants
SARS	Severe Acute Respiratory Syndrome
SC	Stockholm Convention
SERC	State Electrical Regulation Commission
SAWS	State Administration of Work Safety
TCDD	Tetrachlorodibenzo-p-dioxin

TCG	Technical Coordination Group
TEQ	Toxic Equivalent (dioxin emissions)
TOT	Transfer-Operate-Transfer
TOC	Theory of Change
TTR	Terminal Tripartite Review
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization
UP-POPs	Unintentionally produced POPs
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WB	The World Bank
WHO	World Health Organization

Glossary of evaluation-related terms

Term	Definition
Baseline	The situation, prior to an intervention, against which progress can be assessed.
Effect	Intended or unintended change due directly or indirectly to an intervention.
Effectiveness	The extent to which the development intervention's objectives were achieved, or are expected to be achieved.
Efficiency	A measure of how economically resources/inputs (funds, expertise, time, etc.) are converted to results.
Impact	Positive and negative, intended and non-intended, directly and indirectly, long term effects produced by a development intervention.
Indicator	Quantitative or qualitative factors that provide a means to measure the changes caused by an intervention.
Lessons learned	Generalizations based on evaluation experiences that abstract from the specific circumstances to broader situations.
Logframe (logical framework approach)	Management tool used to facilitate the planning, implementation and evaluation of an intervention. It involves identifying strategic elements (activities, outputs, outcome, impact) and their causal relationships, indicators, and assumptions that may affect success or failure. Based on RBM (results-based management) principles.
Outcome	The likely or achieved (short-term and/or medium-term) effects of an intervention's outputs.
Outputs	The products, capital goods and services which result from an intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes.
Relevance	The extent to which the objectives of an intervention are consistent with beneficiaries' requirements, country needs, global priorities and partners' and donor's policies.
Risks	Factors, normally outside the scope of an intervention, which may affect the achievement of an intervention's objectives.
Sustainability	The continuation of benefits from an intervention, after the development assistance has been completed.
Target groups	The specific individuals or organizations for whose benefit an intervention is undertaken.

Executive Summary

The project's overall objective was "to implement environmentally sound management (ESM) and disposal of 10,000 tons of accumulated POPs pesticide wastes and 1,000 tons of dioxin-rich incinerator fly-ash in fulfillment of China's obligations under the Stockholm Convention." The total project budget at design was of USD 42,059,000, of which USD 9,959,000 was financed by a grant of Global Environmental Facility (GEF) and USD 32,100,000 were co-financed by the government of China and participating firms. The project started implementation on April 4, 2009. It was initially scheduled to last five years but it received three extensions from GEF and is scheduled to close on December 31, 2018. The project was implemented by UNIDO and executed by the Foreign Economic Cooperation Office (FECO) of the Ministry of Environmental Protection (MAP) in China.

The project is rated as highly satisfactory as it met or exceeded its objectives and contributed to an important reduction of risks to human populations and the environment through the removal of harmful POPs. The project soundly disposed of 6,352 t pesticide POPs (DDT/HCH) and 42000 t soils contaminated by DDT/HCH. All legacy stockpiles of POPs pesticides known at the time of the project implementation were destroyed within the project duration. The amount of POPs wastes disposed is far beyond the project design requirements. The evaluation estimated that the sound disposal of the POPs pesticides and pesticides wastes reduced the health risks to a population ranging from 4.3 million to over 15 million people. For example, in Hunan province alone, the removal of POP pesticides in the Natian chemical plant has greatly reduced the risks of contamination of the Xiangjiang river which supplies drinking water to the city of Changsha (with a population of four million people). Approximately 50,000 t of dioxin rich fly ash were disposed by cement co-processing and 30,000 t were treated by a high temperature sintering technology.

By the treatment of fly ash around 106.9 g TEQ was destroyed. By the selection of technologies to treat POPs pesticides and pesticide contaminated soil 43 g TEQ of PCDD/F release was avoided compared to the baseline technology. Therefore, around 149.9 g TEQ of dioxin reduction was achieved by this project, which is about 3 times higher than the project expectation of 39.64 g TEQ (including 30.67 g TEQ destruction and 8.97 g TEQ avoided). This has reduced human health risks in the metropolitan area of Beijing (population 20 million) and in the city of Tianjin (population one million).

The project also made important contributions to the transformation towards a sound system for the management of POPs in China. The project adopted an integrated approach to behavioural change, that focused on the removal of barriers to the adoption of best available technologies and best environmental practices (BAT/BEP) for the management and disposal of POPs and POPs contaminated soils and fly ash. The project strategy addressed simultaneously all the key conditions necessary to redirect POPs management towards a more sustainable path. The project helped strengthen the policy and regulatory framework which clarified procedures and standards and provided incentives to adopt the new technologies. A series of technical guidelines and standards for the environmentally sound management of obsolete POPs pesticides stocks and wastes was also developed. The establishment of a regulatory framework for the sound management of obsolete POPs has promoted the identification of obsolete POPs and their sound disposal in 13 provinces and cities.

The project evaluated major POPs destruction technologies including combustion technologies and non-combustion technologies. During the project duration several

state-of-the-art techniques were used or were developed. For POPs pesticide waste disposal cement kiln co-processing and thermal-desorption and ball milling were evaluated and cement kiln and thermal desorption were used in industrial setting while ball milling was developed to pilot scale with further aim of full sale application. For the fly ash treatment technologies were developed in industrial scale including fly ash water-washing combined with cement kiln co-processing and high-temperature sintering for building materials. Some of them were successfully adopted by cities and business participating in the project. All of the selected technologies with the exemption of ball milling were at a stage where they could be tested and adapted in an industrial setting. This allowed the project to engage the business community and to develop and test competitive business models.

Concurrently, the project helped to develop capacities in the public sector on regulation, enforcement, stakeholder engagement and coordination across levels of government and sectors. The project also provided information and raised awareness in communities surrounding contaminated sites and took actions to address local concerns. All of which proved to be key in preventing unrest and for gaining community support for cleanup operations. Participating communities also came to understand the risks of POPs in general and specifically POPs pesticide stockpiles and unintentional POPs like dioxins, and became more vocal in demanding action. Raising awareness among decision makers was also key to build the political will to adopt new regulations.

Ownership among the different levels of the public administration and among the participating firms proved to be critical factor to the project accomplishments. This is most apparent in the high levels of co-financing (USD 80 million) which was more than twice the planned co-financing at project design. But ownership had to be cultivated. From the start, the project design emphasized the benefits of the project for the local populations. When concerns arose on the suitability of international standards for conditions in China, project pilots were used to generate the necessary evidence to convince policy makers that such standards were suited to these conditions. Thus, for example, the government adopted standards on dioxin limits for air emission that are the same as those in Europe and other developed countries.

Benefits to stakeholders were important to engage businesses in the adoption of the technologies. The adoption of new technology allowed firms to provide a social service (disposal of dioxin and heavy metal rich fly ash; destruction of POPs pesticides) at a time when, in Beijing, the cement plants faced risks of being closed by the city government in account of the cement overproduction capacity in region. This is a measure that is likely to be followed by other local governments of large metropolitans in the country. Adoption of the new technology also provided an extra source of income for the treatment of fly ash and helped with modest reductions in the costs of inputs. Information and outreach to the local communities also helped to build local support for– or at least prevented opposition to -- clean up operations, which was a politically sensitive issue for the government and a major concern for the project management.

The project has set up mechanisms that can continue to catalyze change once the project ends. The project provided the principal guidance to provinces and cities for the regulation of POPs and hazardous waste management, which is being adopted with the support of FECO beyond the 13 provinces and cities where the project operated. These regulations, once adopted and mainstreamed, have been critical in generating incentives

for cities and companies to adopt new technology. BBMG, one of the largest cement corporations in China has successfully replicated the co-processing technology by installing a plant with a capacity to process 40 000 t of fly ash a year. EMAN is also in negotiations with other several cities of similar population as the City of Tianjin to replicate sintering technology there. These two firms have also identified business models and have filed for patents to replicate and scale up the fly ash processing technologies.

Adaptive management during project implementation, while resulting in project extensions and a higher cost to UNIDO, was also key in addressing unexpected circumstances and ensuring delivery of project outputs and outcomes. For example, before this project there were no standards for the processing of hazardous waste; it took three years to generate the evidence needed to pass a regulation. In the case of the processing of fly ash in cement kilns, tests had to ensure that levels of dioxin and heavy metals were safe and that the process did not affect the quality of cement. Also, while dealing with the cleanup operation of the Natian Chemical factory in Hunan province, the project management was able to help resolve a long-standing social concern of the local population, and most likely prevented the blocking of key project activities by factory workers seeking redress for their pension fund. Shifting technological trials to an industrial scale was also a key factor that led to the high levels of impact (through the treatment of fly ash and dioxin elimination) and the identification of business models to replicate and scale up the innovations introduced by the project. The closing of cement plants in the Beijing area in 2016 was important contextual factor that gave cement firms incentives to participate in the project and to integrate co-incineration of waste as a business by developing a frame and technology for environmentally sound management of POPs waste. The challenges facing the cement industries were an unexpected development that the project management quickly acknowledged and seized as an opportunity to engage the cement factories.

The project's management structure ensured inter-institutional coordination and the engagement of all the relevant sectors at the various levels of public administration. This process increased the complexity of the project and in the short run slowed down operations while all key stakeholders came on board. On the long run this proved to be a crucial instrument in reaching and engaging the different sectors of government at the national, provincial and local levels. The project's implementation approach also involved the major stakeholders and high-quality technical inputs from international experts, learning visits and exchanges with other countries, and cooperation with scientific institutions in applied research.

Three lessons are derived from this experience

- Successful projects cultivate country ownership throughout the full project cycle.
- Comprehensive approaches, while complicated, are effective tools to build conditions for transformation.
- A focus on the industrial application of technology provides an effective framework to catalyze transformations at scale

The evaluation has two recommendations to the Government of China.

Recommendation 1: It is critical to ensure the proper protocols for feeding of POPs and fly ashes are observed, in terms of sufficiently high temperature at feeding point,

adequate resident time for POPs or fly ash at appropriate temperature and proper training of kiln staff on hazardous waste management.

One of the assumptions in the project theory of change is the sound application of technology during replication. By the end of 2018 approximately 100 cement plants have likely the license to treat hazardous wastes. Such replications and mainstreaming need to be appropriately guided. Given the risks of inadvertently producing of high quantities of dioxins during the destruction of POPs and the thermal treatment of fly ash it is critical that the proper protocols for feeding of POPs and feeding of fly ashes are observed. The temperature at feeding point must be sufficiently high to destroy POPs and dioxins and that the required resident time for POPs or fly ash at the appropriate temperature also needs to be met. The experience in capacity building of the staff handling the waste but also for the management of the facilities should be utilized for training in this mainstreaming effort. Firms will need to ensure that kiln staff is sufficiently trained on hazardous waste management (as was the case in BBMG).

Recommendation 2: Heavy metals present in fly ashes or wastes need to be appropriately assessed and controlled including long term considerations over the life cycle, in addition to POPs.

Project factsheet

Project title	Environmentally sound management and disposal of obsolete POPs pesticides and other POPs wastes in China
UNIDO ID	104147
GEF Project ID	2926
Region	Asia and the Pacific
Country(ies)	China
Project donor(s)	GEF
Project implementation start date	4/4/2009
Expected duration	5 years
Expected implementation end date	30 June 2018
GEF Focal Areas and Operational Project	GEF Operational Program on POPs – OP 14
Implementing agency (ies)	UNIDO
Government coordinating agency	China Ministry of Environmental Protection (MEP)
Executing Partners	MEP/Foreign Economic Cooperation Office (FECO)
UNIDO RBM code	GC33 (Implementation of MEA)
Donor funding	9,973,000 (excluding PPG)
Project GEF CEO endorsement / approval date	15/12/2008
UNIDO input (in kind, USD)	In kind 100,000
Co-financing at CEO Endorsement, as applicable	MEP (cash & in-kind) MOF (cash) Local EPBS (cash & in-kind) Pesticides owners and other private sectors (cash & in-kind)
Total project cost (USD), excluding support costs and PPG	42,073,000

Mid-term review date	March 2014
Planned terminal evaluation date	May 2018

Source: Project document and progress report

Project rating

Table 1: Project Rating Table

#	Evaluation criteria	Mandatory rating
A	**Impact**	**HS**
B	**Project design**	**S**
1	• Overall design	HS
2	• Logframe	HS
C	**Project performance**	**HS**
1	• Relevance	HS
2	• Effectiveness	HS
3	• Efficiency	HS
4	• Sustainability of benefits	HS
D	**Cross-cutting performance criteria**	
1	• Gender mainstreaming	S
2	• M&E: ✓ M&E design ✓ M&E implementation	HS HS HS
3	• Results-based Management (RBM)	HS
E	**Performance of partners**	
1	• UNIDO	HS
2	• National counterparts	HS
3	• Donor	S
F	**Overall assessment**	HS

I. Evaluation Objectives, Questions and Methods

1. Objectives of the evaluation

The purpose of the evaluation is to independently assess the project: *Environmentally Sound Management and Disposal of Obsolete POPs Pesticides and Other POPs Wastes in China,* and to derive lessons to help UNIDO and China improve performance and results of ongoing and future projects. The evaluation has two specific objectives. One is to assess the project performance in terms of relevance, effectiveness, efficiency, sustainability and progress to impact. The project's performance is assessed on the criteria of relevance, effectiveness, efficiency, sustainability and contributions to impact. The evaluation provides an analysis of the delivery and completion of project activities, outputs and outcomes. The evaluation considers the interventions' design, level of national ownership, relevance to various stakeholders and the extent of the exploration of synergies with other UNIDO projects and with related initiatives in China. In accordance with the evaluation terms of reference provided by UNIDO, this evaluation assesses the extent and forms by which the project contributed to the conditions necessary for the broad adoption of environmentally sound POPs management, including the extent to which the project helped build capacities to manage any risks that may impact upon the sustainability of project accomplishments. The second evaluation objective is to develop a series of findings, lessons and recommendations for enhancing the design of other operations. As such, this terminal evaluation identifies good practices arising from the project and also assesses the factors that have contributed to or limited project accomplishments. This terminal evaluation (TE) covered the whole duration of the project from its starting date in 30/04/2009 to the estimated completion date in 30/6/2018.

2. Key evaluation questions

Based on the project objectives, the Theory of Change (TOC) presented in Figure 1, the findings of the midterm evaluation and other documents reviewed, the terminal evaluation asked the following key questions:

1. What have been the project's key results (outputs, outcome and impact)? To what extent have the expected results been achieved or are likely to be achieved? Were results cost effective (that is, did they provide good value for money)? What is the likelihood that project results will be sustained after the completion of the project?
2. To what extent has the project helped put in place the conditions likely to overcome barriers and contribute conditions leading to the sound management of POPs in China?
3. What are the key factors that contributed to or limited progress the long-term project objectives?
4. What lessons can be drawn from the project?

3. Evaluation Methods

The terminal evaluation was carried out in accordance with the UNIDO Evaluation Policy[1], the UNIDO Guidelines for the Technical Cooperation Project and Project Cycle[2], the Global Environment Facility (GEF) Guidelines for GEF Agencies in Conducting Terminal Evaluations[3], the GEF Monitoring and Evaluation Policy[4], and the GEF Minimum Fiduciary Standards for GEF Implementing and Executing Agencies[5]. The evaluation was carried out using a participatory approach seeking to inform and consult with all key parties associated with the project.

The evaluation team adopted a theory of change (TOC) approach to assess the causal links between project activities, outcomes and outputs, and to assess the extent to which the project contributed to conditions necessary to achieve the broad adoption of project results and to overcome the barriers to sound POPs management in China. A mix of methods approach was used to deliver evidence-based qualitative and quantitative information, based on diverse sources. The use of mixed methods allowed the evaluation to triangulate information, to assess causality, and to assess diverse factors affecting the achievement of results (Garcia and Zazueta 2015).

The evaluation took place from April 12 to July 30, 2018. In preparing this report the evaluation team reviewed the documentation of the project provided by UNIDO project management. This included the project document, the midterm evaluation of the project and the project implementation reports. The evaluation team also verified, in consultation with project management and other stakeholders, the theory of change. The evaluation team also examined the overall readiness for project implementation as well as the timeliness by which management put into action the recommendations of the independent midterm evaluation.

Interviews and field visits in China reached 89 stakeholders including those in project management; central, provincial and local governments; businesses, non-governmental (NGOs), and others. Annex 1 includes the persons that were interviewed during the evaluation. In preparation of field work the team developed a series of tables related to project impacts, budget, co-financing and gender that were used to gather, organize and present information. The logical framework-based matrix was also used to guide the systematic collection of information pertaining to the execution of project activities and delivery of outputs. The local member of the evaluation team, in coordination with the

1 UNIDO. (2015). Director General's Bulletin: Evaluation Policy (UNIDO/DGB/(M).98/Rev.1)

2 UNIDO. (2006). Director-General's Administrative Instruction No. 17/Rev.1: Guidelines for the Technical Cooperation Project and Project Cycle (DGAI.17/Rev.1, 24 August 2006)

3 GEF. (2008). Guidelines for GEF Agencies in Conducting Terminal Evaluations (Evaluation Office, Evaluation Document No. 3, 2008)

4 GEF. (2010). The GEF Monitoring and Evaluation Policy (Evaluation Office, November 2010)

5 GEF. (2011). GEF Minimum Fiduciary Standards: Separation of Implementation and Execution Functions in GEF Partner Agencies (GEF/C.41/06/Rev.01, 3 November 2011, prepared by the Trustee)

Project Management Office, gathered the information required to fill in the tables, including the activities and outputs of the project, project expenses and expected and realized co-financing.

The evaluation visit to China took place from 20 to 31 May 2018. Annex 2 contains the questions that were used to guide focus groups, discussions and interviews with stakeholders. The team first interviewed Project Management Office staff, government officials and other stakeholders in Beijing. Subsequently, field visits took place in Hebei, Jiangsu and Hunan provinces and the Tianjin municipality, where the evaluation team interviewed staff from the Regional Management Offices, government officials of institutions participating in the project and other stakeholders. Annex 3 contains the field agenda including the organizations, firms and localities visited.

During the field visits, the evaluation team endeavoured to identify the results of the project by establishing causal links aided by the theory of change. Attention was also given to inquiring about the prevalence of conditions observed. The evaluation team shared emerging findings and conclusions to key national stakeholders prior to leaving China. The team then presented the findings and conclusion in UNIDO's headquarters in Vienna on June 26 and the draft report July 24. A draft of the report was also circulated among stakeholders for comments and corrections of factual errors and errors of interpretation.

II. POPs Management and Disposal in China

China's large agricultural sector is heavily dependent on agro-chemicals; this resulted in the production of a large amount of POPs pesticides by 2009, when production was completely banned. Yet POPs pesticides management transportation and disposal have remained largely unregulated, which has resulted in stockpiles of obsolete pesticides and associated wastes across the country, often in locations unknown to central and local environmental protection agencies. Large amounts of obsolete POPs pesticides are therefore often stored under unsafe conditions, such as outdoor storage, simple enclosure, or open-air disposal with municipal solid waste, all of which constitute a serious threat to human health. This low capacity and the absence of infrastructure for environmentally sound management (ESM) and disposal of POPs pesticide wastes pose significant risks to human health and the environment. Hazardous waste disposal in China has also been dominated by incineration, which generates secondary pollution in the form of dioxins and furans. It is estimated that fly ash containing a high level of dioxins from incineration of hazardous wastes and medical wastes amounts to 11,000 tons per annum. Incineration plants generally dispose of this dioxin-rich fly ash in open dumps or non-sanitary landfills mixed with municipal wastes, thereby increasing the potential POPs pollution risk to water resources and soils. This serious risk of environmental contamination and human exposure can be further exacerbated by natural disaster, such as flooding and earthquakes.

III. Project design and midterm evaluation

1. Project overall and immediate objectives

"The project's overall objective is to implement environmentally sound management (ESM) and disposal of 10,000 tons of accumulated POPs pesticide wastes and 1,000 tons of dioxin-rich incinerator fly-ash in fulfillment of China's obligations under the Stockholm Convention." The "immediate objectives" of the project are to:

- Strengthen the legal and regulatory framework for environmentally sound management (ESM) and disposal of POPs waste
- Improve institutional capacity at all levels of POPs waste disposal management
- Remove POPs pesticide wastes and dioxin-rich incinerator fly ash from targeted contaminated sites, and transport them to disposal centers
- Dispose of wastes in an environmentally sound manner (including the disposal of 10,000 tons of accumulated POPs pesticide wastes and 1,000 tones dioxin rich incinerator fly-ash)
- Complete qualitative environmental risk assessment (QERA) site prioritization.

2. Theory of change

The theory of change (TOC) is a heuristic tool to help clarify the links between project activities and long-term objectives. As few projects under implementation have developed TOCs, evaluators typically develop a tentative TOC that is verified and amended during interviews with key project stakeholders. Key in the development of a TOC is the identification of the conditions likely to bring about the behavioural changes required to achieve the long-term goal of the project (Chen 1990; Mayne 2008), typically referred to as system transformations. Given the complex nature of the interactions of human behaviour and the environment (the social ecological system), and the unpredictability of outcomes of these interactions, it is also critical to identify the key assumptions made during project design (Folke *et al*. 2002; Levin 2003). The use of a theory of change in an evaluation does not mean that the project will be held accountable for having resulted in system change. System transformations take time, and rarely do they take place within the time span of a project. Nevertheless, the TOC can be used by the evaluator to assess the extent to which project activities correctly targeted the conditions that are likely to contribute to the long-term goals of the project. Most importantly, TOCs are an important tool that can help us better understand the processes that projects seek to influence, in order to derive lessons and provide recommendations to improve future projects.

There was no explicit TOC developed for this project. However, the project document provides sufficient information on the long-term objectives, project

assumptions and root causes that the project seeks to overcome in the long run. The project document stated the overall objective of the project as the disposal of 10,000 tons of POPs waste and 1000 tons of dioxin-rich fly ash. The first sentence of the project document points towards a much broader and transformative objective by stating, "The project will enable environmentally sound management (ESM) and disposal of targeted obsolete POPs pesticides and associated wastes in fulfillment of China's commitments under the Stockholm Convention." Project preparation identified seventeen barriers preventing the sound management and safe disposal of POPs in China. These barriers pertained to issues related to legal and regulatory systems, institutional capacities, access to technology, science and information and engagement of the business sector (Annex 4). The project was designed to help China overcome these barriers and put into place a system for the sound management and safe disposal of POPs in the country.

As indicated in TOC diagram in Figure 1, the project was structured to directly contribute to the conditions that would lead to the capacities and incentives to transform the way POPs are managed in China, and to ultimately to reduce the risks cause by POPs to human health and the environment. Figure 1 also indicates five key conditions needed for this transformation that can be deduced from the description in the project document. These are:

- Policy, regulatory and institutional framework supportive to sound POPs management
- Inter-institutional capacities for sound POPs management
- Business models for sound POPs management
- System to transfer and replicate best available technique (BAT)
- Information on existence and location of POPs

The project's logical framework also included 15 outputs and 76 activities (Annex 5). The broad reach of the project required the engagement of multiple stakeholders (including government institutions, private firms and civil society) at the national, provincial and local scales. While seeking to strengthen the country's legal and regulatory framework for POPs management and disposal, the project also included pilot activities in six provinces to test and demonstrate new technologies, approaches to institutional coordination and forms to engage the private sector that could be later replicated in other provinces. The project design also included the support of public awareness campaigns in several of its components and support to universities to develop and apply technologies and to the mainstreaming the sound management of POPs in other endeavours (such as the Environmental Impact Assessments).

Three important assumptions in the project document are 1) that there is genuine interest at the country-level on establishing a sound system for the POPs management; 2) that stakeholders, particularly current plant operators and POP owners, will ultimately see the benefits on the sound management and disposal

of POPs; and 3) The technology would be applied following necessary safety measures.

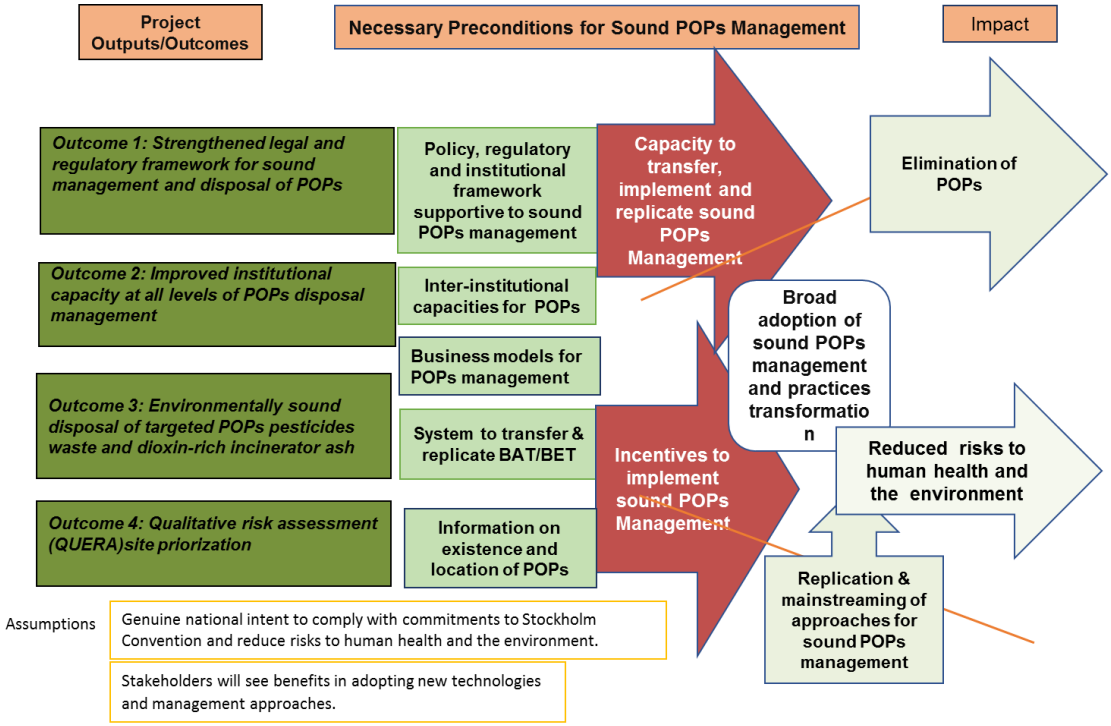


Figure 1. Project theory of change

Project design also anticipated several operational challenges related to complex systems, including:

- The need for the project to address problems at multiple scales, including global (the Commitments to the Convention), macro (government and legal frameworks), meso (national providers of services and provincial administration) and micro (businesses and other organizations);
- The need to develop pathways to move from the successful demonstration of a technology or an approach to the broader adoption through mechanisms such as mainstreaming, replication and scaling-up;
- The need to raise awareness and engage multiple stakeholders in the public sector, private sector and civil society and to promote synergy;
- The need to facilitate the transfer of information, knowledge and sharing of experiences across stakeholders, sectors and scales.

3. Project implementation structure and budget

The project management was assigned to the Convention Implementation Office of FECO in the Ministry of Environmental Protection. The project management team was made responsible for coordination of project activities, arranging study tours, monitoring impacts and outputs and procuring technical assistance and make project adjustment to ensure achievement of the objectives of the project.

The results monitoring was contracted out to four different specialized laboratories that ensured the application of best environmental practices, tracked environmental risks and verified and reported on pops disposal. To ensure the engagement of key stakeholders the project established a National Steering Group and a Regional Steering Group to provide oversight. Figure 2 presents a of the implementation structure of the project which indicated the engagement of different stakeholders at different scales.

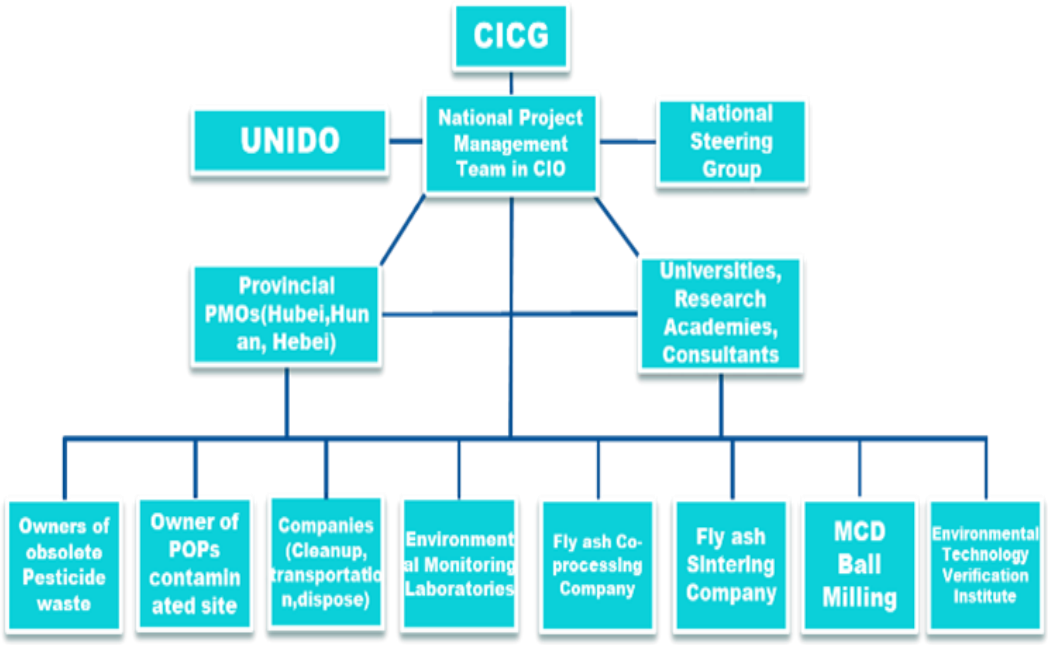


Figure 2. Implementation structure of the project

The total budget at project design was USD 42,073,000 of which USD 9.959,000 were provided by the GEF grant and the rest (*32,100,000 USD)* were from various cofounding sources6. Table 2 presents the budget distribution and co-financing across the different project outcomes at project design. By June 2018, when the field work for this evaluation took place, co-funding had grown to close to USD 80 million, in effect more than doubling the resources available to the project. Also, by this time the GEF funds had been spent with only of around USD 25,000 that was programmed spent by the end of the year (Annex 6). A large proportion of the project co-financing consisted on investments in equipment for the transportation and disposal of POPs waste and dioxin-rich fly ash. GEF grant funds were used in accordance with the budget in the project document: this included funds for POPs pesticide disposal and technical assistance, to test, adapt and demonstrate technologies and procedures for the management and disposal of POPs and for project management.

6 Project document cover page (also see P 54, paragraph 171)

Table 1: Project budget and co-financing by outcome at project design (USD)

Project outcomes	GEF	Co-Financing	Total USD
1. Strengthened legal and regulatory framework for environmentally sound management (ESM) and disposal of POPs waste	852,400	2,069,650	**2,922,050**
2. Improved institutional capacity at all levels of POPs waste disposal management	924,000	1,841,175	**2,765,175**
3. Environmentally sound disposal of targeted POPs pesticide waste and dioxin rich incinerator fly ash	7,063,600	26,400,825	**33,464,425**
4. Qualitative environmental risk assessment (QERA) site prioritization	642,500	1,051,100	**1,693,600**
5. Project management, monitoring and evaluation	476,500	737,250	**1,213,750**
Total (USD)	**9,959,000**	**32,100,000**	**42,059,000**

4. Midterm Evaluation Findings and Recommendations

The midterm evaluation rated the project as Highly Satisfactory. The project was also found to be efficiently executed. Some of the key project accomplishments pointed out by the midterm evaluation include:

- A strengthened regulatory framework for the sound management of obsolete POPs pesticides and wastes had been achieved.
- Guidelines for ESM of obsolete POPs pesticides stocks and wastes had been developed.
- Strengthened capacity for the destruction of POPs and other hazardous wastes in the Hubei and Hebei provinces had been established through significant investment of private partners (Huaxin Environment Company and Jinyu Mangrove Environmental Protection Company) to upgrade cement kilns.
- 4,951.6 tons of POPs pesticides and wastes had been packed, transported and soundly disposed of at the upgraded cement kilns.
- Key stakeholders at different levels had been properly engaged in the project.

However, the midterm evaluation reported delays in the delivery of the mobile unit for destruction of POPs pesticides and wastes using non-combustion technology.

The midterm evaluation made six recommendations, all of which were addressed by the project management by the time this terminal evaluation took place. Table

2 presents the midterm review recommendations and the actions taken by the project.

Table 2: Follow up to the recommendations of the midterm evaluation

Mid-term evaluation recommendations	**Actions taken by the project management in response to the midterm evaluation recommendations.**
1. All identified contaminated sites should be properly safeguarded, and the population living in the vicinity should be adequately informed to minimize or eliminate risk of exposure.	The identified contaminated sites have been properly safeguarded by setting visible signs, security fences, anti-leakage measures, and so on. The population living in the vicinity were also informed by informal broadcasting, posters and meetings that called people's attentions to ways to avoid the risk of exposure.
2. Assist the local authorities in putting in place a mechanism and long-term strategy for the remediation of the contaminated site near the pesticide factory in Hunan.	Covered under this project, the mechanism and long-term strategy for pesticide POPs waste disposal and remediation of the contaminated sites have been put in place by the Environmental Protection Department of Hunan province and the environmental protection Bureau of Xiangtan city.
3. A no-cost, two-year extension should be given to allow for the completion of activities for delivery of the mobile unit for the Mechano-Chemical Dechlorination (MCD) technology.	Ball mining for POPs waste disposal is a new promising technique. This technique is still in the state of laboratory scale, especially for POPs waste disposal. The primary aim in this project is to define the underlying mechanism of this technology for POPs waste. Although not required by the project, a pilot scale test ball milling for POPs waste disposal was performed in Wuxi city.
4. Ensure that planned co-financing materializes.	Materialized co-financing was achieved and exceeded. The total amount from the co-financing sources is about 449,114,000 RMB. Among them the amount from central finance is about 50,000,000 RMB.
5. Summarize successful replication experiences and lessons as a basis for project implementation in other provinces for the second phase.	The management mechanisms for environmentally sound management and disposal of obsolete POPs pesticides and other POPs wastes have been successfully established in Hunan province and in other provinces such as Jiangsu province. Co-

Mid-term evaluation recommendations	Actions taken by the project management in response to the midterm evaluation recommendations.
	financing involving local and central institutions has been replicated in Jiangxi, Guangxi and Hubei provinces, and Chongqing municipality.
6. Ensure that regulations and guidelines for ESM of obsolete POPs pesticides stocks and wastes and other hazardous wastes are enforced at all levels.	A series of regulations and technical guidelines for the environmentally sound management and disposal of POPs wastes have been promulgated. For example, a series of technical guidelines and emission control standards were issued for cement kilns co-processing hazardous wastes. Many technical guidelines for the identification and risk assessment of POPs contaminated sites also promulgated. Those regulations and technical guidelines have been enforced at all levels. The staff in the Environment Provincial Bureaus have also been trained to monitor compliance with standards.

IV. Project technologies used and description

1. Destruction of DDT pesticide with cement kiln

Cement kilns possess several advantages, which make them suited for the destruction of organic hazardous waste including POPs. The main burner is operated at a temperature of 2000 °C and the overall kiln temperature at the hot end of kiln is around 1450°C. If POPs waste is fed at the hot end of the kiln (main flame), the materials have a long residence time and good mixing conditions/turbulence, and some surplus oxygen.

Co-processing of wastes as alternative fuel and raw materials is widely adopted in many industrial and some developing countries. The use of wastes in cement manufacturing, either as a supplementary fuel or substitute for other raw materials, provides an option for eliminating waste and recovering energy and materials at the same time. This concept has been developed and used for co-processing problematic waste such as plastic waste, sewage sludge, POPs waste, contaminated soil, and fly ash from MSWI.

In China at the beginning of the project, no experience on POPs pesticide destruction in cement kilns existed. The POPs project described here was the first POPs destruction project with a strong impact on developing the overall frame for co-incineration and this project has been playing a catalytic role for further studies. The Chinese public is increasingly concerned about whether incineration processes will release pollutants into the environment.

There are several potential feed points for hazardous waste to the cement kiln system, including the main burner at the rotatory kiln outlet, the flue gas chamber at the rotatory kiln inlet and the precalciner, where the flue gas temperature reach 2000 °C, 1100 °C and 900 °C respectively. The residence time of flue gas at temperatures above 800 °C is in order of 13 s for the main burner, 3–4 s in the flue gas chamber and 1–3 s in the precalciner. The main burner is usually fed with homogeneous liquids or fine powders with smaller particle sizes, not lump solid wastes, which is normally fed into flue gas chamber at the kiln inlet or directly into the precalciner. The obsolete pesticides and even PCB oil were thoroughly destroyed when fed through the main burner (Karstensen et al. 2006, 2010).

Limited studies and test burns have been carried out with feeding obsolete pesticide or contaminated soil to the flue gas chamber at the kiln inlet, usually because the temperatures and the residence time are considerably lower (950-1150°C) compared to the hot end of the kiln (1450 to 2000). These feeding points at the inlet of the kiln are used in China and therefore were the primary interest of these study to confirm if the feeding point at kiln inlet can be used if the selected kiln has sufficient temperature and residence time at this position.

Cement plants used, establishing management and test conditions

One challenge und barrier for cement companies to enter the hazardous waste business is the technical capacity of employees to handle hazardous waste. BBMG Corporation Ltd. is a cement producer and property developer with the headquarter in Beijing. It is the largest supplier of building materials in Beijing, Tianjin and Hebei province. For the BBMG company won two tenders within the POPs pesticide stockpile project. For the main test and the destruction of POPs pesticides, Huaxin Wuxue Cement in Hubei Province and the Hebei Yanxin Cement, Hebei Province were used. Overall, 4 cement plants have been capacitated within the POPs pesticide destruction project to manage and destroy POPs pesticides.

BBMG company had a subsidiary which already was experienced in waste management. This subsidiary was responsible for the management, handling, packaging and transport of the pesticide waste at the DDT factory. Also this subsidiary were responsible for the support of the POPs waste management in the cement company. During the project then waste management capacity was built within the cement factory that at the end of the project the cement factory had staff with experience and licenses to manage POPs and other waste in the factory.

A schematic diagram and major test parameters for DDT powder destruction in kiln A and the contaminated soil in kiln B are shown in Table 2 and Figure 3.

Table 2: Cement plants and test conditions

	Test with DDT powder Plant A (29, 30 December 2010)	**Test with DDT contaminated soil Plant B (25, 26 November 2011)**
Name of cement plant	Huaxin Wuxue Cement, Hubei Province	Hebei Yanxin Cement, Hebei Province
Air pollution control eq.	Bag house filter	Elector static precipitator
Raw meal consumption (t/h)	364	118
Coal consumption (t/h)	30	11
Clinker production (t/h)	228	74
Cement kiln dust prod. (t/h)	22	7

	Test with DDT powder Plant A (29, 30 December 2010)		Test with DDT contaminated soil Plant B (25, 26 November 2011)	
Exit gas volume (Nm^3/h)	471,000		200,000	
Feed rate of DDT waste (t/h)				
Baseline test	0		0	
Feed rate of DDT waste (t/h)	**1.0**		**0.83**	
Average DDT concentration	A-Test1	10.63%, DDT powder	B-Test1	1350 mg/kg
	A-Test2		B-Test2	1470 mg/kg
	A-Test3		B-Test3	3390 mg/kg

1. Raw meal (RM) and flue were sampled under the A-Test0; Flue was sampled under the A-Test1, A-Test2 and A-Test3; the clinker (CK) and cement kiln dust (CKD) was respectively sampled during the process of A-Test1, A-Test2 and A-Test3, then blending into one sample as A-Test1,2,3-CK and A-Test1,2,3-CKD. The PCDD/Fs and DDT were analyzed for all samples under the A-Test.
2. RM, CKD, CK and flue were sampled under the B-Test0; Flue gas, CK and DDT contaminated soil (DCS) was sampled under the B-Test1, B-Test2 and B-Test3, respectively; the (CKD) was sampled during the process of B-Test1, B-Test2 and B-Test3, then blending into one sample as B-Test1,2,3-CKD. The PCDD/Fs, DDT and HCB were analyzed for all samples under the B-Test.

Both A and B kiln system have similar technical outline and the sampling points are indicated in the *Figure 3*. Flue gas was sampled at location of S1 in main stack, cement kiln dust (CKD) was sampled at the hopper of the bag filter in plant A and in the ESP of plant B (S2); raw meal (RM) was sampled at the raw meal homogenizing silo (S4); the DDT powder and contaminated soil was sampled at the S3; and cement clinker was sampled from the conveyer belt after the grate cooler at S5.

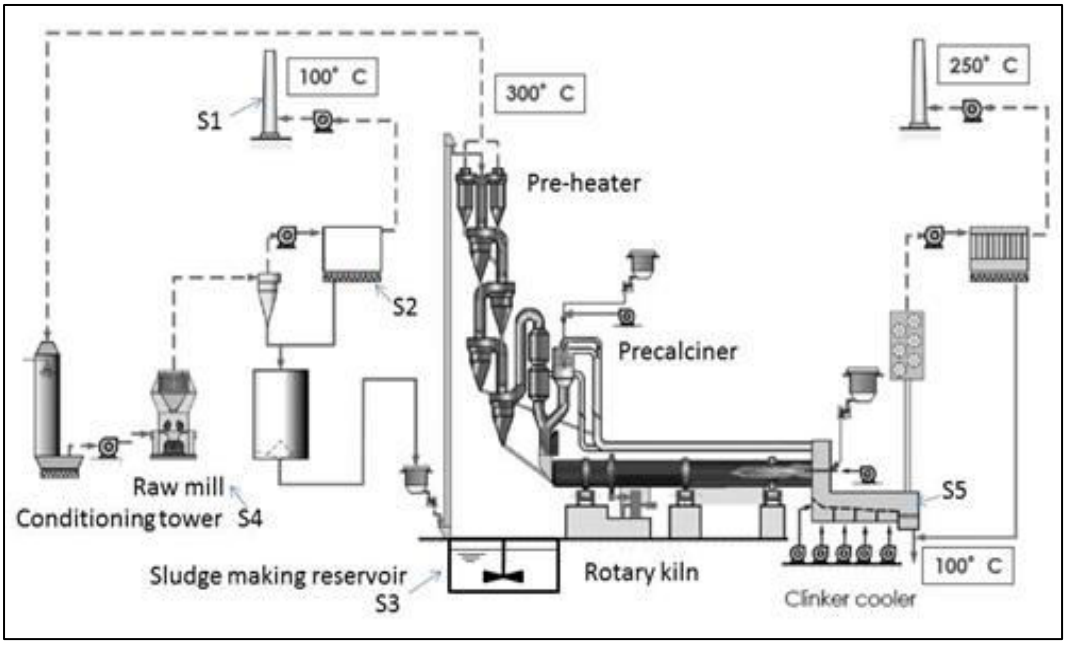


Figure 3: Dry process cement kiln with preheater and precalciner (sampling points indicated)

DDT Emissions in flue gas and clinker

Figure 4 shows the DDT concentration in flue gas when feeding the DDT powder in kiln A and DDT contaminated soil in kiln B. The DDT concentrations were 14.8 ng/Nm^3 in the baseline blank test (no DDT-feeding). In the test burn with DDT powder the levels increased to 38.8 ng/Nm^3 (A-Test 1) and 42.1 ng/Nm^3 (A-Test 2) and declined in the third test to 9.2 ng/Nm^3 (A-Test 3) when feeding 1 ton DDT powder/h in all three tests.

For the test burn of DDT contaminated soil (DCS), the DDT concentrations were 7.4 ng/Nm^3 in the baseline blank test (no DDT-feeding); increasing to 97.6 ng/Nm^3 (B-Test 1), then declining to 20.6 ng/Nm^3 (B-Test 2), then increasing to 43.7 ng/Nm^3 (B-Test 3), done when feeding 0.833 ton DDT-contaminated soil/h.

DDT was identified and quantified in the flue gas under baseline conditions, i.e. when not feeding DDT in both plants. It can also be observed that the concentration of DDT in flue gas increases when both kilns are feeding DDT powder and contaminated soil. It may indicate that DDT is not completely destroyed and circulate from CKD to raw meal.

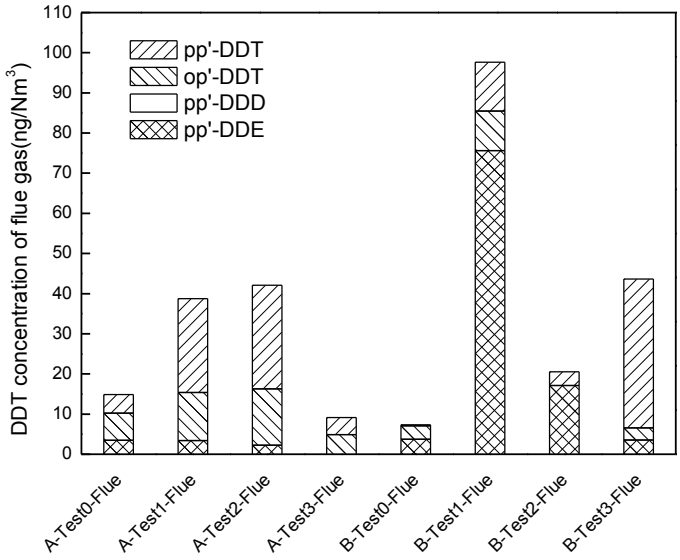


Figure 4: DDT Concentrations in the flue gas from cement kilns A and B

In the test burn with DDT contaminated soil in plant B, DDT was detected in cement clinker in the range of 0.21 to 1.32 ng/g and in cement kiln dust at 89.2 ng/g (B-Test1,2,3-CKD). In plant B DDT was also detected in raw meal at 7.27 ng/g. Furthermore, DDT was detected in cement kiln dust at surprisingly high concentration in the baseline condition (60.56 ng/g) similar to the test run demonstrating a memory effect from DDT destruction activities before. Since both kilns had been disposing large quantities of DDT/POPs-wastes prior to the test burn, this caused some accumulation and build-up of DDT in the system.

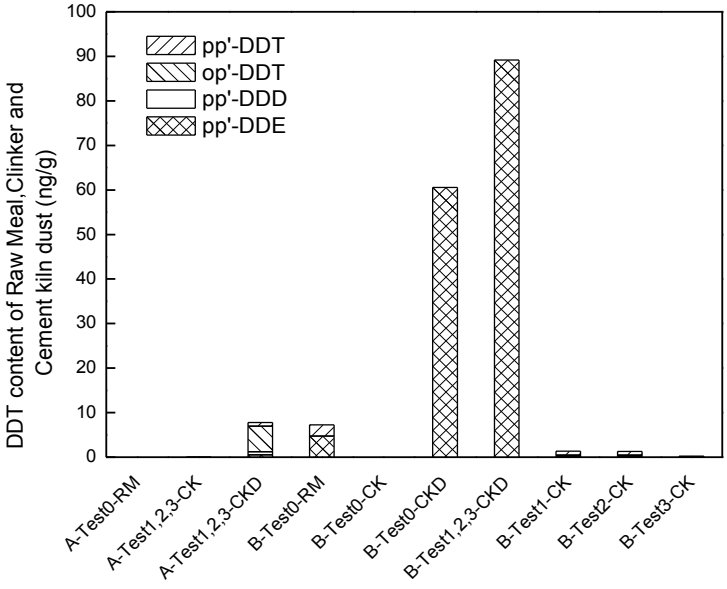


Figure 5: DDT content of in raw meal, clinker and cement kiln dust

Conclusion for destruction efficiency of DDT waste and PCDD/F and HCB levels

The test burns with DDT powder and DDT contaminated soil fed into the flue gas chamber at the cement kiln inlet in two modern preheater/precalciner cement kiln systems showed that the DDT were destroyed to a high degree but that the calculated destruction efficiency did not always reach the demanding Basel Convention criteria. The DE and DRE was 99.99997% and 99.99999% respectively when feeding DDT powder to kiln A. While the DE and DRE was in range of 99.9889–99.9991% and 99.9983–99.9997% respectively when feeding DDT-contaminated soil to kiln B. The lower calculated destruction efficiency when feeding soil contaminated with DDT is likely the memory effect from former DDT destruction which has a larger impact on DE/DRE of DDT in the soil experiments due to the lower overall feed of DDT in the soil experiments.

This study indicates that feeding of DDT and POPs-wastes at the kiln inlet with lower temperature (950 to 1150°C) of the cement kiln system can result in sufficient destruction efficiency of DDT. The long-term destruction over weeks and months result in some DDT accumulation in the system, which subsequently lead to emissions over a longer period. The levels observed in the current projects were low and the concentrations at the chimney were much below TDI if a person would respire the stack emission continuously. However, the release indicates that there is some risk of release of non-destroyed POPs. Therefore, the destruction efficiency also in other projects need also to be critically assessed and observed when POPs waste is fed at the kiln inlet.

The current project has shown that POPs waste can be fed at kiln inlet for a BAT kiln with sufficient temperature and residence time at this position. A thorough control and monitoring of POPs destruction projects e.g. by long-term sampling is recommended for projects (Reinmann et al. 2010).

The emission of PCDD/Fs in flue gas varied from 0.0019 to 0.0171 ng I-TEQ/Nm^3, in compliance with Chinese, U.S. EPA and European Union regulation of 0.1 ng TEQ/m^3. The PCDD/F emission factor for flue gas varied from 0.0137 to 0.0281 µg I-TEQ/tonne clinker and were lower compared to the UNEP toolkit for BAT kiln 0.05 µg I-TEQ/t. The emission of HCB of flue gas varied from 0.0064 to 0.0404 µg/Nm^3, and the subsequent emission factor varied 17.32 to 109.34 µg/t clinker.

The feeding of DDT powder and contaminated soil resulted in a chlorine input to the kiln system of 0.053 t and 0.002 t, equivalent to 0.013% and 0.0007% of the total throughput of the raw meal respectively. The project observed that this chlorine input to the kiln did not result in any clogging in the kiln.

2. Thermal desorption and high temperature destruction of POPs pesticides

Thermal desorption and high temperature destruction of POPs pesticides contaminated soils: Background on thermal desorption technology

Thermal Desorption is listed in the Secretariat of the Basel Convention's (SBC) updated general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs) (hereinafter referred to as 'TGs') under the following section:

IV. Guidance on environmentally sound management (ESM)

G. Environmentally sound disposal

2. Destruction and irreversible transformation methods

(j) Thermal Desorption

Thermal desorption is a remediation technology that utilizes heat to increase the volatility of contaminants such that they can be removed (separated) from the solid matrix (typically soil, sediments or sludge). Thermal desorption has not been used for large remediation of POPs pesticide contaminated soils in China. In the system used in this destruction project, the flue gas treatment included a post combustion system directly destroying the desorbed POPs/pollutants.

Description of the applied thermal desorption process

The POPs polluted soil was excavated and transported to the pre-treatment area. The pre-treatment includes crushing, screening, desiccation and magnetic separating to have a relative homogeneous soil material with particle size of less than 50 mm to facilitate the following desorption process. The process scheme of the thermal desorption is shown in Figure 6 and a picture of the facility is show in Figure 7. The soil is transported by a conveyor belt into the thermal desorption equipment consisting of a rotary kiln. The rotary kiln is operated in the temperature window of 300 to 325 ℃ to facilitate the thermal desorption and volatilization of POPs (here DDTs and HCHs pesticides) and other (semi)volatile pollutants from the soil. The aim is to remove pollutants below a limit defined by soil standards or other limits considered by a project (

Table **3**). The thermal desorption equipment is controlled by a suction and ventilating system resulting in a negative pressure condition to prevent the release of POPs or other pollutants to the environment. The off gas containing the evaporated POPs is treated in an air pollution control device (APCD) with a cyclone dust collector, a high temperature oxidation chamber (operation temperature of 1,200 ℃), a quench tower, a chamber with a bag filter for further dust removal and an acid gas scrubbing tower before it is emitted via the chimney (Figure 6).

After the thermal treatment, the soil is conveyed to the soil mixer from the thermal desorption rotary kiln exit. The temperature is quenched by the addition of water, then conveyed by the discharge system to the material area for storage. There the treated soil is transferred to the storage yard to be inspected, and directly backfilled on the site after meeting the requirement. In respect to air emissions, it is required that the concentration of the released pollutants via chimney into the atmosphere are lower than the limited value of the respective emission standards.

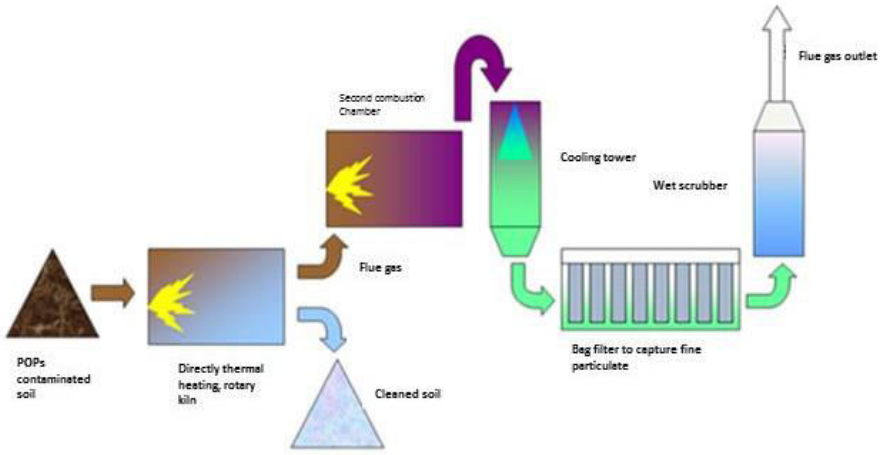


Figure 6: Flow sheet of the direct thermal desorption facility used for soil decontamination

Figure 7: Thermal desorption and high temperature destruction unit at soil treatment site

Evaluation of the thermal desorption test and conclusion

The sampling evaluation on the soil before the thermal desorption disposal, soil after the thermal desorption disposal, stack gas and air in the plant of the Thermal Desorption Disposal Project shows that the destruction efficiency and treatment for the POPs polluted soil by the thermal desorption equipment were below the standards (see Table 4). Specific conclusions are as follows:

(1) POPs in the soil after the thermal desorption treatment, including α-HCH, β-HCH, γ-HCH, DDD, DDE and DDT, were below detection limit (0.1 mg/kg) and therefore considerably lower than target values for remediation;

(2) Through the thermal desorption and destruction, the destruction removal efficiency of the POPs pesticides from the polluted soil was approx. 99.4%;

(3) The relevant evaluation parameter of the thermal desorption unit for the stack gas is to reach the emission gas standards in the Pollution Control Standard for Hazardous Wastes Incineration of 0.5 ng TEQ/Nm^3 (GB18484-2001). The discharge concentration of PCDD/F was even lower than 0.1 ng-TEQ/Nm^3.

(4) The relevant indexes of the air in the plant have met the limited value of the emission specified in the *Comprehensive Emission Standard of Air Pollutants* (GB16297-1996).

Table 3: POPs pesticide target values for soil after treatment

	Test Index	Standard limit	Reference standard
Soil after treatment	α-hexachlorocyclohexane	0.2 mg/kg	Target value for recovery of soil
	β-hexachlorocyclohexane	0.2 mg/kg	
	γ-hexachlorocyclohexane	0.3 mg/kg	
	DDD	2 mg.kg	
	DDE	1 mg/kg	
	DDT	1 mg/kg	

3. Treatment of fly ash from municipal waste incinerators in cement kiln

Background and international status of treating fly ashes in cement kiln

Fly ash from municipal solid waste incinerators (MSWI-FA) containing heavy metals and PCDD/Fs is a growing hazardous waste with potential to generate contaminated sites if not properly managed. On the other hand, some elements and compounds contained in MSWI-FA are beneficial for the cement process while other could have negative effect for cement clinker production and concrete use. The beneficial elements which can be used as raw material in cement production include CaO, SiO_2, Al_2O_3, and Fe_2O_3, and typically accounts for less than 50% of the composition of fly ash. The problematic substances with negative impacts on the process or the environment are chloride, Na and K salts, and toxic trace heavy metals (HM) such as Hg, Cd, Pb, As, Cr, and Tl. Large amounts of sodium chloride (NaCl) and potassium chloride (KCl) make the concrete porous and decrease its strength. Furthermore, the deposition of chloride compounds on ducts and induction fans may cause corrosion and clogging in the cement kiln system.

The water washing pretreatment and co-processing technology is used to produce ordinary cement clinker in which part of the raw material is substituted with dechlorinated MSWI-FA. There are two steps to the technology. The first step involves a water-washing pre-treatment to remove alkali chlorides such as NaCl, KCl, and $CaCl_2$, other soluble salts, and the amphoteric HM in the fly ash, such as Pb and Zn. The HMs are precipitated from washing effluents by reacting with CO_2 or other chemicals and then are reintroduced and mixed with washed MSWI-FA, ready to be fed into the cement kiln. The second step involves co-processing by feeding the dechlorinated MSWI-FA into the flue gas chamber at the kiln inlet to produce ordinary clinker.

Previous studies of the effects of co-processing MSWI-FA to clinker have reported that the compression strength and setting time of the clinker produced from MSWI-FA were similar to those of normal clinker and have concluded that the quality might satisfy the requirements for general use. The distribution of HMs and PCDD/Fs in the water washing and co-processing method and the

impacts of pre-treatment on the destruction of PCDD/Fs and transfer of HMs into cement clinker were examined in this project.

Treatment of MSWI fly ashes and destruction of PCDD/F in cement kiln

The project objective and requirement was to treat at least 1000 t fly ashes in a cement kiln to show the destruction capacity for PCDD/Fs and to assess the overall fate of pollutants. Furthermore, due to the relevance of heavy metals (HMs) and their fate, in this study in addition to PCDD/F also the fate of toxic HMs were assessed. For the assessment of PCDD/F and heavy metals, the input (original MSWI-FA(FA), coal, and raw meal (RM)) (RM refers to a mixture of raw materials as calcareous, clay material and a small amount of correction materials according to the proportion, grinding to certain fineness), intermediate (washed MSWI-FA(WFA), washing water, HM sludge, dried-washed MSWI-FA(DWFA), and salt), and releases and output materials (clinker (CK), cement kiln dust (CKD) and flue gas) produced during pre-treatment and co-processing in a cement kiln, were systematically measured.

Characterization of MSWI-FA and pre-treated MSWI-FA

MSWI-FA from a municipal solid waste incinerator with grate-based technology and a daily disposal capacity of 1000 tons was used in this field study. The chemical compositions of the original and pretreated MSWI-FAs were analyzed, as shown in Table 4. The major beneficial components of the original fly ash (FA), which accounted for 49.52% of the total, were CaO, SiO_2, Fe_2O_3, and Al_2O_3, while Cl, Na, and K accounted for 20.32% of the total composition. After water washing and drying process, the major useful components of the dried washed fly ash (DWFA) accounted for 65.19%, and the detrimental components accounted for 2.36%, of the total content.

Table 4: Composition of the FA, WFA, and DWFA

Compositions	FA	WFA	DWFA	Salt
Moisture(%)	6.63	37.77	0.72	0.66
LoI(%)	23.00	57.63	23.45	5.84
Ash(%)	79.12	42.34	76.99	95.68
Cl(%)	14.47	0.50	1.04	59.91
Na(%)	2.46	0.32	0.82	33.58
K(%)	3.32	0.21	0.5	0.37
SO3(%)	4.64	1.80	3.92	0.11
Al2O3(%)	3.64	2.36	3.88	--
Fe2O3(%)	1.19	0.89	1.2	--
MgO(%)	3.06	1.98	3.19	--
CaO(%)	34.87	29.25	48.84	--
SiO2(%)	9.82	6.60	11.27	--

1. -- No detectable; 2. LOI and Ash are given in dry-basis, and the other variables are given in wet basis

The washing pre-treatment and co-processing system

The system consists of a pre-treatment facility and a preheating–precalcining cement kiln. The plant is equipped with state-of-the-art air pollution control devices, and has a daily clinker production capacity of 2700 t. The pretreatment is designed to remove the NaCl and KCl dissolved salts without extracting the dissolvable HMs contained in the MSWI-FA. The pretreatment process and the cement kiln system are shown in Figure 8.

The process involves three rounds of washing-dewatering to maximize the removal of soluble salts from the FA. After the washing process, the HMs dissolved in washing water are precipitated in the chemical depositing tank, and the clean salt solution on the surface goes through the mechanical vapour recompression (MVR) tower, in which the industrial salt is crystalized and the condensate water is recirculated into the washing tank. The deposited HM sludge is pumped into the 3rd washing tank, and then join with washed FA in the 3rd mechanical drying process to obtain WFA. The WFA is further dried by hot air from the clinker cooler to form DWFA. The DWFA is stored in a silo until it is fed into the flue gas chamber at the inlet of the rotary kiln.

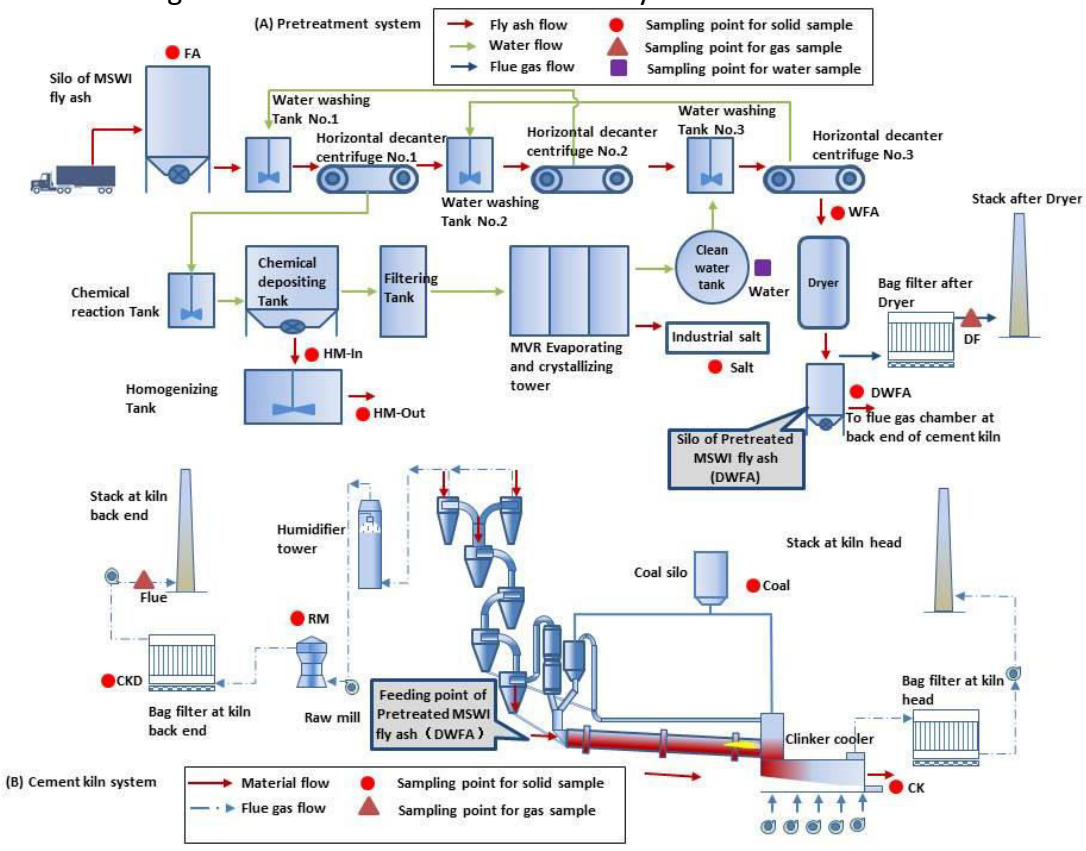


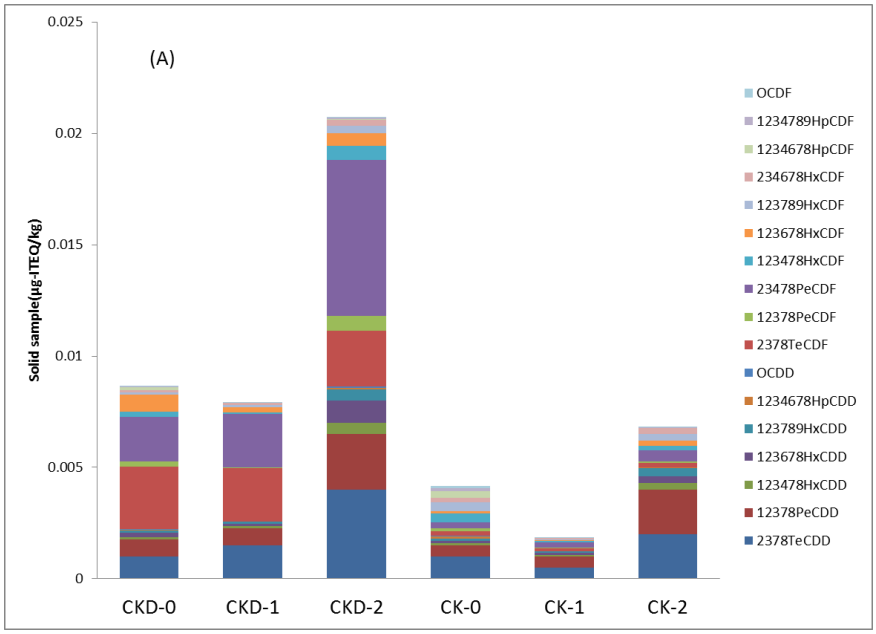
Figure 8: Sampling points in the pre-treatment process and in the cement kiln system

PCDD/F distribution in the sintering processes in the cement kiln

Almost all PCDD/F are transferred to the dried fly ash with minor amount of PCDD/F in the washing water (recirculated) and the salt.

Distribution of PCDD/Fs during the co-processing phase

As shown in Figure 9 (A), the PCDD/F contents of CK and CKD ranged from 0.0079 to 0.021 µg-TEQ/kg and from 0.0018 to 0.0068 µg-TEQ/kg, respectively; these concentrations are within the normal concentration range for PCDD/Fs in CK and CKD during normal cement production without waste co-processing. Figure 9 (B) shows that the PCDD/F concentrations of flue gas under working conditions without co-processing of fly ash ranged from 0.022 to 0.039 ng-TEQ/Nm^3, while the concentrations during co-processing ranged from 0.01 to 0.031 ng-TEQ/Nm^3, which indicates that the co-processing of fly ash did not impact negatively on the formation of PCDD/Fs. As outlined in the pollution control standards, the national standard for PCDD/F emissions in flue gas during waste co-processing in a cement kiln is 0.1 TEQ/Nm^3 (Ministry of Environmental Protection, P.R. China, 2013).



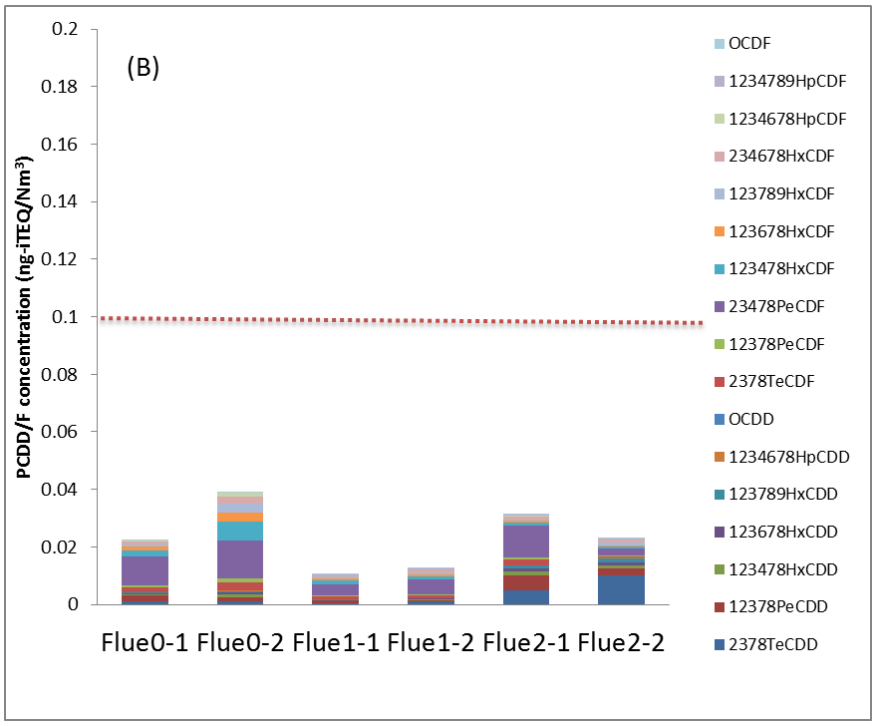


Figure 9: (A) PCDD/F contents in solid samples, (B) PCDD/F level in flue gas in cement kiln co-processing system

PCDD/F mass balance during pretreatment and co-processing in the cement kiln

As shown in Figure 10 , the PCDD/F mass balance can be separated into pretreatment and co-processing sections. For the pretreatment, the input of 2562 µg-TEQ/h, calculated from the flow of MSWI fly ash, is almost the same as the output of 2655 µg-TEQ/h, calculated from the flow of DWFA, DF, and salt. For the co-processing, the total input of 2838 µg-TEQ/h was calculated from the flow of pretreated MSWI fly ash, coal, and raw meal, and the total output of 490 µg-TEQ/h was calculated from the flow of flue gas and CK; the PCDD/Fs decreased by 82.7% in the co-processing section, which, when the overall reduction during the pretreatment and co-processing was considered, equated to a decrease of 82.6%. Ideally, the PCDD/Fs in the MSWI fly ash are destroyed by the high temperature atmosphere during the co-processing in the cement kiln.

Accounting for between 50% and 70%, PCDDs dominated in the CK, with 1,2,3,7,8-PeCDD and 2,3,7,8-TeCDD as the dominant TEQ-contributing congeners. PCDFs dominated in the CDK, accounting there for between 58% and 74%, were dominated by the 2,3,4,7,8-PeCDF, 2,3,7,8-TeCDF, and 2,3,7,8-TeCDD congeners. The rapid cooling of the clinker from the CK may have prevented the formation of PCDD/Fs, while the particulate output from the preheater that passes through the cooler region, the raw meal, and the bag filter, may facilitate further formation of new PCDFs.

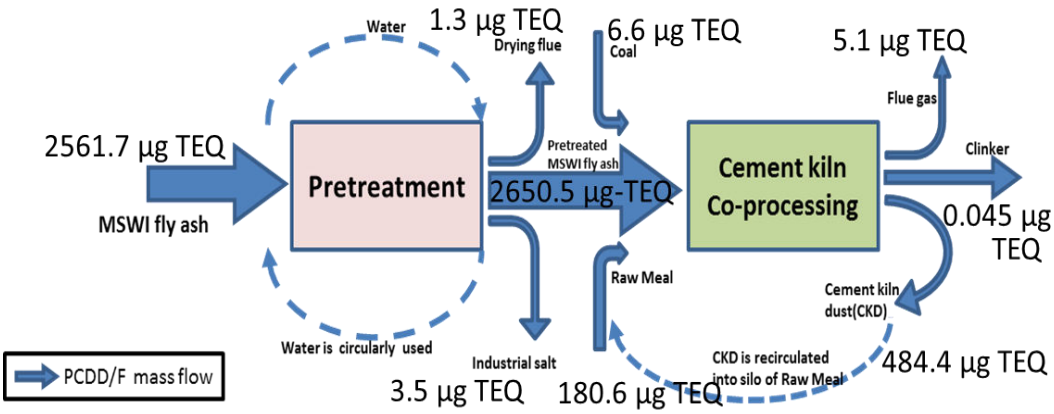


Figure 10: PCDD/F mass balance during pre-treatment and co-processing in the cement kiln

Behaviour of heavy metals in the cement kiln

A) Heavy metal emissions from stack gas

We compared the concentration of individual HM and the total HM in this study with those from other studies (Table 5). Under the test conditions, the Hg concentration of test 0 with no DWFA input was 28.6 µg Nm^{-3} but then increased to 61.95 and 35.40 µg Nm^{-3} in tests 1 and 2, respectively. The decrease in the Hg concentration in test 2 may reflect the reduced feeding rate of DWFA, as suggested by the results of tests 1 and 2. The Hg concentration in flue gas from test 1 was higher than the Chinese national limit of 50 µg Nm^{-3}.

As outlined in the Chinese standards for co-processing of solid wastes in cement kilns (Ministry of Environmental Protection, P.R. China,2013), Tl, Cd, Pb and As are classified as semi-volatile HM, and their total concentration should be less than 1000 µg Nm^{-3}. The results in our study were 3 orders of magnitude lower than the limit. Metals such as Be, Cr, Sn, Sb, Cu, Co, Mn, Ni, and V are classified as low-volatility HMs, for which the threshold for the whole group is 500 µg Nm^{-3}. The measured concentrations of low-volatility HMs were much lower than the legal threshold.

Of the HMs, the concentrations of Hg, Cr, Mn, Ni, and Zn were relatively high in stack effluent, but there were no noticeable impacts from these metals under baseline conditions and during the FA co-processing. The concentrations of the other metals were either low or below the levels of detection.

Table 5: Heavy metal concentrations in stack gas

Metal (µgNm^{-3})	Flue-0	Flue-1	Flue-2	S.Zemba et al. (2011)	J.A. Conesa et al.(2008)
Hg	28.60(4.2)	61.95(8.6)	35.40(1.1)	0.2-27	4.0-25
Tl	0.03(0.01)	0.06(0.002)	1.06(0.35)	0.12-2.8	0.09-1.2
Cd	0.04(0.01)	0.03(0.02)	ND	0.1-37	0.02-0.3
Pb	0.72(0.01)	2.09(1.34)	ND	0.3-88	0.65-50.4
As	0.28(0.03)	0.17(0.02)	4.50(3.82)	0.2-4.1	0.9-3.7
Be	ND	ND	ND		
Cr	6.12(1.2)	12.38(5.03)	7.85(2.15)	0.4-83	0.51-3.1
Sb	0.11(0.01)	0.24(0.15)	0.07(0.05)	0.33-3.1	0.3-1.7
Cu	0.35(0.14)	1.16(0.91)	0.27(0.18)	0.4-37	1.65-19.6
Co	0.12(0.06)	0.18(0.05)	0.03(0.01)	0.1-19	0.3-3.4
Mn	2.16(0.01)	4.3(0.72)	4.50(0.05)	0.1-210	4.3-85.46
Ni	4.03(1.83)	4.23(0.95)	0.78(0.21)	0.3-44	1.8-4.5
V	0.17(0.06)	0.42(0.02)	8.75(2.25)	0.2-30	1.6-6.2
Zn	1.30(0.30)	5.99(4.82)	2.55(0.75)		0.01-329.63
Mo	0.24(0.07)	0.184(0.06)	0.25(0.15)		
Ba	ND	ND	ND		
(Tl+Cd+Pb+As)	1.07(0.03)	2.82(1.6)	5.34(4.16)	1000	
(Be+Cr+Sn+Sb +Cu+Co+Mn +Ni+V)	13.05(3.27)	22.9(7.8)	19.21(4.44)	500	

Conclusions on fly ash treatment in cement kilns

Co-processing of FA did not influence on the release of PCDD/Fs from the cement kiln; baseline and co-processing values ranged from 0.022 to 0.039 ng-TEQ/Nm^3, and from 0.01 to 0.031 ng-TEQ/Nm^3, respectively. The total destruction efficiency for PCDD/Fs in MSWI fly was 82.6% considering PCDD/F in the process (flue gas, CK and CKD). The destruction efficiency is not higher since the cement kiln also has an own PCDD/F formation potential. Since the PCDD/F did not increase, the actual destruction efficiency is higher and rather close to 100%. Stack emission of Hg seems to correlate with feeding rate of MSWI fly ash. However, a considerable amount of Hg also comes from the coal and raw meal. Further assessment is necessary and verification studies need to be carried out in other cement plants in particular also to the Hg emission limit to air.

Co-processing of DWFA had no observable impact on heavy metal content of clinker with the exception of Cd, Pb and Sb (which came mainly from FA). Overall, this technology seems to be an environmentally sound option for the disposal of MSWI-FA if the heavy metal impact is appropriately assessed and controlled.

4. Sintering of fly ash for production of base building materials

Background, objective and description of the process

Two sintering lines were built by Tianjin Eman Environmental Technology Co., Ltd. For demonstration of production of Base Building Materials by sintering of waste incineration fly ash at high temperature. During the development of the process 14 patents were submitted.

The output of the tests provided the basis for evaluation of technical performance for selection of incineration fly ash treatment enterprises to develop the fly ash treatment technical demonstration work for the "GEF-China POPs Waste Environment Harmless Management and Treatment Project".

The production line of base building materials by sintering fly ash from municipal waste incineration plants at high temperature is described in Figure 11. The facility has two rotary kiln lines for fly ash treatment. Each line with a capacity of approx. 140 t/day. The capacity of treatment and utilization of fly ash is up to 100,000 t/year. The proportion of fly ash to the materials in the kiln is about 60% (see Table 6). Currently the Tianjin city generates approx. 80,000 t of fly ash and therefore the process can take all ashes from the waste incinerators of Tianjin city. Fly ash is introduced to a rotary kiln at 850°C and then further heated up to 1250°C. At this temperature fly ash has a high catalytic destruction potential for PCDD/F and Dioxins are largely destroyed at this high temperature. Fly as with chlorides are evaporated at this temperature and the ash is sintered together with auxiliary materials added (see Table 6). The kiln is currently heating by coal burner (similar to cement kilns) but is expected to be changed to natural gas.

The intended product use includes e.g.

- Materials in road and space construction (breathing layer under the top layer
- Coverings of landfill
- Bricks – but rather to fill bricks with the pebbles

The objective of this technical performance evaluation is to assess the treatment effect of fly ash from waste incineration and the prevention effect of secondary pollution through production of base building materials by sintering at high temperature, to specify the specific indexes, such as dioxin decomposition removal rate, heavy metal curing effect, pollutant emissions, quality influence of base building materials.

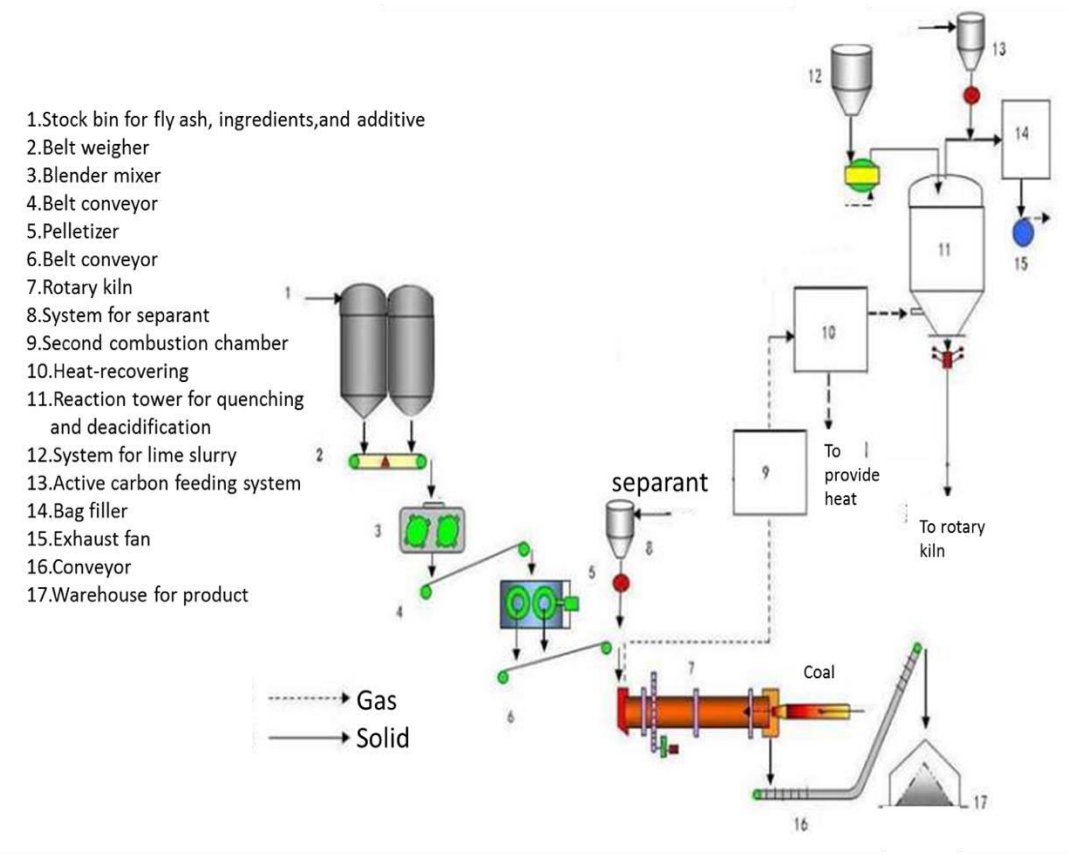


Figure 11: Process schematic diagram of preparation of base building materials by sintering the incineration fly ash at high temperature

Assessment and certification of the fly ash sintering process

The sintering facility was tested twice for performance and for PCDD/F and other releases in February and July 2017. Several national policies (5) and standards (4) were relevant for the assessment of the performance. The test conditions of fly ash sintering process are described in Table 6. The test were performed under full operation of the facility with 135 to 154 t total feed consisting of fly ash (84 and 96 t), auxiliary materials (42 and 48 t) and raw coal (8.9 and 10.3 t) (Table 6).

Table 6: Test working conditions

Operating data	**First test (24.02.2017)**	**Second test (24.07.2017)**
Raw coal feeding quantity (t/d)	8.9	10.3
Fly ash feeding quantity (t/d)	84	96
Auxiliary materials (t/d)	42	48
Total feeding quantity (t/d)	134.9	154.3

Operating data	First test (24.02.2017)	Second test (24.07.2017)
Concentrated secondary fly ash generation quantity (t/d)	12	14
Base building material output (t/d)	101.2	114
Flue gas exhaust quantity (Nm^3/h)	58600	41200

Table 7: Analysis of heavy metals of raw materials (mg/kg)

Analyzed item	Original fly ash		Auxiliary materials	Braise
	Heavy metal leaching	Heavy metal content	Heavy metal content	Heavy metal content
As	0.0016	24.9	0.29	0.09
Pb	0.0085	566	ND	1.47
Cd	0.0009	75.4	ND	0.56
Cr	0.01	64.6	9.41	14.14
Cu	0.082	946	17.09	20
Ni	0.01	55	6.8	8.85
Zn	0.78	4900	196.9	30.98
Mn	0.02	652	499	198.9
Cr6+	0.004	2	NA	NA
Hg	0.0001	7.6	NA	NA
Be	0.005	1.27	NA	NA
Ba	65.2	2050	NA	NA
Ag	0.0002	4.4	NA	NA
Se	0.0026	2.26	NA	NA

Leaching of heavy metal from base construction products

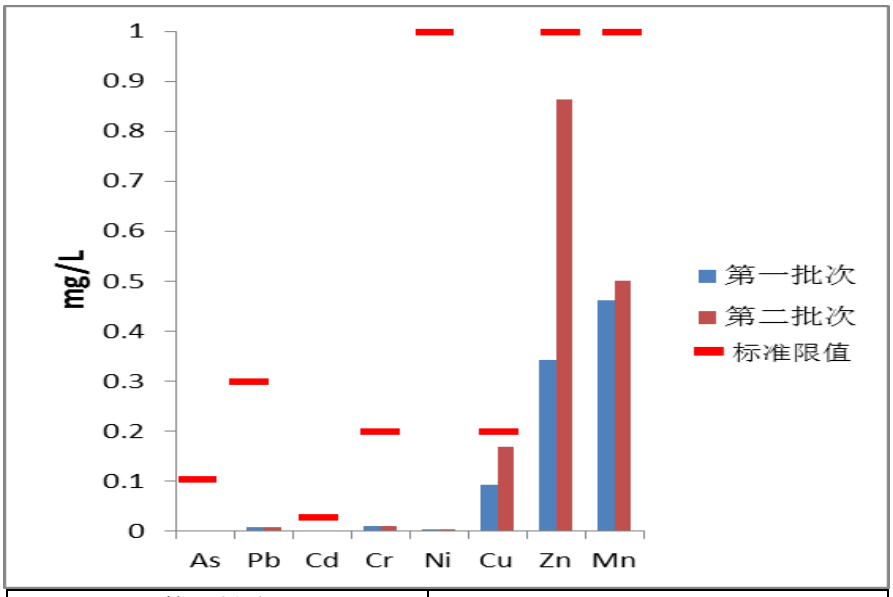
In the thermal treatment of fly ash during high temperature sintering to prepare building material and base material, some heavy metals are immobilized in the sintered body and the leaching has reduced., Some of them volatilizes in gaseous form and are adsorbed in the secondary fly ash in the bag-filter. The technical performance evaluation aims at testing the leaching toxicity of the heavy metal in the building material and base material products. The result of it is as shown in the Table 8 and Table 9. According to Technical specification of solid waste disposal for cement kiln (GB30760-2014), the limiting value of leachable heavy metal of cement clinker is: As—0.1 mg/L; Pb—0.3 mg/L; Cd—0.03 mg/L; Cr—0.2 mg/L; Cu—1.0 mg/L; Ni—0.2 mg/L; Zn—1.0 mg/L; Mn—1.0 mg/L. It can be seen

from Table 9 and Figure 12 that the leaching toxicity of the heavy metal of building material and base material products tested met the current Chinese standard.

While this qualifies to use the material for construction, it is stressed that the material still contain heavy metals where the long-term fate should be considered.

Table 8: Leaching concentration of heavy metals from base building material (mg/L)

Heavy metal type	The first batch	The second batch	Reference standards	Standard limit
As	0.0005	0.0005	Technical Specifications for Solid Waste Treatment with Coordination of Cement Kiln (GB30760-2014)	0.1
Pb	0.009	0.009		0.3
Cd	0.001	0.001		0.03
Cr	0.011	0.011		0.2
Cu	0.092	0.169		1
Ni	0.003	0.003		0.2
Zn	0.342	0.864		1
Mn	0.462	0.5		1



第一批次	First batch
第二批次	Second batch
标准限值	Standard limit

Figure 12: Leaching of heavy metal from the base material products compared to standard for building material

PCDD/F emission and destruction of PCDD/Fs (DRE) in the process

(A) Flue gas dioxin compliance

The stack gas contained low PCDD/F levels (0.024 and 0.019 ng TEQ/m^3) (Table 10). Therefore, it was considerably below the emission standard for hazardous waste incinerators (0.5 ng TEQ/m^3) and below the stringent standard for municipal waste incinerators and the Draft for "Hazardous Waste Incineration Pollution Control Standards" (Draft for Comment, October 2014) with a limit of 0.1 ng TEQ/Nm^3. This limit is also considered BAT from Stockholm Convention BAT/BEP guidance (UNEP 2007).

(B) Destruction and Removal Efficiency (DRE)

The PCDD/F data needed for calculation of DRE is shown in Table 10. The PCDD/F in the original fly ash (2.6 ng TEQ/g) were partly destroyed by the sinter process and the sintered material contained only low PCDD/F (0.0017 and 0.0089 ng TEQ/g) while the newly generated minor amount of fly ash from the sinter process contained elevated level (14.0 ng TEQ/g) (Table 10).

DRE is to calculate the difference between amount of dioxin entering into the kiln system and the amount of dioxin released of the kiln system, and divide this difference by the amount of dioxin entering into the kiln system

$$DRE = \frac{Wi - Wo}{Wi} \times 100\%$$

Where:

W_i is the total amountofdioxinsenteringthesystemper unit time, ug/h

W_o is the amount of dioxin that is excluded from the system per unit time, ug/h

Based on the data of PCDD/F output and PCDD/F input (

) the total DRE is 52.2%. In total 30,000 tonnes of fly ashes from MSWI were treated by the sintering process within the project. With the calculated total destruction[7] efficiency of 52.2% in the kiln the total PCDD/PCDF destruction in this process was 40.7 g TEQ.

Table 9: Total dioxin input and output the sintering process in each phase

Matrix	Inputs/outputs	Dioxin	Total dioxin
Raw fly ash	4 t/h	2.6 µg TEQ/kg	10400 ug/h
Excipient	2 t/h	0.017 µg TEQ/kg	34 ug/h
Concentrated	353.33 kg/h	14 µg TEQ/kg	4946.7 ug/h
Kiln exhaust gas	41200 Nm^3/h	0.019 ng TEQ/Nm^3	0.783 µg/h
Building	4.75 t/h	0.0089 µg TEQ/kg	42.275 ug/h

Table 10: Content of dioxin in different phases of the process of production of base building material by incineration fly ash at high temperature

Time / Sample	The first batch	The second batch	Reference standard	Standard limit
Stack gas (ng TEQ/m^3)	0.024	0.019	Pollution Control Standard for Hazardous Wastes Incineration (GB18484-2001)	0.5
Base building materials (ng TEQ/g)	0.0017	0.0089	Risk Screening Guideline Values for Soil Contamination of Development Land (Exposure Draft)	0.094
Concentrated ash (ng TEQ/g)	----	14.0		
Original fly ash (ng TEQ/g)	2.7	2.6		

[7] PCDD/Fs are also unintentionally formed in thermal processes. Therefore the destruction efficiencies are lower compare to the destruction of POPs in a thermal process.

C) Dioxins in base building materials

At present, there are no relevant standards for the indicators of various pollutants in products prepared by incineration fly ash. The limit standards for solid phase dioxin content in China include: "Standards for Pollution Control of Domestic Waste Landfill Sites" (GB 16889-2008), the domestic waste incineration fly ash and medical waste incineration residue should meet the dioxin limit of 3 μg TEQ/kg after treatment; the "Beijing Municipal Waste water Treatment Plant Pollutant Discharge Standard" (GB 18918-2002), the dioxin content is not higher than 0.1 μg TEQ/kg dry sludge (sludge for agricultural use); "Guidelines for screening soil pollution risk of construction land" (three consultation drafts, March 2016), residential sensitive land dioxin (total) not higher than 0.094 μg TEQ/kg, industrial non-sensitive land dioxin total amount) is not higher than 0.33 μgTEQ/kg. The German fertilizer regulation has a general regulatory limit for fertilizer of 0.030 μg TEQ/kg for the sum of PCDD/F and dl-PCB and a maximum limit for the use of fertilizer on grassland for forage production and on arable land with non-tilling soil cultivation of 0.008 μg TEQ/kg for the sum of PCDD/F and dl-PCB.

The levels in the base building materials produced by high-temperature sintering of incineration fly ash were 0.0017 μg TEQ/kg and 0.0089 μg TEQ/kg, respectively. These were below the "Guidelines for Screening Soil Pollution Risk of Construction Land" (three consultation drafts, March 2016) of 0.094 μg TEQ/kg (Table 10) and also below the German limit for fertilizer of 0.030 μg TEQ/kg. The levels in the first test second test 0.0017 μg TEQ/kg even met the stringent limit for fertilizer use on pasture land (0.008 μg TEQ/kg) and the second test (0.0089 μg TEQ/kg) were close to that stringent limit.

5. Development and assessment of technology: Mechanochemical destruction (MCD)

Selection of non-combustion technology

To introduce and demonstrate non-incineration technologies in accordance with the Convention plays an essential role in this GEF project. As a requirement of the project document, FECO and UNIDO organized several technical seminars. International and domestic experts, as well as technique suppliers were invited to give detailed information on non-combustion technologies to evaluate and discuss the choice of technologies and facilities. On February 26, 2013, in the coordination meeting among all three parties, officers from UNIDO and attended experts all agreed to choose the Mechanochemical Destruction (MCD) "Ball Milling" as the targeted technology, to be introduced and demonstrated by building a non-incineration facility.

Mechanochemical Destruction technology is distinct and uncomplicated. MCD works in mild conditions and can degrade POPs thoroughly without the formation

of secondary pollutions. MCD does not require severe conditions such as high temperature or high pressure or hazardous chemicals as reactants. It can realize the reaction between POPs wastes and the regent in sealed mills. The operation is safe and uncomplicated. Besides, the reaction equipment is small and can be moved. Thus, MCD also has the potential capability of in-situ treatment. It is considered to be an environment-friendly technology, which is applicable to the disposal of POPs in wastes and soil.

Japan and New Zealand have achieved the industrial application of MCD. In German, Italy and China, several institutions have conducted research for some time on POPs disposal using MCD. Some companies have developed business cases using MCD for the treatment of POPs wastes including the Radical-Planet Research Institution Japan Ltd. and EDL Company in New Zealand.
In 2009, “The Research and Demonstration of the Treatment Technology of Industrial Wastes Containing Chlorinated Organic Compounds” (Project# 2009AA064001) was listed as one of the key projects in the National High-tech R&D Program (863 Program). In this project, the development of the technologies and facilities concerning with MCD treatment of POPs pesticides from flue gas was listed as an important research part. In 2013, the other key project of the 863 Program, “The Pollution Control Technology of High-Concern Organic Chemicals in the Environment” (Project#2013AA062705), also considered the research and development of MCD technologies and facilities on POPs contaminated soil as one of the most important research topics. Mechanochemical treatment (“Ball milling”) is recognized as a non-combustion POP destruction technology by the Basel Convention, as a good non-thermal candidate for effective and (ICS-UNIDO, 2007; USEPA, 2010).

Use areas of MCD technology and advantages
MCD technology (Ball milling) can be applied to different matrices and pollutants.

- Destruction of pure organic substances (chlorinated, brominated, fluorinated POPs)
- Destruction of other pollutants (PAHs; asbestos)
- Soil remediation
- Synthesis of products possibly from wastes

Development of frontier research and a pilot MCD plant
The GEF project initiated and supported innovative frontier research on MC technology at the Tsinghua University. This research effort lead to more than 25 peer reviewed research articles in scientific journals and a patent. Various POPs were destroyed with high efficiency (>99%) in the studies of the Tsinghua group addressing chlorinated POPs pesticides and also new listed industrial POPs like brominated flame retardants (PBDEs, HBCD) and perfluorinated alkylated substances (Perfluoro octane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA). Furthermore, several of the studies aim not only for the destruction of

POPs but to also produce a degradation product which might be used as a product in industrial processes. Based on the experiences in the laboratory study, the School of Environment, Tsinghua University, developed the multi-stage-series-type, continuous-high-energy, spheroidal-graphite MCD reactor. The volume of the reactor is more than 60 L, with 3 series units for each reactor. The drum ball mill (Figure 13), the primary functional unit of MCD, consists of a horizontal barrel, a hollow shaft and a grinding head. Figure 14 shows the demonstrated equipment: WSM horizontal drum whirligig (WSM Mechanochemical POPs Decomposer , MCD). The multi-level series continuous high energy ball mill machinery chemical reaction device is driven directly by motor and bearing. Material enters the first level ball mill evenly from the mouth containing hollow shaft helical vanes. In the mill, there are three different specifications of the ball medium. The cylinder body rotates to generate centrifugal force, which brings the ball medium to a certain height. And then the ball falls down to produce a heavy blow and grinding effect on the material. After the kibbling in the first hopper, by monolayer partition panel, the material enters the second, which has four different specifications of the ball medium inside to grind material further. In the third hopper cylinder body, the balls with same specification continue to grind material into the same particle size. Then powder is expelled through the discharging mouth, and enters the vibrating screen machine to make classification and finish grinding operation.

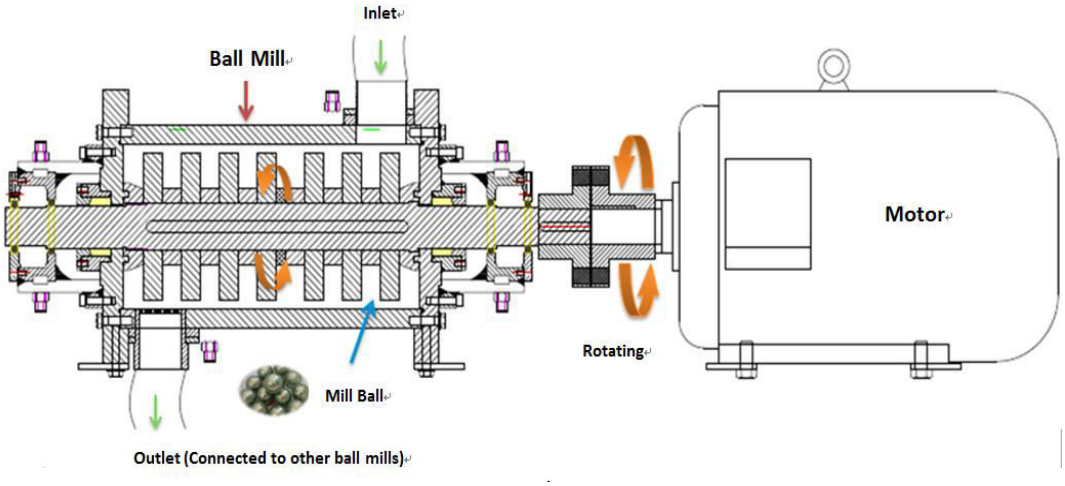


Figure 13: Structure of Ball Mill

Figure 14: WSM Mechanochemical POPs Polluted Soil Decomposer

After optimization of operation and equipment improvement, the optimal process was determined as 60 min disposal time, 18 kg disposal capacity, 20 kg/barrel grinding ball filling amount, 400 r/min running speed. The target of 10 days stability operation to treat 1 t POPs contaminated soil in 10 days was successfully completed. A residence time of 2 hours achieved to >90%, the concentration of 100 mg/kg Dechlorane Plus (DP) could be less than 10 mg/kg after disposal. Due to the relevance of PCDD/F formation in POPs destruction (Weber 2007), the formation and destruction potential of PCDD/Fs was assessed in soils (Lu et al. 2017). Under initial operation conditions of the pilot-scale MCD process PCDD/Fs were formed when major dioxin-precursors (PCBs and PBDEs) were destroyed (Lu et al. 2017). After modification of the system with an efficient cooling system, the PCDD/Fs could effectively prevent the formation. The inhibition of PCDD/F and PBDD/F formation by cooling indicate that the dioxins were formed due to the elevated temperature in the ball milling without cooling and not by the direct mechanochemical effect.

Outlook for further development of the MCD technology

As the prevention action plan of soil contamination in China has been issued, the investment to the industry of soil remediation will be expanded greatly and the demand of technology and device will increase accordingly. Therefore, developed reasonable soil treatment technologies are expected to have a growing market in future. The disposal capacity of the developed pilot scale MCD treatment is limited. If the facility would be operated 24 hours/day, the yearly capacity is still below 80 t/year. According to planning, the disposal capacity will be improved to

a full-scale plant. There are already full-scale MC systems in operation in New Zealand and Russia. For the application of destruction technologies. Prof. Huang from Tsinghua University developed a factsheet according to the Basel Convention criteria and the fact sheet accepted by the evaluation team of Basel Convention/UN.

V. Assessment of Project Results

Following UNIDOs Evaluation Policy, project results are assessed based on their Relevance, Effectiveness, Efficiency and Sustainability and defined in Box 1.

Box 1. Evaluation Criteria Definitions

Relevance The extent to which a development intervention is consistent with beneficiaries' requirements, country needs, global priorities and partners' and donors' policies

Effectiveness The extent to which the development intervention's objectives were achieved, or are expected to be achieved.

Efficiency A measure of how economic resources/inputs (funds, expertise, time, etc.) are converted to results.

Sustainability refers to the likelihood that benefits generated by the program will continue over time. The resilience to risk of the net benefit flows over time.

1. Relevance

Relevance pertains to the extent to which a development intervention is consistent with beneficiaries' requirements, country needs, global priorities and partners' and donors' policies. The project results are highly relevant to China and the Stockholm Convention on Persistent Organic Pollutants (POPs), UNIDO and the GEF.

China's large agricultural sector dependence on agro-chemicals contributed the production of about 574,000 tons of POPs pesticides up to 2009 when production was banned. Although domestic regulations now prohibit POPs pesticides production, historical stockpiles continue to pose significant risks to human health and the environment. Fly ash from municipal waste incinerators is a hazardous waste containing heavy metals (lead, cadmium, mercury) partly in soluble form of chlorides. Furthermore, fly ash contains organic pollutants like polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDFs) and other unintentional POPs and polyaromatic hydrocarbons (PAH) as well as heavy metals (Liu et al., 2015). Fly ash from municipal solid waste incinerators is increasingly generated due to the growing waste incineration capacity in China and globally. In total, four million tons of fly ash is generated each year in China currently largely stabilized and sent to landfills[8].

Table 11: POPs eliminated with the project support

Treatment process	Project requirement	Contribution	Evaluation
Destruction of pesticides in cement kiln	Avoidance of 8.97 g TEQ of PCDD/Fs	3.74 g TEQ	Approx. 43 g TEQ of PCDD/Fs, **exceeded the target almost 5 times**.
Destruction by BAT/BEP hazardous Waste incinerator		1.63 g TEQ	

8 Personal communication from Roland Weber.

Treatment process	Project requirement	Contribution	Evaluation
Thermal desorption from soil		37.7 g TEQ	
Fly ash treated in cement kiln co-processing	Destroy 30.67 g TEQ of PCDD/Fs	66.2	103.3 g TEQ met and **exceeded the target 3 times.**
Fly ash sintering for light weight construction		40.7 g TEQ	

The project helped address these challenges by building China's capacities to address the Article 5 of the Stockholm Convention, which requests that Parties to take measures to reduce releases of unintentionally produced POPs listed in Part I Annex C with the goal of their minimization and eventual elimination when possible. The project helped China in the elimination and disposal of POPs pesticides and associated waste which are also a high priority of the long-term strategy in China's National Implementation Plan (NIP). The project also supported the National Program of Disposal Facilities Construction for Hazardous Wastes and Medical Wastes Treatment by giving special attention to environmental management systems (EMS) and BAT/BEP pertaining to the management of POP's. The project strategy planned activities and expected outcomes contained in the original project design still remain relevant to the institutional, policy, financial and technological conditions in China. The attention given by the project to the treatment of fly ash is particularly relevant and has a wide applicability in China, as fly ash has become the one of biggest sources of solid industrial waste in the country, much of it also generated by municipal solid waste incineration plants which is low in dioxins (He and Qingming 2012) but from hazardous and medical waste incinerators with high dioxin and heavy metal content.

The project results are rated as highly relevant to the GEF, since they directly address the destruction of POPs listed in Part I Annex C of the Stockholm Convention. The results are also highly relevant to UNIDO's pledge since the early 1990s to help countries address problems of toxic waste and meet their commitments to international environmental convention regarding management of POPs.

2. Impact

The assessment of impact refers to the extent to which the project brought about changes in the human condition or in the environment. Changes can be positive or negative, intended or unintended. The project helped reduce risks to human health and the environment by disposing of POPs pesticides and dioxins. These harmful chemicals last a long time and tend to enter the food chain and

accumulate in the fatty tissue of animals and humans. For the large obsolete pesticides legacy in Eastern Europe, the Caucasus and Central Asia (EECCA) countries of ~240,000 t, it has been documented that these pesticides are mainly in unregulated storages without adequate safety control being a huge risk to the environment and human health (Vijgen et al. 2013). The 12th and 13th Forum of the International HCH and Pesticides Association (IHPA) in 2013 and 2015 addressed the health consequences of pesticides and other POPs. Papers presented in the Forum provided evidence of these chemical's high capacity as endocrine disruptors and their links to abnormal concentration of hormones in children, abnormal sexual maturation, development disorders, liver diseases and cancer. Evidence was also provided of the influence of dioxin on sperm quantity (Galimova et al. 2015; Weber et al 2015; Vijgen et al. 2018). A recent study on the pollution of POPs pesticides in Kyrgyzstan, mainly DDT and HCHs (Toichuev and et al 2017a), demonstrated acute detrimental chronic effects on pregnant woman and fetus/new-born (Toichuev and et al 2017b). The situation of the known POPs pesticides stocks in China at the beginning of the project was similar to the situation described for the EECCA region. Some POPs pesticide wastes in China were stored in open-air and simple enclosures, with a relatively high risk of environment contamination and human exposure.

Table 12: Disposal of fly ash and pesticide waste

Item	Expected	Completed
Disposal of pesticide POPs wastes	10,000 t Estimate in the 20014-06 NIP.	6,352 t pesticide POPs (DDT/HCH) were soundly disposed (All POPs pesticides identified in China during implementation). 42000 t soils contaminated by DDT/HCH were soundly disposed. **Over 4 times of the project requirement was achieved.**
Disposal of fly ash	1,000 t	50,000 t and 30,000 t of fly ash were disposed by cement co-processing technology and high temperature sintering technology respectively. **Around 80 times of the project requirement was achieved.**

The challenges in managing fly ash and the associated pollution risk for the food chain were recently demonstrated by a report from the International POPs Elimination Network (IPEN 2017). The urgency of the current and future challenges for fly ash management and disposal in China was also recently described in a peer reviewed article in Environmental Science & Technology (Tang et al 2013).

The project helped China eliminate a larger amount of POPs than expected at project design. As indicated in Table 3, the project document promised to eliminate 8.97 g TEQ of PCDD/Fs from pesticides. At the time of the evaluation, the project reported the elimination of approximately 43 g TEQ of PCDD/Fs, which exceeded five times the target. With respect to fly-ash dioxins, the project document had promised to eliminate 30.67 g TEQ of PCDD/F. During the final evaluation the project reported the elimination of 106.9 g TEQ, which exceeded the target 3 times the amount of PCDD/Fs promised in the project document. Also, as shown in Table 4, the project supported the treatment of four times the expected amount pesticide POPs waste and 80 times the expected fly ash. These higher than expected results were possible because the project successfully engaged the provincial governments in the disposal of POPs pesticides and was able to introduce the technological changes for dioxin elimination at an industrial scale, developments made possible by the policy incentives promoted by the project.

The project document indicated that the project would remove 10.000 t. of POPs pesticides. But during the project implementation the total identified stock/waste was 6,352 t of POPs pesticides and at a former production site additional 42,000 t POPs pesticide contaminated soil. All of which were removed/treated. The known POPs pesticide stockpiles that were removed by the project were mainly distributed in eight provinces or regions including Jiangsu, Hunan, Sichuan, Shandong, Tianjin, Shanxi, Hebei and Liaoning. The removal of this POPs pesticide stockpile in effect also removed exposure and health risk factors for the population in these provinces. The removal of such pesticides reduced risks of contamination for a population that ranged from 30 900 to 1’030 000 people (Table 15). By the end of 2018, when the project finishes the cleanup of the Nantian Chemical plant in Xiangtan, Hunan province, the project will also have reduced risks of POPs pesticide contamination of the Xiangjiang river which supplies drinking water to an four million people living in the city of Changsha.

Table 13: Reduction of risks to human health due to removal of POPs pesticides

Area	Contamination sites	Population (range)
Hubei	73	219000-730000
Hebei province	2	6000-20000
Hunan province	5	15000-50000 + 4000000 (Changsha)
Chongqing city	8	24000-80000
Sichuan	1	3000-10000
Jiangsu	1	3000-10000

Area	Contamination sites	Population (range)
Shanxi	1	3000-10000
Jilin	1	3000-10000
Tibetan	7	21000-70000
Shangdong	1	3000-10000
Tianjin	1	3000-10000
Guangdong	1	3000-10000
Shanghai	1	3000-10000
Total	**103**	**30900-1030000** **+ 4000000** (Changsha)

The health and environmental benefits of fly ash treatment are more difficult to quantify. The alternative to treatment is to dispose of fly ash in sanitary fields mixed with other waste, with little or no precautions. This results in risks in the form of leaking of dioxins and contamination of soil and the water tables. By supporting the capacity to treat 70% of the fly ash generated in the Beijing area and 100% of the waste in the Tainjin area, the project helped to reduce health and environmental risks to 20 million and 1 million people living in these two metropolitan areas. Also, by the shift of treating POPs stockpiles from non-BAT hazardous waste incinerators to cement kilns and to thermal desorption with post-combustion meeting the stringent standard of 0.1 ng TEQ/m^3, PCDD/F releases was avoided compared to the baseline scenario (see Table 13) contributing to this benefit.

Table 14: Delivery of project outputs

	Main tasks	Achieved promised outputs	Exceeded promised Outputs	Total
Objective I	Formulation and revision of policies and standards	10	4	14
Objective II	Capacity building and training	8	4	12
Objective III	Disposal of pesticide POPs wastes	22	6	28
Objective IV	Risk assessment on contaminated sites	7		7
Objective V	Project supervision and assessment	15		15
Total		62	14	76

The evaluation found no evidence of negative impacts of the treatment processes on the environment or on human welfare. An important factor in this regard is that the project introduced EMS and BAT/ BEP to manage the risks to human health and the environment in the process. The project also hired independent laboratories to systematically monitor toxic substances in the air, water and soil in and around project locations to ensure no leaking was taking place during POPs removal, transportation and disposal or while testing and using technologies to treat fly ashes and destroy dioxins. The project also ensured that the local authorities responsible for executing activities informed the local residents of potential risks involved in POPs removal and took the necessary steps to restrict access to areas under treatment.

3. Effectiveness

Effectiveness pertains to the extent to which the development intervention's objectives were achieved or are expected to be achieved. Effectiveness is rated as highly satisfactory. The project met or exceeded all outputs promised at entry. The evaluation team could identify 76 outputs in the logical framework; of these 62 were fully met and 14 were exceeded. Thus, the project exceeded results in 23% of the expected outputs (Table 16). Annex 5 presents the extent to which the project delivered the outputs under each objective specified in the logical framework. The project activities addressed all 17 barriers to the sound management of POPs in China that had been identified during project preparation. Table 17 illustrates some of the main project accomplishments for each of the project objectives, all of which contributed to the conditions necessary for the long-term transformation identified in the theory of change presented earlier in this report. In the process of disposing of POPs pesticides, the project also made major contributions to the establishment of the conditions needed to transform the management of POPs pesticides in China identified in the theory of change presented earlier in this report. The project supported the development of 30 policy instruments that included regulations and standards at the national, provincial, county and city scales. The project also used technological trials to generate evidence to convince decision makers of the feasibility of regulations and standards. The project tested or introduced six technologies to dispose of POPs (Figure 15). Chapter IV of this report describes at length the technologies introduced by the project. The combination of regulatory enhancement, capacity building, and awareness rising provided the incentives for the adoption of the technologies promoted by the project. About 420 tons of POPs waste disposal was supported by the businesses and local government in Tianjin, Chongqing and Jiangsu provinces adhering to the international emission standards that had been promoted by the project and adopted by national regulators.

Table 15: Achievement of project objectives

	Main tasks	Assessment indicator	Achieved Performance
Objective I	Formulation and revision of policies and standards	15 items	30 items. Among them, 3 policy recommendation submitted to MEP.
Objective II	Capacity building and training	1,000 person-times	5600 person-times
Objective III	Disposal of pesticide POPs wastes	10,000 t	6352 t + 42000 t, 43.0 g TEQ PCDD/Fs was reduced from emission.
	Disposal of fly ash	1,000 t	80000 t of fly ash were disposed by cement co-processing and high temperature sintering technology. 106.9 g TEQ PCDD/Fs was destructed.
	Introduction and construction of disposal facilities	Built-up disposal facilities	4 cement kiln co-processing plants were established 1 co-processing cement plant for fly ash disposal was established 1 Sintering plant for fly ash disposal was established 1 set of MCD ball milling facility at pilot scale was established
Objective IV	Risk assessment on contaminated sites	Assessment report	1. A database based on site investigation and risk assessment was developed 2. Two risk assessments were conducted
Objective V	Project supervision and assessment		The annual report and financial audit were conducted in 2010-2017

The project also helped test approaches to develop capacities of provincial, municipal and city governments for effective project management, coordination, promotion of sound management of POPs stockpiles and waste, for the adoption of policy instruments and for enforcement. Information on existences of POPs

pesticides was improved through the development of a waste reporting and registration system that was provisionally established in FECO. The project also contributed to the state of knowledge on POPs management through 10 applied scientific publications.

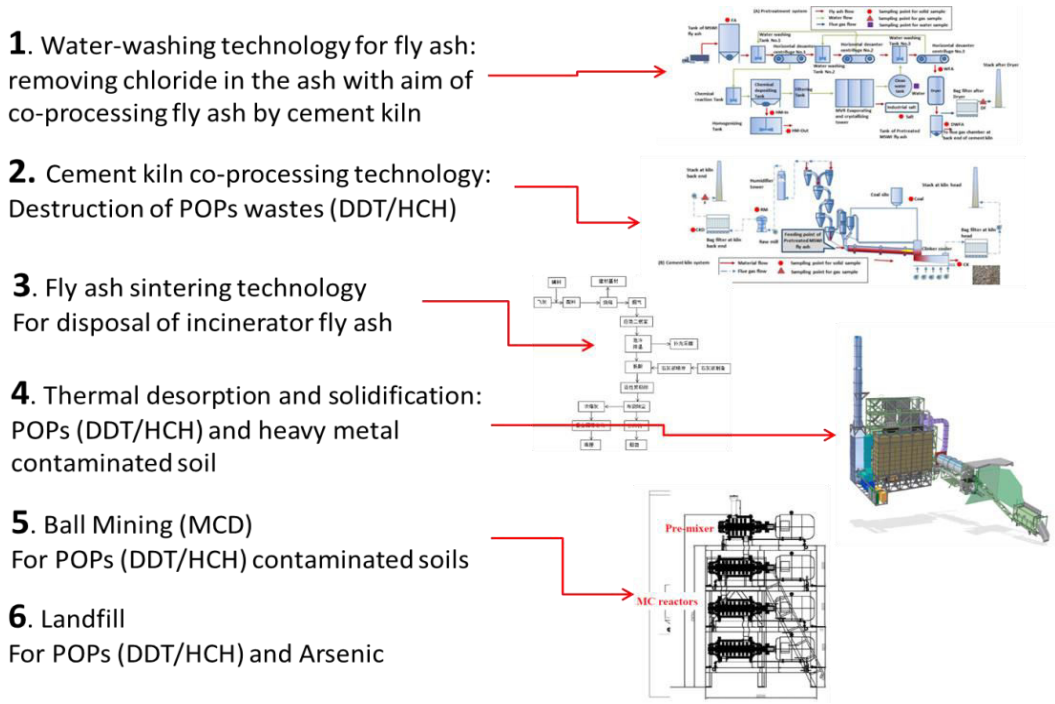


Figure 15: Technologies tested and introduced by the project.

4. Efficiency

Efficiency assesses how economic and other resources and inputs (funds, expertise, time etc.) are converted to results. The project started implementation in April 30, 2009 and is expected to end on December 31, 2018. The project received thee extensions amounting to four years and eight months, for a total duration of the project of eight years and eight months. The average duration of an UNIDO GEF project is six years (GEF 2017). The extensions were needed to address several developments that emerged during implementation. One of such developments pertained to delays in the clean-up of the Nantian Industrial Co in Xiangtan, province of Hunan, one of the biggest DDT factories in China. Prior to initiation of clean-up, the City of Xiangtan had to negotiate the acquisition of the plant. The company had declared bankruptcy two decades before. Workers had placed a lawsuit to secure companies' pension plan, but this lawsuit had not be resolved. It took one year for the city to negotiate an agreement that required the financial support of the central and provincial governments. In this process, the city also negotiated additional financing to carry out the clean-up of sections of the factory that were contaminated with POPs pesticides (DDT, HCH), arsenic

and other heavy metals. This further contributed to the reduction of risks to human health and the environment. Another factor that contributed to delays was the need to repeat three times the tendering process for the selection of companies that participated in the treatment of fly ash and related disposal of dioxins. During the first two tenders, none of the companies that competed met the necessary requirements. During the third tender the project management opted for selecting the companies that were in the best condition, and to assist them to develop the additional capacities needed.

The cost of project execution was also higher than initially expected, calculated at USD 660,000 US as opposed to the USD 475,000 initially budgeted. This cost can be explained in part due to the project extensions. Yet this additional cost is relatively small when considering the extent to which the project exceeded expected results, as presented in tables 3, 4, 5 and 7.

The GEF Score Card (2017) identifies as an indicator of efficiency and effectiveness the co-financing ratio (Project co-financing: GEF financing). For GEF 6 the desirable co-financing ratio is 6:1. The co-financing for this project is 8:1 (79,950,915/9,959,000)9. An analysis of the costs of the treatment of fly ash and disposal of POPs pesticides to the GEF grant indicates that the per-unit costs of disposal were much lower than initially expected. The average disposal costs (to the GEF grant) per ton of fly ash was in the range of USD 160-250 US and of POPs pesticides was in the range of USD 300-400 US and POPs pesticides contaminated soil was in range of USD 70-80 US. The initial expectation for POPs pesticide destruction was USD 642 US. This is much lower than the anticipated cost at entry10. The adoption of an industrial-scale approach and the co-financing contributions from the central and local governments and the participating firms were an important factor that helped stretch the benefits derived from the GEF grant. But these factors aside, the technologies that were tested and adapted by the project were considerably more efficient than alternative technologies, making them more competitive in the market (Table 18).

Table 16: Comparative advantages of key technology used by the project

	Cost of new tech	**Cost of alternative technology**	**Other advantages**
Cement kiln Co-processing	300-400 USD per ton	1000 USD per ton (hazardous waste incinerator)	
Fly ash sintering	200 USD per ton	1500 USD per ton (Vitrification by electric arc	

9 GEF Corporate Score Card October 31, 2017. https://www.thegef.org/sites/default/files/council-meeting-documents/EN_GEF.C.53.Inf_.03_Scorecard.pdf. Consulted on July 19, 2018.

10 The actual project expenses in "Outcome 3: the cost rate of disposal of targeted POPs pesticide waste, contaminated soil and dioxin rich incinerator fly ash were based on actual charge rate by facility owner. The project had originally budgeted 7 063000 USD to treat 1000 t of fly ash and 10000t of POPs pesticides at a cost of 642 USD per t. "

	Cost of new tech	Cost of alternative technology	Other advantages
technology		furnace)	
Ball mining emergency spills	500 USD per ton	Not previously applied to POPs	mobility

Another factor that should be considered when assessing the project's efficiency is the reach of the project. In the case of this project, one important factor in the high levels of accomplishment was its broad reach. The large number of firms, province, and cities the project interacted with could only be achieved with diligence and efficiency in the use of time and resources. The extension of the project was an important factor contributing to its success. The additional time allowed the project management to address the unforeseen developments and to manage risks in ways that prevented downstream problems. Only 15% of GEF projects implemented by different agencies in all over the world reach such levels of accomplishment (GEF IEO 2014).

5. Progress to the broader transformation of POPs management

The previous sections of this report assessed the project's contributions to the conditions necessary to bring transformation to the sound management of POPs in China. This section will address the catalytic effect of the project, including the extent to which the project's innovations have been adopted within or beyond the domains and scales originally targeted. Given the nature of the challenges related to the identification, transportation, storage and disposal of POPs, the complete transformation of the system is not likely to take place during the time span of the project. This mismatch between the project duration and the time necessary to bring about behavioural change at broader scales requires that mechanisms be in place to continue the process adoption after the project ends (Garcia and Zazueta 2015). Three mechanisms frequently used by projects to promote the broader adoption of its innovations are: mainstreaming, replication and scaling- up:

- **Mainstreaming** takes place when information, lessons or specific results supported by the project are incorporated into broader institutional mandates and operations such as laws, policies, regulations and programs. The evaluation found several indications that mainstreaming is taking place. Technological trials, lessons learned and research supported by the project contributed to 30 plans, regulations, standards and guidelines that have been integrated into public administration agencies operating at the national, provincial, city and county levels. Participating

companies and laboratories in 13 provinces and cities have adopted and applied to the management of hazardous waste the protocols and safety procedures introduced by the project.

- **Replication** occurs when the initiatives, technologies or innovations supported by the project are reproduced or adopted at a comparable scale, which can be administrative, geopolitical or ecological, or business scale. The firms that adopted fly ash co-processing and cindering technologies reported that they had taken steps to establish the replication of these technologies. BBMG, one of the biggest cement corporations, had replicated the water washing installation for fly ash processing with a capacity of 40,000 t per year. EMAN was in advanced negotiations with Dingzhou City (population of 1.2 million people) to transfer sintering technology for fly ash processing. The management of EMAN also reported that 10 additional cities had expressed interest in adopting this technology. BBMG and EMAN also reported that they had filed for 40 patents each, an indication that these two companies see technology transfer as a business option.

- **Scaling-up** takes place when the supported initiatives are implemented at a larger scale. These can be administrative, geopolitical, ecological or business scales. Initiatives that are scaled up are often expanded or adapted to accommodate new aspects or concerns relative to the new scales. The project simultaneously addressed barriers and domains at different scales (national, provincial, county), also involving the key stakeholders (government, business, academic). This was an important feature of project design because it led to the systematic establishment of links between the sectors and stakeholders operating at all relevant scales. As a result, the project was able to test and establish legal, regulatory and administrative functions at the different scales. The businesses participating in the project also reported scaling of innovations introduced by the project. BBMG reported that it has started an assessment of its operations to identify the plants in which they can incorporate co-processing. This firm is also considering marketing its knowledge on co-processing to other firms in China and perhaps 20 countries in which the firm has business partners. For this purpose, they have developed four possible business models for technology transfer. The projects had modest achievements in the introduction of ball-mining technology to dispose of POPs pesticides11. A prototype was built based on technology that had been tested in the laboratory. This prototype has the advantage that it is portable and allows rapid deployment for onsite treatment in small contamination incidents. Researchers in China continue to look for ways to scale up the technology and to explore its use at an industrial scale.

11 Ball mining technology used mechanical impacts to break the chemical bods of chemicals.

The removal of barriers has also contributed to behavioural change and the sound management of POPs in China. Prior to the project there were only two cement companies that had permits to treat hazardous waste in China. The process to acquire a permit was lengthy and expensive as no procedures or criteria had been defined. The project provided technical support to the development of the permitting procedure. The establishment of a process and criteria greatly facilitated the permit granting process. At the time of the field visit for this evaluation in May 2018, fifty firms had been granted permission to co-process hazardous waste in cement kiln. The project manager reported that it was very likely that up to 100 cement plants will be granted the permits by December 2018, the time the project is scheduled to close.

Remaining challenges

While the project has made important contributions to the management of POPs in China, big challenges remain. Much more needs to be done to spread the technologies introduced by the project to fully eliminate the risks posed by fly ashes including dioxins and heavy metals. Incentives for the adoption of the new technologies are mostly present in the densely populated regions that have land scarcity, in which there is little appetite for the expansion of sanitary landfills. Other areas that are less densely populated are likely to go through a slower transition. While the project helped the country dispose of the known stockpiles of POPs pesticides, heavily agricultural provinces, like the Hunan province, still face large areas contaminated soil with lower concentrations of POPs pesticides. Given the broad spread of the problem in agricultural areas, the provincial governments are adopting risk management approaches based on the assessed risks to human populations. Thus, in some instances of low contamination, provinces are adopting strategies that mitigate risks as opposed to eliminating them. For instance, turning the soil in lightly contaminated areas instead of treating the soil to dispose of pesticides. Another concern that remains is heavy metals. There are many mining operations that have resulted in high levels of contamination with heavy metals including among others mercury, arsenic and lead.

As indicated earlier, the project also helped remove technological barriers by introducing and adapting fly ash co-processing and sintering technologies. Prior to the project there was no installed capacity at an industrial scale of any of these technologies. Currently 70% of the fly ash in Beijing is treated with that technology and by the end of 2018 it is expected that sufficient capacity will be installed to treat all the fly ash produced in the Beijing metropolitan area, population 21 million people. Given the incentives for firms to adopt this technology, the project management reported that it is possible that an additional 150,000 to 300,000 t /y will be installed by 2023. In the case of the introduction of sintering technology, the project has helped develop a processing capacity of fly ash of 100,000 t per year for the city of Tianjin (10 million people). Given the interest in the technology express by other cities, it is likely that 10 more similar plans will be established in the next five years serving a total population of 30 million people. The lack of information on the existence and localization of POP pesticides was also an important barrier prior to the project. The establishment of the inventory and reporting system of POPs pesticides is

helping to overcome this barrier and encourage the treatment and removal of the remainder legacy pesticide stockpiles.

6. Sustainability

Sustainability pertains to the likelihood that project results will last. In the case of projects or programs that seek behavioral changes at scale, the focus of the sustainability analysis is best place on the assessment of the resilience to risks of the transformational process – the resilience of the momentum and redirection towards sound environmental management. This analysis can include risks that are internal or external to the project. Four risks to sustainability are assessed: Institutional and governance, Socio political, Financial and Environmental.

- **Sociopolitical risks**. Sociopolitical risks to the process of transformation are low. There is strong support for addressing pollution in metropolitan areas and improving hazardous waste management across the country. There is also an excess capacity of cement production in the country, so that the government of the city of Beijing recently closed five out of seven cement factories operating in region. In this context, the cement factories have a strong incentive to cultivate good will and demonstrate that they perform a service to the community by disposing of dioxins in fly ash. Fly ash co-processing also offers the cement factories an additional source of income while reducing the costs for some of the inputs required to produce cement.
- **Institutional framework and governance risks.** Institutional and governance risks are rated as low. The government has established a legal and regulatory framework that specifies reporting responsibilities of POPs, and has established country standards for dioxins in fly ash comparable to the standards in developing countries. Training and awareness raising have also significantly improved institutional regulatory and enforcement capacity at the national level and in the provinces and localities where the project operated. The rapid-expansion innovations introduced by the project are likely to place significant oversight demand form the government. Yet given previous experiences in China with regards to the replication and scaling up of tested approaches, it is likely that the institutional constrains will not represent block the process.
- **Financial risks**. Financial risks are rated as low. As indicated earlier, there are strong incentives for cement companies to adopt co-processing fly ash treatment technology to help prevent the shutdown of production of plant operations.
- **Environmental risks.** Environmental risks are rated as moderate. The project introduced a host of regulations and procedures to ensure the sound management of fly ash and POPs pesticide disposal. But, cement kilns operators need to make sure that temperature at feeding point is sufficiently high for the required residence time (over 900 $^{\circ}$C; 2 s). Firms will need to ensure that kiln staff is sufficiently trained on hazardous waste management (as it was the case in BBMG). Also, while the leaching toxicity of the heavy

metal of tested building material resulting from fly ash sintering met the current Chinese standard, these materials still contains heavy metals that should be monitored over the long term.

While this qualifies to use the material for construction, it is stressed that the material still contain heavy metals where the long-term fate should be considered.

7. Gender

By eliminating POPs, the project also reduced risks that specifically affect women and youth. Dioxins are highly toxic chemicals that pose risks to all human populations; they cause reproductive and developmental problems, damage the immune system, interfere with hormones and can cause cancer. Once dioxins enter the body, they last a long time because of their chemical stability and their ability to be absorbed by fat tissue, where they are stored in the body. Their half-life in the body is estimated to be 7 to 11 years and for some congeners up to 40 years. Youth at greater risks of reaching harmful concentrations starting with POPs accumulation from human milk consumption12 (Lorber and Phillips 2002; Van den Berg et al. 2017) and due to their low body weight. Dioxins can also cause birth defects, and pregnant women exposed to DDT are more likely to give birth prematurely or to low-weight babies (Toichuev et al. 2018b). Males are affected as well, as it has been found that POPs reduce sperm count (Galimova et al. 2014).

Project management reported that training workshops and capacity-building activities were open to all staff of FECO and participating agencies, and that it was very likely that the ratio of gender participation in the project's workshops was comparable to the staff ratio, which in FECO is 64% women and 36% men. Similarly, it was reported by the project management that training workshops to decision makers include gender aspects related to POPs.

12 It needs to be stressed that the benefits of breast feeding far outweigh the risk due to pollutants (Mead 2008). The WHO recommends therefore 6 month exclusive breast feeding.

VI. Project management

1. Implementation approach: Project role in improving POPs management in China

As indicated above, since the project started, there has been considerable progress made towards the sound management and disposal of POPs in China. Clear links were also established between the progress that took place and the activities supported by the project. Nevertheless, when dealing with complex systems, such as the system that this project addressed, only in a few cases it is possible to attribute accomplishments to one intervention. This is because it is rarely feasible to isolate the effects of one factor or actor in complex systems. Nevertheless, it is possible to assess the project contributions towards long-term objectives (Zazueta and Garcia 2014; Mayne 2008). One way to assess such contributions is by exploring with stakeholders "with and without" project scenarios. This was done during this evaluation by asking stakeholders at the end of each interview to reflect on the likely condition had the project not taken place. The responses were very consistent across all types of stakeholders. Most considered that the process would have taken place without the project's support, but it would have been different. The comments of stakeholders were as follows:

- "The processes would have taken place but slower and with a lower quality of outputs."
- "Regulatory reform would not be as advanced."
- "Standards would likely not be at international levels."
- "Not all known DDT POPs would be destroyed."
- "There would be a lower capacity for POPs management in China."
- "There would be a lower awareness of the risks of POPs among policy makers and affected populations."

When asked specifically what was the role of the project in the process, stakeholders responded that:

- "The project helped **speed up** the process"
- "The project facilitated access to state-of-the-art knowledge to **improve the quality** of regulations and technology." (BAT/BET; International level standards, regulations)
- "The project financing allowed us to **expand the** disposal DDT pops and dioxins"
- "The project supported **capacity development** at multiple levels and sectors"

In summary, the contributions of the project were to speed up the process, provide access to state- of-the-art knowledge, regulations and technology, and to build national, capacities and expand the benefits.

2. UNIDO implementation and backstopping

Implementation is rated as highly satisfactory. UNIDO carried out regular oversight visits to China and monitored budget execution and achievement of targets and outputs. UNIDO also assisted FECO in the identification of consultations and the transfer of state-of-the-art knowledge of regulations, standards and technology. UNIDO also helped FECO plan and execute multiple learning visits to several countries and facilitated cooperation with Egypt, Iran, South Africa, Germany, Norway, Ethiopia, Nigeria, Austria, New Zealand and Russia on various topics related to POPs management. UNIDO showed the flexibility and foresight to request the project extensions and to absorb the additional costs these required. The ongoing support provided by UNIDO and the continuity in project management were key factors in the outstanding accomplishments of the project.

3. FECO Execution

Execution is rated as highly satisfactory. The project was executed through the Foreign Economic Cooperation Office (FECO) of the Ministry of the Environmental Protection of China. FECO is a national entity with the mandate to coordinate international cooperation in the environment. It is also the entity responsible for coordinating activities related to the Stockholm Convention on Persistent Organic Pollutants. A team within FECO coordinated the day to day activities of the project and interacted with other stakeholders. The placement of the project management team in FECO was also an important factor that facilitated the promotion of regulations and standards, and the coordination with governmental and business stakeholders across sectors and administrative levels. The FECO project team also ensured the systematic monitoring of quality control at all stages of the process. The project management team is mostly credited for the large co-financing realized by the project, which was an important factor in the high level of impact the project achieved. Co-financing at project design was set at USD 32 million, realized co-financing turned out to be nearly USD 80 million. These high levels of co-financing are an indicator of the effectiveness of FECO in promoting the project. FECO's intense promotion and dedicated management were important factors contributing to the project success.

Table 17: Co-financing

Materialized co-financing was more than double than expected					
Co-financing source	Cash at entry	In-kind at entry	Total co-financing at entry	Materialized co-financing (RMB)	Materialized co-financing (USD) USD: RMB = 1:6.323117
Central Government (MEP)	3,900,000	3,850,000	7,750,000	¥ 53,144,404.00	USD 8,404,779.48
Waste Management Industry	1,080,000	6,230,000	7,310,00	¥ 3,280,000.00	USD 518,731.51
Private/ public sectors:	6,750,000	10,190,000	16,940,000	¥ 449,114,590.52	USD 71,027,404.76
UNIDO		100,000	100,000		
Total Co-financing	11,730,000	20,370,000	32,100,000	¥ 505,538,994.52	USD 79,950,915.75

4. Monitoring and Evaluation

M&E Design. The project document included a detail description of the project's M&E activities. These included quarterly and annual reports, Project Implementation Reports (PRI) for the GEF, a midterm external evaluation, a terminal report and a final external evaluation. M&E activities included an inception workshop with stakeholders, annual tripartite meetings (between the government, project management and UNIDO), biannual Steering Committee Group meetings and biannual visits of selected project sites. The monitoring system was designed to provide information to learn and adjust project activities. The plan adopted a systematic approach to M&E geared towards informing project implementation.

M&E Implementation. The project produced the quarterly and annual reports which management used to keep track of project outputs and targets. Similarly, tripartite and Project Steering Committee meetings were used to assess progress and adapt the project to changing conditions. The midterm evaluation, which was carried out in March 2014, was thorough and technically sound. As indicated earlier, the midterm external evaluation made six recommendations, all of which were addressed by the project in a timely manner. The project encountered several unforeseen situations that required modifications of the implementation plan. Initially there was the delay in the first disbursement of the GEF Grant. Subsequently, tendering of contracts for POPs pesticides disposal and fly ash treatment were declared deserted two times, because bidding companies did not meet the requirements. Having learned from the two first tenders, the project adopted a different approach in the third tender and worked with bidding companies to ensure that they would develop the necessary capacities and precautions to collect, transport, store and dispose of POPs. The project gave special attention to safety issues to ensure that POPs disposal met international standards. Contracting companies were required to observe BAT/BEP and to monitor and report disposal of POPs. In addition, the project contracted four independent laboratories to carry out audits on BAT/BEP observance and to confirm that treated waste met the required standards. The project approved payments to the contracting companies only when laboratory results had confirmed that standards had been met. As result of this careful monitoring, the project can accurately report on the number of tons of POPs and contaminated soil that were treated.

Budgeting and Funding for M&E actives. A total amount of USD 281,500 was budgeted for M&E activities. Some of the line items of the monitoring budget were not sufficiently funded, such as the midterm and final evaluations. Nevertheless, funds to pay for the laboratory analysis and other more technical monitoring activities were included in the budgets of other project components. During implementation sufficient funding was allocated from all monitoring and evaluation functions, including for the midterm and the final evaluation. This

was an important decision that ensured observance of BAT/BEP, and resulted in very reliable information on project impacts.

VII. Conclusions and recommendations

So far, this evaluation report has addressed the extent to which the project met its objectives and how the project has contributed to the transformation of the management of POPs in China. The report has presented evidence that the project help disposed of a large quantity of POPs pesticides and by so doing reduced the risks of contamination to a large number of people. This report also explained how in the process, the project also made important contributions to the development of a national system for the sustainable management of POPs in China. The project accomplished this by adopting an integrated approach that addressed the key barriers at the national, provincial and local levels, by incorporating key actors from the relevant sectors (both public and private) and by helping put in place mechanisms that continue to canalize behavioural change towards the sustainable management of POPs. In this concluding chapter the evaluation report draws from the evidence presented above to identify the key project characteristics that contributed to the project's results and to identify lessons that can be used in follow-up activities to the project or applied to other projects.

1. Factors affecting project results

There are five project characteristics that contributed to the high levels of accomplishment.

An integrated approach. As indicated in the above discussion on the project's theory of change, the project adopted an integrated approach to behavioural change, focused on the removal of barriers to the adoption of BAT/BEP technologies for the management and disposal of POPs. In so doing, the project addressed simultaneously all the key conditions necessary to redirect POPs management in China towards a more sustainable path. The project helped strengthen the policy and regulatory framework which clarified procedures and standards and provided incentives to adopt the new technologies. Most of the selected technologies were at a stage where they could be tested and adapted in an industrial setting. This allowed the project to engage the business community and to develop and test competitive business models. The project simultaneously helped to develop capacities in the public sector on regulation, enforcement, stakeholder engagement and coordination across levels of government and sectors. The project also provided information and raised awareness in communities surrounding contaminated sites, and took actions to address local concerns. All of which proved to be key in preventing unrest and gaining community support for cleanup operations. These communities also came to understand the dangers of dioxins and other POPs, and became more vocal in demanding action. Raising awareness among decision makers was also key to build the political will to adopt new regulations.

Country ownership. One of the assumptions made during project design

pertained to a high level of country ownership; this was a critical assumption sustained throughout the project. Ownership among the different levels of the public administration and among the participating firms proved to be critical factor to the project accomplishments, (clearly apparent in the high levels of co-financing realized by the project). But ownership had to be cultivated. From the start, the project design emphasized the benefits of the project for the local populations. When concerns arose on the suitability of international standards for conditions in China, project pilots were used to generate the necessary evidence to convince policy makers that such standards were suited to these conditions. Thus, for example, the government adopted standards on dioxin limits in stack emissions that are the same as those in Europe and other developing countries.

Benefits to stakeholders. Project design also assumed that stakeholders would see benefits in the adoption of the new technologies and management approaches. This was particularly important to engage businesses in the adoption of the technologies introduced by the project. The adoption of new technology allowed firms to provide a social service (disposal of dioxins) at a time when, in Beijing, the cement plants faced risks of being closed by the city government in account of the overproduction capacity in their region. This is a measure is likely to be followed in other governments of large metropolitan areas. Adoption of the new technology also provided an extra source of income for the treatment of fly ash and destruction of POPs pesticides, and helped with modest reductions of the costs of inputs. Information and outreach to the local communities also helped to build local support for– or at least prevented opposition to -- clean up operations, which was a politically sensitive issue for the government and a major concern for the project management

Mechanisms to catalyze change beyond the duration of the project. The project provided the principal guidance to provinces and cities for the regulation of POPs and hazardous waste management, which is being adopted with the support of FECO beyond the 13 provinces and cities where the project operated. These regulations, once adopted and mainstreamed, have been critical in generating incentives for cities and companies to adopt new technology. The firms participating in the project have also identified business models to replicate and scale up the adoption of the technologies introduced by the project in ways that are compatible with the market and are likely to improve competitiveness.

Adaptive management. Excellent project management was also a key factor contributing to the project's high levels of accomplishment. Project design properly identified and targeted the key barriers to the adoption of BAT /BEP for POPs management. FECO had an important role in coordinating all the interventions, and in ensuring resources were used in support of the overall strategy – including resources from GEF, the central government, provinces and businesses. Adaptive management during project implementation, while

resulting in project extensions and a higher cost to UNIDO, was also key in addressing unexpected circumstances and ensuring delivery of project outputs and outcomes. For example, before this project there were no standards for the processing of hazardous waste; it took three years to generate the evidence needed to pass a regulation. In the case of the processing of fly ash in cement kilns, tests had to ensure that levels of dioxin and heavy metals were safe and that the process did not affect the quality of the cement. Also, indicated earlier, while dealing with the cleanup operation of the Natian Chemical factory in Hunan province, the project management was able to help resolve a long-standing social concern of the local population, and most likely prevented the blocking of key project activities by factory workers seeking redress for their pension fund. Shifting technological trials to an industrial scale was also a key factor leading to the high levels of impact (in POPs destruction and dioxin elimination) and the identification of business models to replicate and scale up the innovations introduced by the project. The closing of cement plants in the Beijing area in 2016 was also important contextual factor that gave cement firms incentives participate in the project. An unexpected development that the project management quickly recognized and seized as an opportunity to engage the cement factories. The project set up a management structure that ensured inter-institutional coordination and the engagement of all the relevant sectors at the various scales. This process increased the complexity of the project and in the short run slowed down operations while all key stakeholders came on board. On the long run this proved to a crucial instrument in reaching and engaging the different sectors of government at the national, provincial and local levels.

2. Lessons

Three lessons are derived from this project:

A. **Successful projects cultivate country ownership.** China's commitments to the Stockholm Convention were an important factor during the identification of the project. Commitment was strengthened during preparation by ensuring that the project also addressed national priorities, including the reduction of risks of POPs to humans and the environment, technology transfers and capacity development. Execution through FECO was key as it ensured the institutional will in the national agency responsible for formulating and adopting the required regulations and convening stakeholders on POPs issues across the public administration. The use of pilots to generate evidence to convince decision makers to adopt strict regulations was also important. Similarly, the strategy of selecting participating firms through tendering processes ensured private sector ownership and commitment to the adoption of and investments in the new technologies.

B. **Comprehensive approaches, while complicated, are effective tools to build conditions for transformation.** Projects or programs that are most likely to

contribute to transformations adopt integrated approaches that address the key conditions necessary to achieve long term objectives. For this project, five domains were critical for the transformation to an environmentally sound POPs management system. These are policy and regulatory frameworks, technology, institutional capacities, business models and finances, and information awareness raising. It is also essential that projects and programs give attention to mechanisms that guarantee change will continue in the desired trajectory once the project ends. (This includes mechanisms to ensure mainstreaming, replication and scaling up of project results.) Yet while addressing long term conditions, projects must also cultivate short-term action towards the desired change by building on on-going processes, expanding capacities and generating short-term benefits to stakeholders. Given the highly unpredictable nature of these complex processes, unexpected developments encountered by these types of projects are also likely to require flexibility in the use of time and other resources.

C. **A focus on the industrial application of technology provides an effective framework to catalyze transformations at scale.** A significant factor in the project's high accomplishments is the technological change at an industrial scale. This was possible in part due to contextual conditions, mainly the closure of cement factories by the city of Beijing.

3. Recommendation

The evaluation has two recommendations to the Government of China.

Recommendation 1: It is critical to ensure the proper protocols for feeding of POPs and fly ashes are observed, in terms of sufficiently high temperature at feeding point, adequate resident time for POPs or fly ash at appropriate temperature and proper training of kiln staff on hazardous waste management.

One of the assumptions in the project theory of change is the sound application of technology during replication. Such replications and mainstreaming need to be appropriately guided. Given the risks of inadvertently producing of high quantities of dioxins during the destruction of POPs (Weber 2007) and the thermal treatment of fly ash (Stieglitz et al. 1989; Weber et al. 1999) it is critical that the proper protocols for feeding of POPs and feeding of fly ashes are observed. The temperature at feeding point must be sufficiently high to destroy POPs and dioxins and that the required resident time for POPs or fly ash at the appropriate temperature also needs to be met.

When temperature drops below 900℃, the risk of generating dioxins instead of destroying them increases drastically. Also, the destruction efficiency of POPs are reduced with associated risk of releases of POPs as has been recently

discovered in a POP/HCB destruction project in an Austrian cement kiln with POP release and contamination of 300 farms (Weber et al. 2015).

By the end of 2018 approximately 100 cement plants have likely the license to treat hazardous wastes. The experience in capacity building of the staff handling the waste but also for the management of the facilities should be utilized for training in this mainstreaming effort. Firms will need to ensure that kiln staff is sufficiently trained on hazardous waste management (as was the case in BBMG).

Recommendation 2: Heavy metals present in fly ashes or wastes need to be appropriately assessed and controlled including long term considerations over the life cycle, in addition to POPs.

ANNEXES

Annex 1: Persons interviewed

Persons interviewed				
May 2018	**No.**	**Name**	**Gender**	**Company/Institute**
May 21.	1	PENG Zheng	Male	FECO
	2	ZHU Jianxin	Male	Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences
	3	YAN Dahai	male	Chinese Research Academy of Environmental Sciences
	4	Roland Weber	Male	Consult for POPs, Germany
	5	JIANG Lin	male	Beijing Municipal Research Institute of Environmental Protection
	6	Giovannni Cagnetta	male	Tsinghua University
	7	XIAO Xuezhi	Male	FECO
	8	REN Yong	Male	FECO
	9	WANG Haoyang	Female	FECO
May 22.	10	LI Yan	male	Beijing Jinyu Liushui Environmental Tech. & Science Co. (Beijing Jinyu Liushui), BBMG
	11	WU Cungen	male	Beijing Jinyu Liushui, BBMG
	12	ZHANG Guoliang	male	Beijing Jinyu Liushui, BBMG
	13	CAO Xiangdong	male	Beijing Jinyu Liushui, BBMG
	14	GUO Yuquan	male	Beijing Jinyu Liushui, BBMG
	15	FANG Wei	male	Beijing Jinyu Liushui, BBMG
	16	HUANG Lan	Female	Beijing Jinyu Liushui, BBMG
	17	WANG Chunhua	Female	Beijing Jinyu Liushui, BBMG
	18	YIN Qin	Female	Beijing Jinyu Liushui, BBMG
	19	WEI Baiyong	male	Beijing Jinyu Liushui, BBMG
	20	YU Shuhui	Female	Beijing Jinyu Liushui, BBMG
	21	GU Jun	male	Beijing Jinyu Liushui, BBMG
	22	ZHU Tingchen	male	Beijing Jinyu Liushui, BBMG
	23	ZHENG Chunguang	male	Beijing Jinyu Liushui, BBMG
	24	ZHAO Wenjian	male	Beijing Jinyu Liushui, BBMG

Persons interviewed				
May 2018	**No.**	**Name**	**Gender**	**Company/Institute**
	25	WANG Gang	male	Beijing Jinyu Liushui, BBMG
	26	XU Xiaojing	Female	Beijing Jinyu Liushui, BBMG
	27	LU Yong	male	CSD IDEA (Beijing) Environmental Test & Analysis Co.,Ltd (CETA)
	28	LI Xin	Female	CETA
	29	PENG Qian	Female	CETA
	30	ZHANG Xiaohui	Female	CETA
	31	CHEN Wenjing	Female	CETA
	32	LUO Yunpeng	Female	CETA
	34	SHANQI Jiaozheng	male	CETA
	33	ZHANG Shun	male	CSD Emerging Environmental Technology Center (CETC) Company
May 23.	35	FU Ruide	male	Heibei Zhuolu Jinyu, BBMG
	36	LI Jirong	male	Heibei Zhuolu Jinyu, BBMG
	37	QIAO Zhu	male	Heibei Zhuolu Jinyu, BBMG
	38	HAN Zhiguo	male	Heibei Zhuolu Jinyu, BBMG
	39	WANG Hai	male	Heibei Zhuolu Jinyu, BBMG
May 24.	40	Ji Tao	male	Tianjin EMAN Company
	41	Zhang Shuguang	male	Tianjin EMAN Company
	42	Wang Juanjuan	Female	Tianjin EMAN Company
	43	Liu Liansheng	male	Tianjin EMAN Company
	44	Wang Jianwei	male	Tianjin EMAN Company
May 25.	45	ZHU Zhiming	male	Wuxi Minghai company
	46	LV Xiaowu	male	CETC
	47	DENG Shanshan	Female	Tsinghua University
May 28	48	Pan Biling	Male	Hunan provincial EPD
	49	LONG Jun	Male	Hunan provincial EPD
	50	LIU Yu	Female	Hunan provincial EPD
	51	ZHANG Zhenhua	Male	Hunan provincial EPD
	52	HU Fanglin	Male	Zhuzhou city EPB
	53	XIE Shun		Zhuzhou city EPB

Persons interviewed				
May 2018	**No.**	**Name**	**Gender**	**Company/Institute**
	54	LIAO Weikang	Male	Zhuzhou city EPB
	55	LIU Bendun	Male	Zhuzhou Husong district EPB
	56	WU Jian	Female	Zhuzhou Qinglan company
	57	WAN Peng	Male	China Energy Conservation DADI Environmental Remediation Co., Ltd.
	58	ZHANG Jianbin	Male	China Energy Conservation DADI Environmental Remediation Co., Ltd.
	59	ZHOU Zhiyong	Female	Local community in Zhuzhou city
	60	WANG Xihui	Male	Local community in Zhuzhou city
May 29	61	ZHANG Lihua	Male	Government of Xiangtan city
	62	LI Junjie	Male	The Administrative Committee of Zhaoshan district in Xiangtan city
	63	LIAO Yong	Male	EPB of Xiangtan city
	64	WANG Yu	Female	EPB of Xiangtan city
	65	ZHNG Jiangping	Male	EPB of Zhaoshan district in Xiangtan city
	66	FU Ruide	Male	Heibei Zhuolu Jinyu, BBMG
	67	JIANG Cheng	Male	Economic development department in Zhaoshan district, Xiangtan city
	68	SUN Fuyun	Male	EPB of Zhaoshan district in Xiangtan city
	69	HAN Zhiguo	Male	Heibei Jinyu Mangrove, BBMG
	70	LI Jiancheng	Male	Heibei Jinyu Mangrove, BBMG
	71	YAN Lingzhi	Female	Resident, Zhaoshan villiage, Xiangtan city
	72	MENG Zhongping	Male	Resident, Zhaoshan villiage, Xiangtan city
	73	ZHOU Zhenyu	Male	EPB of Zhaoshan district in Xiangtan city
	74	PENG Kejian	Female	Hunan provincial EPD
	75	LONG Youfa	Male	Xiangtan Industrial investment co. LTD
	76	LUO Jiaqiao	Female	Xiangtan city resident

Persons interviewed				
May 2018	**No.**	**Name**	**Gender**	**Company/Institute**
	77	QIU Liqiu	Male	Xiangtan city resident
	78	LI Xuqing		Xiangtan Industrial investment co. LTD
	79	WANG Yanwei		Beijing Construction and Engineering Group
	80	SUN Qian	Female	Chinese Academy for Environmental Planning (CAEP)
	81	WANG Peng	Male	China Energy Conservation DADI Environmental Remediation Co., Ltd.
	82	CHEN Dan	Female	SUSTC Engineering Innovation Center(Beijing)
	83	YU Du	Male	Xiangtan Industrial investment co. LTD
	84	WANG Fan	Male	College of Changsha Environment
	85	LIU Lisi	Male	Hunan Lianda company
	86	LUO Yi	Male	Hunan Hetian company
	87	YIN Qianmin	Male	Jingli Test company
	88	Jiao Xinjiang	Male	Beijing Construction and Engineering Group
	89	LI Shupeng	Male	Beijing Construction and Engineering Group

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Annex 3: Preparatory interview questionnaire sent to stakeholders – source interview

Preparatory questionnaire sent to stakeholders for interviews – Source interview[13]

表 B1: 访谈问卷

Independent terminal evaluation of the project:
Environmentally sound management and disposal of obsolete POPs pesticides and other POPs in China. UNIDO
项目独立终期评估：联合国工业发展组织在中国的杀虫剂类POPs和其它POPs的环境健全管理和处置项目

Name of Institution 机构名称 Location of institution 地址

Name and position of person interviewed 受访人的姓名和职务

1) Can you tell us briefly what are the functions (or businesses) of your organization (or firm)?
   请说明贵研究机构（或公司）的职能（或业务）。
2) What has been your Organization's (firm) role in the project? How long have you been engaged with the project?
   本项目中贵研究机构（或公司）的任务是什么？已参与本项目多久？
3) What were the most important obstacles or challenges related to the sound management and disposal of POPs that your organization /firm faced prior to the project?
   本项目开始前，贵机构（或公司）在 POPs 的健全管理和处置工作有哪些主要的困难和挑战？
4) To what extent has your organization or firm been able to overcome these obstacles?
   目前已在多大程度上解决这些困难？
5) In what ways has the project helped your organization or firm address these obstacles?

[13] These questions are adapted for observers, academia, government and private firms in Tables B2, B3, B4, B5

UNIDO POPs 项目如何促进这些问题的解决？

6) Has your organization/ firm applied any approaches or lessons that came from the project to other aspects of your operations? If so what has been applied?
贵机构（或公司）是否将 UNIDO POPs 项目中的方法/经验等应用于其它业务？应用了哪些方法？

7) Will your organization continue to use or expand the project practices, approaches or technologies once the project ends? If so, what actions have you undertaken or what are your plans on this regard?
贵机构（或公司）是否将继续运用或拓展 UNIDO POPs 项目的经验、方法或技术？如果是，有哪些具体的行动或计划？

8) Aside from the UNIDO POPs Project, what other projects, processes, events, or other factors have contributed to capacities in POP's management of your organization / firm? How have they done so?
除了 UNIDO POPs 项目，还有哪些其他项目或其它因素促使贵机构在 POPs 管理能力的提升？它们是如何做到的？

9) What would be the status or condition of your organization's or firm's capacities to address POPs had the POPs Project **not** taken place?
如果没有该 POPs 项目，你认为贵机构（或公司）关于 POPs 管理能力的状况将会如何？

10) What challenges or obstacles does your organization or firm is still facing related to the sound management of POP's?
贵机构（或公司）现阶段仍面临哪些 POPs 管理方面的困难或挑战？

11) What have been the most important accomplishments of the POP's project in general?
UNIDO POPs 项目最重要的成就是什么？

12) What would you take out, add to, or do differently in the POPs project?
你认为 POPs 项目应该增减或修改哪些内容？

Questionnaire for Independent Observers

表 B2 调查问卷：针对独立观察员

Independent terminal evaluation of the project:

Environmentally sound management and disposal of obsolete POPs pesticides and other POPs in China. UNIDO

项目独立终期评估：联合国工业发展组织在中国的杀虫剂类 POPs 和其它 POPs 的环境健全管理和处置项目

May 2018

Name of Institution 机构名称_____

Date filling the questionnaire 填表日期_____

1: Briefly indicate what is the mission or functions of your Institution. **简要说明贵研究机构的职能。**	
How did you come to know about the UNIDO China POPs project and how long have you known about it? **你如何知道的中国 UNIDO POPs 项目，了解该项目多久？**	
2: What were the most important obstacles or challenges related to the sound management and disposal of POPs in China back in 2014 before the project begun? **早在 2014 年，本项目开始前，贵机构在 POPs 的健全管理和处置工作有哪些主要的困难和挑战？**	
3: To what extent have these challenges and obstacles have been overcome? **目前已在多大程度上解决这些挑战或困难？**	
4: How has the UNIDO POPs project helped address these obstacles and challenges? **UNIDO POPs 项目如何促进这些问题的解决？**	
5: Has your institution benefited from the lessons, knowledge or approaches derived	

from the UNIDO POPs project? If so How? 贵机构是否受益于 UNIDO POPs 项目中的经验、知识和方法？如何受益？	
6: Will your institution continue to use or expand on the knowledge or lessons resulting from the UNIDO POPs project? If so, have you taken any actions or made any specific plans in this regard? 贵机构是否将继续运用或拓展 UNIDO POPs 项目的知识或经验？如果是，有哪些具体的行动或计划？	
7: Aside from the UNIDO POPs Project, what other projects, processes, events, or other factors have contributed to capacities in POP's management in China? How have they done so? 除了 UNIDO POPs 项目，还有哪些其他项目和因素导致了贵机构在 POPs 管理能力的提升？它们是如何做到的？	
8: What would be the status POPs management in China had the POPs Project **not** taken place? 如果没有该 POPs 项目，你认为贵机构（或公司）关于 POPs 管理能力的状况将会如何？	
9: What challenges or obstacles **remain** for the sound management of POP's in China? 贵机构现阶段仍面临哪些 POPs 管理方面的困难或挑战？	
10: What have been the most important accomplishments of the UNIDO POP's project in general? UNIDO POPs 项目最重要的成就是什么？	

11: What would you take out, add to, or do differently in the POPs project? 你认为 POPs 项目应该增减或修改哪些内容？	

Questionnaire for Participating Academic Institutions

表B3 调查问卷：针对参与项目的学术机构

Independent terminal evaluation of the project:
Environmentally sound management and disposal of obsolete POPs pesticides and other POPs in China. UNIDO
项目独立终期评估：联合国工业发展组织在中国的杀虫剂类POPs和其它POPs的环境健全管理和处置项目
May 2018

Name of Institution 机构名称_____

Location 地址_____ Date filling the questionnaire 填表时间_____

1: Briefly indicate what is the mission or role of your Institution. 简要说明研究机构的职能	
2:What has been your institution's role in the project? How long have you been engaged with the project? 本项目中贵研究机构的任务是什么？已参与本项目多久？	
3: What were the most important obstacles or challenges related to your work pertaining the sound management and disposal of POPs did your institution faced back in 2014 before the project begun? 早在 2014 年，本项目开始前，贵机构在 POPs 的健全管理和处置工作有哪些主要的困难和挑战？	
4: To what extent has you been able to overcome these challenges or obstacles? 目前已在多大程度上解决这些挑战或困难？	
5: How has the UNIDO POPs project contributed to these achievements?	

UNIDO POPs 项目如何促进这些问题的解决？	
6: Has your institution applied any approaches or lessons that came from the UNIDO POPs project to other aspects of your operations? If so what has been applied? 贵机构是否将 UNIDO POPs 项目中的方法、经验应用于其它业务？应用了哪些方法？	
7: Will your institution continue to use or expand on the knowledge or lessons resulting from the UNIDO POPs project? If so, have you taken any actions or made any specific plans in this regard? 贵机构是否将继续运用或拓展 UNIDO POPs 项目的知识或经验？如果是，有哪些具体的行动或计划？	
8: Aside from the UNIDO POPs Project, what other projects, processes, events, or other factors have contributed to capacities in POP's management of your institution? How have they done so? 除了 UNIDO POPs 项目，还有哪些其他项目或因素促使贵机构在 POPs 管理能力的提升？它们是如何做到的？	
9: What would be the status or condition of your institutions' capacities related to POPs had the UNIDO POPs Project **not** taken place? 如果没有该 POPs 项目，你认为贵机构（或公司）关于 POPs 管理能力的状况将会如何？	
10: What challenges or obstacles is your institution still facing (**challenges that remain)** with regards to POPs management? 贵机构现阶段仍面临哪些 POPs 管理方面的困难或挑战？	
11: What have been the most important accomplishments of the UNIDO POP's project in	

general? UNIDO POPs 项目最重要的成就是什么？	
12: What would you take out, add to, or do differently in the POPs project? 你认为 POPs 项目应该增减或修改哪些内容？	

Questionnaire for Government Offices

表B4 调查问卷：针对政府机关

Independent terminal evaluation of the project:
Environmentally sound management and disposal of obsolete POPs pesticides and other POPs in China. UNIDO
项目独立终期评估：联合国工业发展组织在中国的杀虫剂类POPs和其它POPs的环境健全管理和处置项目
May 2018

Name of Institution 机构名称_____

Location 地址_____ Date filling the questionnaire 填表日期_____

1: Briefly indicte what is the mission or role of your Institution. 简要说明贵研究机构的职能	
2:What has been your institution's role in the project? How long have you been engaged with the project? 本项目中贵研究机构的任务是什么？已参与本项目多久？	
3: What were the most important obstacles or challenges related to the sound management and disposal of POPs did your institution faced back in 2014 before the project begun? 早在 2014 年，本项目开始前，贵机构在 POPs 的健全管理和处置工作有哪些主要的困难和挑战？	
4: To what extent has you been able to overcome these challenges or obstacles? 目前已在多大程度上解决这些挑战或困难？	
5: How has the UNIDO POPs project contributed to these achievements? UNIDO POPs 项目如何促进这些问题的解决？	

6: Has your institution applied any approaches or lessons that came from the UNIDO POPs project to other aspects of your operations? If so what has been applied? 贵机构是否将 UNIDO POPs 项目中的方法、经验应用于其它业务？应用了哪些方法？	
7: Will your institution continue to use or expand on the knowledge or lessons resulting from the UNIDO POPs project? If so, have you taken any actions or made any specific plans in this regard? 贵机构是否将继续运用或拓展 UNIDO POPs 项目的知识或经验？如果是，有哪些具体的行动或计划？	
8: Aside from the UNIDO POPs Project, what other projects, processes, events, or other factors have contributed to capacities in POP's management of your institution? How have they done so? 除了 UNIDO POPs 项目，还有哪些其他项目或因素导致了贵机构在 POPs 管理能力的提升？它们是如何做到的？	
9: What would be the status or condition of your institutions' capacities to address POPs had the POPs Project **not** taken place? 如果没有该 POPs 项目，你认为贵机构（或公司）关于 POPs 管理能力的状况将会如何？	
10: What challenges or obstacles is your institution still facing (**challenges that remain)** to improve POPs management? 贵机构现阶段仍面临哪些 POPs 管理方面的困难或挑战？	
11: What have been the most important accomplishments of the UNIDO POP's project in general? UNIDO POPs 项目最重要的成就是什么？	

12: What would you take out, add to, or do differently in the POPs project? 你认为 POPs 项目应该增减或修改哪些内容？	

Questionnaire for Firms and Enterprises

表B5 调查问卷：针对公司和企业

Independent terminal evaluation of the project:
Environmentally sound management and disposal of obsolete POPs pesticides and other POPs in China. UNIDO
项目独立终期评估：联合国工业发展组织在中国的杀虫剂类POPs和其它POPs的环境健全管理和处置项目
May 2018

Name of Firm 公司名称_____

Location 地址_____ Date filling the questionnaire 填表日期_____

1: Briefly indicte what is the business of your firm 简要说明贵公司业务。	
2:What has been your firm's role in the project? How long have you been engaged with the project? 本项目中贵公司的任务是什么？已参与本项目多久？	
3: What were the most important obstacles or challenges related to the sound management and disposal of POPs did your firm faced back in 2014 before the project begun? 早在 2014 年，本项目开始前，贵公司在 POPs 的健全管理和处置工作有哪些主要的困难和挑战？	
4: To what extent has you been able to overcome these challenges or obstacles? 目前已在多大程度上解决这些挑战或困难？	
5: How has the UNIDO POPs project contributed to these achievements?	

UNIDO POPs 项目如何促进这些问题的解决？	
6: Has your firm applied any approaches or lessons that came from the UNIDO POPs project to other aspects of your operations? If so what has been applied? 贵公司是否将 UNIDO POPs 项目中的方法等应用于其它业务？应用了哪些方法？	
7: Will your firm continue to use or expand on the knowledge or lessons resulting from the UNIDO POPs project? If so, have you taken any actions or made any specific plans in this regard? 贵公司是否将继续运用或拓展 UNIDO POPs 项目的知识或经验？如果是，有哪些具体的行动或计划？	
8: Aside from the UNIDO POPs Project, what other projects, processes, events, or other factors have contributed to capacities or provided incentives in your firm's POP's management? How have they done so? 除了 UNIDO POPs 项目，还有哪些其他项目或因素促使贵公司在 POPs 管理能力的提升？它们是如何做到的？	
9: What would be the status or condition of your firm's capacities to address POPs had the POPs Project **not** taken place? 如果没有该 POPs 项目，你认为贵机构（或公司）关于 POPs 管理能力的状况将会如何？	
10: What challenges or obstacles is your firm still facing (**challenges that remain)** to improve POPs management? 贵公司现阶段仍面临哪些 POPs 管理方面的困难或挑战？	
11: What have been the most important accomplishments of the UNIDO POP's project	

in general? UNIDO POPs 项目最重要的成就是什么？	
12: What would you take out, add to, or do differently in the POPs project? 你认为 POPs 项目应该增减或修改哪些内容？	

Annex 4: Schedule of field visits

	May 2018	Location	Traveling	Organization, Firm or Plant visited	Description
	Sunday, 20		Zazueta		From New York to Beijing
Day 1	Monday, 21st	Beijing	Zazueta	FECO	The general introduction of the implementation and output of this project by stakeholders in the meeting in FECO.
Day 2	Tuesday, 22nd	Beijing	Zazueta	Beijing Jinyu Liushui Environmental Tech. & Science Co.; CSD IDEA (Beijing) Environmental Test & Analysis Co., Ltd.	Field investigation on the co-processing of municipal solid waste incinerator fly ash by cement kiln. Investigated the capacity and improvement of POPs analysis and performance test by the individual monitoring company.
Day 3	Wednesday, 23rd	Zulu, Hebei province (stay in Beijing)	Zazueta	Jinyu Zhuolu Cement Co. (Hebei)	Field investigation on the co-processing of DDT/HCH wastes by cement kiln.
Day 4	Thursday, 24th	Tianjin city	Zazueta & Liu	Tianjin Eman Environmental Co.(Tianjin)	Field investigation on the high temperature sintering plants of municipal solid waste incinerator fly ash. Travel to Wuxi
Day 5	Friday, 25th	Wuxi, Jiangsu province	Zazueta & Liu	Minghai company in Wuxi city	Investigate the ball mining technique for POPs contaminated soils.
Day 6	Saturday, 26th	Wuxi, Jiangsu province	Zazueta & Liu		Travel from Wuxi to Changsha

	May 2018	Location	Traveling	Organization, Firm or Plant visited	Description
Day 7	Sunday, 27th	Changsha, Hunan province	Zazueta & Liu		Summarize the field investigations.
Day 8	Monday, 28th	Changsha, Zhuzhou city, Hunan province	Zazueta & Liu	Hunan provincial EPD, Zhuzhou city EPB.	Investigate the DDT/HCH waste disposal in Zhuzhou city
Day 9	Tuesday, 29th	Xiangtan, Hunan province	Zazueta & Liu	EPB of Xiangtan city, Beijing Construction and Engineering Group, The obsolete POPs pesticide company (Nantian) in Xiangtan	Investigate the DDT/HCH waste disposal in Xiangtan city
Day 10	Wednesday, 30th	Changsha, Hunan	Zazueta & Liu		Travel from Changsha to Beijing
Day 11	Thursday, 31st	Beijing	Zazueta	FECO	Presented a report on the preliminary findings of this field investigation to FECO
	1st June		Zazueta	Back to New York	

Annex 5: Barriers to the sound management of POPs in China

Barriers to the sound management of POPs in China identified during project design	
a	*Existing laws and regulations related to hazardous wastes are too general and their implementation is not supported by detailed regulations and technical guidelines.*
B	*Existing standards for waste pollution control are too broad and specific standards for POPs pesticides do not exist*
c	*China's Nationwide Hazardous Waste Treatment Facility Construction Program has been developed without considering technology and knowledge transfer of ESM measures particularly in considering alternative technologies*
d	*Lack of policy instruments promoting adoption of ESM in a market economy*
e	*Historical pesticides manufacturing sites that stopped production long ago might not have production records*
f	*Weak institutional capacities for supervision and inspection of POPs waste owners' sites and dedicated disposal facilities in the areas of pollution monitoring, environmental impact assessment, and risk assessment of disposal operations*
g	*Lack of effective personnel training systems to provide qualified human resources for ESM of POPs pesticides*
H	*Lack of stakeholder awareness raising and education*
i	*Lack of effective mechanism to promote research, development, and application of feasible techniques*
j	*Lack of POPs waste disposal capacity*
K	*Slow commercial application of innovative POPs waste disposal technologies*
l	*Distribution and properties of obsolete pesticides and dioxin-rich fly ash*
m	*Lack of experience in operating mobile disposal facilities*
n	*Lack of cooperative and coordinated ESM for POPs waste disposal*
o	*Lack of certification program to provide reliable and comparable information for reviewing technical and performance*
p	*Lack of inter-ministerial mechanism of coordination and guidance upon cross-sectoral policy and implementation issued*
Q	*Stakeholder conflict of interests*

Annex 6: Logical framework and delivery inputs and outputs of project by June 2018.

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
Output 1.1 Technological and economic policies and regulations in place for promoting environmentally sustainable management and disposal of POPs wastes						Exceeded Completed Incomplete
1.1.1 * Develop and formulate technological and economic policies through interdepartmental coordination, awareness raising, public hearings, and NGO outreach	Completed	- 12th Five-year Program for the Prevention and Control of Pollution Caused by POPs from Major Industries in China - The second revision of the revised edition of the Technology Policy for the Prevention and Control	HS HS	- Promote the ESM disposal technology and economic policies of POPs wastes. - Promote new regulations and policies on ESM technology.	- 12th Five-year Program for the Prevention and Control of Pollution Caused by POPs from Major Industries in China. - The second revision of the Technology Policy for the Prevention and Control of Pollution Caused by Hazardous	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
1.1.2* Provide training on new technological and economic policies for managerial staff from provincial EPBs 1.1.3* Raise awareness of new technological	Completed Completed	of Pollution Caused by Hazardous Wastes was completed - Notice of the Provincial Department of Environment Protection on Strengthening the Management of Abandoned Pesticides and Pesticide Packages (E.H.B.[2012] No. 321) - 12th Five-year Work Program for Implementation plan of International Environment	HS		Wastes was completed - Notice of the Provincial Department of Environment Protection on Strengthening the Management of Abandoned Pesticides and Pesticide Packages (E.H.B.[2012] No. 321) - 12th Five-year Work Program for the Implementation plan of the International Environment Conventions. About 600 managerial	Achieved Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
and economic policies and enforcement mechanisms		Conventions (for comments) -The trainings on the identification and investigation as well as environmentally sound management and disposal of POPs wastes are conducted, during which training sessions are held for 8 times and more than 1000 person-times participated from provincial EPBs and waste disposal Companies.		- Complete the ESM technology training course for 4,000 managerial and technical staff. - Develop the training materials. - To complete the public awareness, strengthen activities with 20 “medias” and 100 communities	staffs and 5000 technical staffs were trained. *Completed the training report in Hebei and Hubei provinces and also completed the training vedio materials for cement kiln co-processing solid wastes. Completed the capacity building of POPs waste management in Hubei, Hebei and Hunan provinces.	Achieved Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
		- National and provincial news media such as China Environment News, Hubei Daily, Hebei Daily, and People's Daily Online, Chinanews.com, CNR.cn, China Economic Net, reported the environmentally sound disposal of POPs obsolete pesticides -A series of awareness raise campaigns organized by national		participation.	At least 6 times reported by National newspaper: Environmental daily (4), China Environmental news (1), China Science and Technology daily(1) More than 10 times reported by National news websites by People's Daily online, Chinanews.com,www.CNR.cn,www.chinaeconomic.net,www.environmentaldaily.com; More than 15 times	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
		and provincial level - Technical Training Reports of Hubei Province and Hebei Province			reported by provincial and city medias such as Hubei Daily, Hebei Daily, Zhuzhou Daily etc. At least of 130 communities participated.	
Output 1.2: Technical standards and guidelines developed for ESM of POPs waste						
1.2.1* Develop and formulate guidelines, standards, and specifications	On-going	- The compilation of the Guidelines for Investigation and Identification of Pesticide POPs Wastes was completed	S	– To compile the ESM management technology and operation guidance according to the "Stockholm	Completed the following technical documents: Draft for comment of 《Control standards of pollutants for hazardous waste incineration》	Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
1.2.2* Provide training on guidelines, standards and specifications for managerial staff from provincial EPBs	Completed Completed	- The compilation of the Standard on Control of Pollution Caused by Co-processing of Hazardous Wastes with Cement Kilns is open for comments - The revision of the Standard on Pollution prevention Caused by hazardous waste high temperature incineration is open for comments - Risk assessment guidelines for	HS HS	Convention on POPs" and "Basel Convention".	(revised edition); 《Control standard of pollutants for cement kiln co-processing solid wastes》（GB30485-2013） 《Technical specification for environmental protection of cement kiln co-processing solid wastes》（HJ662-2013） 《Technical specification for cement kiln co-processing solid	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
1.2.3* Develop standard operation procedures for analysis and monitoring		contaminated sites - The compilation of the Environmental Protection Technology Specifications on Co-processing of Hazardous Wastes with Cement Kilns was completed - At least 500 specialized managerial and monitoring staff received training - The compilation of the Technical Guidance for Co-processing of			wastes》（GB30760-2014） 《Technical policies on pollution prevention and control from cement kiln co-processing solid wastes》(2016) 《Examination guideline for business licence of cement kiln co-processing hazardous wastes》(2017) 《Technical guidelines for environmental site investigation》（HJ25.1-2014）	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
		Wastes with Cement Kilns is being discussed internally - The compilation of the Technical Specifications of Hubei Province on Co-processing of Hazardous Wastes with Cement Kilns was completed - Measures for the Administration of Operation Permit of Hazardous Wastes			《Technical guidelines for environmental site monitoring》（HJ25.2-2014） 《Technical guidelines for risk assessment of contaminated sites》(HJ25.3-2014) 《Technical specification for cement rotary kiln co-processing hazardous waste in Hubei province》 《Guidelines on identification and investigation of	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					pesticide POP wastes》 《Technical guidelines on identification of pesticide POP wastes》 《Technical guidelines on identification and disposed of POPs wastes in contaminated sites》 《Technical requirements and facility assessment methods for cement kiln co-processing POP wastes》 《 Technical requirements and	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				– Compile the guidance of the risk assessment and emergency response guideline on POP	facility assessment methods for high-temperature incineration of POP wastes》 《Technical requirements and facility operation procedures for water scrubbing methods of waste incineration fly ash before co-processed by cement kilns》 《Technical requirements and facility operation procedure for ball	Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				waste disposal. – Complete the technical assessment and authorization standard for POP waste disposal.	milling method to dispose POP wastes》. Completed the Guidance of hazardous waste incineration facility operation. Completed the 《Technical guidance of environmental protection for cement kiln co-processing solid waste》(HJ662-2013) Completed the business licence management	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				– To compile the manuals for waste disposal facility operation.	method for hazardous wastes. Completed the business licence examination guideline for cement kilns. Completed the 《Control standard of pollutants from cement kiln co-processing solid waste》 （GB30485-2013） Completed the 《Technical guidance on the environmental protection on cement kiln co-processing solid	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					waste》（HJ662-2013）	Achieved
				– Complete the effectiveness evaluation and management of disposal cost.	Completed the business licence management method for hazardous wastes disposal by combustion facilities. Completed the business licence examination guideline for cement kilns. Completed the《Control standard of	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				– Technical specifications for monitoring in POP wastes and contaminated sites.	pollutant from cement kiln co-processing solid waste》（GB30485-2013） Completed the《Technical guidance on environmental protection of cement kiln co-processing solid waste》（HJ662-2013） Completed the technical assessment for POP disposal by cement kilns, high-temperature incineration and non-	Exceeded Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				– Train at least 500 staffs involved in management and monitoring activities. – To complete the training materials.	incineration method. 《Technical guidelines for environmental site investigation》（HJ25.1-2014） 《Technical guidelines for environmental site monitoring》（HJ25.2-2014） 《Technical guidelines for risk assessment on contaminated sites》(HJ25.3-2014)	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				– To compile the standard operation procedure for monitoring of POP waste and	About 200 managerial staffs and 1000 staffs with monitoring and operating activities involved were trained. 《Technical guidelines for environmental site investigation》（HJ25.1-2014） 《Technical guidelines for environmental site monitoring》（HJ25.2-2014）	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				contaminated sites	《Technical guidelines for risk assessment on contaminated sites》(HJ25.3-2014) 《Technical guidelines on the identification on waste disposal of POP contaminated sites》 Completed the risk assessment guidelines for contaminated sites and the compilation of 《Technical guidelines on identification and disposed of POPs wastes	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					in contaminated sites》.	
Output 2.1: Communication and coordination sustained between stakeholders in waste management and disposal						
2.1.1* Establish national, regional, and local coordination framework for integrated POPs waste management 2.1.2 Periodically review stakeholder recommendations and action proposals related to POPs wastes ESM 2.1.3Hold periodic fora	Completed for Hebei and Hubei Provinces On-going On-going	- National Convention Implementation Coordination Group and Project Management Office established - Hubei and Hubei Provincial Convention Implementation Coordination Group and Project Management Office were set up	HS S S	– The establishment and operation of national, provincial, and local POPs waste committee	* National Convention Implementation Coordination Group and Project Management Office established and NCCG met at least once a year, the Project National Coordination Meeting took place every three months. Hubei Provincial Convention Implementation	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
for public and private stakeholders, NGOs, and the general public to promote good governance and increased effectiveness		- Local coordination meetings in Hebei Province and Hubei Province to review progress National and provincial news media such as China Environment News, Hubei Daily, Hebei Daily, and People's Daily Online, Chinanews.com, CNR.cn, China Economic Net, reported the environmentally sound		– Stakeholder recommendations and action proposals about POPs wastes ESM. – Local POPs waste cross management and coordination	Coordination Group and Project Management Office established * Hebei Provincial Convention Implementation Coordination Group and Project Management Office established * Hunan Provincial Convention Implementation Collaboration Group and Project Management Office established Convention	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
		disposal of POPs obsolete pesticides -A series of awareness raise campaigns organized by national and provincial level		framework – Identify and resolve potential conflicts of interest or disputes. – Involvement of NGOs and further stakeholders	implementation TCG meeting is held annually Any disputes will be settled via mutual negotiation with coordination of National Convention Implementation Coordination Group and Project Management Office as well as provincial Project Management Office. Hebei, Hubei and Hunan provincial local coordination	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				– Feedback and opinions of private stakeholders.	committees. NGOs are mainly involved for the activities of public awareness raising for POPs knowledge education and participating in various training workshops organized in this project. The major stakeholders are authorities at central government such as MEP, Ministry of Agriculture and Ministry of Health.	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					They provide feedback through the National Convention Implementation Coordination Group meeting. The other main stakeholders are the pesticide POPs waste (PPW) owners such as former pesticide plants and local governments carrying out the duty for disposal of PPW if the owner have gone bankrupt or are incapable to fulfil their	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					duty. Other stakeholders are the specialized companies of PPW clean-up and disposals. Stakeholders also include some research academies and universities who provided technical consultation for this project implementation. The project has received feedbacks from different stakeholders. For examples, the project received feedback	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					associated with the obsolete DDT disposal from The health and epidemic prevention department. The project incorporated their feedback for the obsolete DDT disposal. The project also received the feedback on obsolete pesticide disposal from Agriculture and Animal Husbandry Bureau of Changdu city, Tibet.	
Output 2.2: Institutional capacity enhanced for POPs waste management at local level						

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
2.2.1* Enhance overall institutional capacity for program development 2.2.2* Adapt and implement national policy and regulatory framework at local level 2.2.3* Develop trial local-level responsibility system for obsolete POPs pesticide management and disposal 2.2.4* Develop and test pricing mechanisms POPs waste disposal 2.2.5* Establish and	Completed Completed Completed Completed Completed	- In Hubei Province, a notice on strengthening the management of pesticide wastes was issued - National policy and regulatory framework adapted in Hebei and Hubei provinces - Treatment and disposal of POPs wastes was carried out either by self-financing in Tianjin, Chongqing and so on	S S S S S	– Develop responsibility system for obsolete POPs pesticide management and disposal. – Develop pricing mechanisms for POPs waste disposal	In Hubei Province, a bulletin on strengthening the management of pesticide wastes was issued *In Hunani Province, a sustained management document on prevention of POPs waste pollution was issued The price for POPs waste disposal is set by the market., The hazardous waste disposal firms compete and adjust	Achieved Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
implement reporting system to collect and analyze data on creation, transport, and treatment of POPs waste 2.2.6* Establish inspection and prosecution system for the discarded POPs wastes and contaminated site 2.2.7* Promote widespread local participation through increasing local input of personnel and financial	Completed Completed in Hebei and Hubei provinces Completed	-Regulation on Disposal fee of hazardous waste disposal in Hubei province - System establish within local EPBs Routine work of local EPB officers include inspection and monitoring for obsolete POPs pesticides and other	S S S	– Establish and implement reporting system to collect and analyze data on creation, transport, and treatment of POPs waste. – Establish inspection and prosecution system for the discarded POPs wastes and contaminated site. –	their pricing accordingly. The prosecution system was established. For examples, the strict law for environmental protection has been promulgated and entered into force in 2015. The law makes provitions for the prosecution and punishment of serious accidents discarding POPs wastes. Reporting and	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
resources 2.2.8* Incorporate ESM principles, norms and requirements into current EIA guidelines 2.2.9* Prepare ESM inspection manuals 2.2.10* Provide training for local solid waste management centers to implement ESM	Completed Completed in Hebei and Hubei provinces	hazardous wastes Major stakeholders including various departments (e.g. EPBs, Health, Agriculture), waste centers, etc. involved at local level Guidelines on ESM developed by CRAES Training was provided to waste centres in	S	– – – – – The increasing of local input of personnel and financial resources	processing flow of discarded POPs wastes (under the project) Complaint hotline for discarded POPs wastes and contaminated site adapted in Hebei and Hubei provinces. Hotline is open for reporting new founding PPW and illegally dealing with PPW. But so far there have been no reports torugh the hotline.	Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
		Hubei and Hebei provinces		– Adoption of EIA guidelines. – Development of ESM	Treatment and disposal of POPs wastes was carried out either by self-financing in Tianjin, Chongqing and so on (about 2 million RMB) Huaxin and Jinyu group invest in cement kiln for POPs waste disposal (about 80 million RMB) Hunan Nantian chemical plant contaminated land management and restoration project has been included in the 2016 annual soil	Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				inspection manuals	pollution prevention and control project in Hunan province.(about 170 million RMB) Evaluation the POPs contaminated site in Zhuzhou and Nantian enterprises with the method of environmental risk assessment. Guidelines on collection, packaging and transport of pesticide POPs	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
Output 2.3: Public awareness on POPs activities undertaken						
2.3.1* Develop TV and other mass media programs to disseminate knowledge of POPs 2.3.2* Publish articles or reports for public education in national and local newspapers. 2.3.3* Develop and produce brochures to raise awareness regarding health and safety protection from POPs pesticide wastes and	All activities for this output completed for Hebei and Hubei provinces	- Documentary TV films for management of DDT wastes in health field - Promotion films for POPs waste management trainings in Hubei Province and Hebei Province - News reports and documentary audio-visual materials with regard to the supervision over disposal of wastes in Hubei Province and	S	– Two TV and/or other media programs that disseminate knowledge of POPs	* Documentary TV films for management of DDT wastes in health field * Promotion films for POPs waste management trainings in Hubei Province and Hebei Province * News reports and documentary audio-visual materials with regard to the supervision over disposal of wastes in Hubei and Hebei	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
dioxin rich fly ash 2.3.4* Hold public hearings regarding POPs waste stockpile reporting, emergency response, and health and safety protection 2.3.5* Hotline established for POPs related health and safety issues		Hebei Province - Relevant reports were published in People's Daily Online, China Forum of Environmental Journalists, Hubei Daily, Chutian Golden Newspaper and so on. - 5,000 brochures were printed and distributed in Hubei province -500 souvenirs foldable knapsack and 4500 souvenirs ball pens were produced and distributed by FECO		– Sixty articles from national and/or local newspapers.	Provinces *News reports and documentary audio-visual materials with regard to the supervision over disposal of wastes in Hunan Province *Publicity brochures and films under the project. Relevant reports were published in People's Daily Online, China Forum of Environmental Journalists, Hubei Daily, Chutian Golden	Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
		- Hubei and Hubei Department of Environment Protection Hotline		– Ten thousand (10,000) brochures to raise awareness regarding health and safety.	Newspaper, UNIDO website and so on. In total over 75 articles were published in various medias. Among them, 3 research papers were published in world class research Journals, 5 research papers were orally presented in International symposiums and POPs forum in China. Two times reported in UNIDO website. At least 10 times reported in national and	Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					provincial news medias. In the three provinces including Hubei, Hebei and Hunan Provinces, 5000 brochures was distributed. In whole China, totally over 10,000 brochures was distributed. Communication and coordination meeting of project implementation process in Hubei, Hebei,	Exceeded Achieved

- Hold four hearings.
- At least 200 people attend the hearing.

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				– Hotline number/report. – 3-5 hotline staff	Hunan, Shanxi and Jilin provinces. At least 10 hearings held. Hotlines in Departments of Environment Protection of Hubei, Hebei and Hunan provinces.	
Output 3.1 Safe and effective collection, packaging, and transportation of POPs pesticide wastes for disposal adopted						
3.1.1* Identify location, type, status of POPs pesticide wastes and associated waste	All activities for this output completed for Hebei	- List of national pesticide POPs wastes - Guidelines for collection, packaging	S	– Locating the obsolete POPs pesticide, POPs waste and	Complete the list of national POPs pesticide.	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
matrices at targeted hot spots 3.1.2* Develop operating manual for collection, packaging, and transportation of the POPs pesticide waste 3.1.3* Prepare detailed terms of reference and contracts for the provincial HWDCs according to expertise in the fields	and Hubei Provinces	and transportation of pesticide POPs wastes - Working outline of Hubei and Hebei provincial solid waste centers for treatment of pesticide POPs wastes - Contract of Hubei and Hebei provincial solid waste centers for treatment of pesticide POPs wastes - Collection, packaging and transportation of 4,951.6 tons POPs pesticide wastes		contaminated site. – Operating manuals for collection, packaging, transportation and contingency plan of POPs pesticide wastes. – Detailed terms of reference and contracts for the provincial solid waste centers for	Compiled the operating manual for collection, packaging and transportation of POPs pesticide wastes Terms of references for treatment of POPs pesticide wastes from provincial solid waste centers for treatment of pesticide POPs wastes in Hubei, Hebei, Jilin, Shanxi, Hunan, Tibet and so on. Contracts for treatments	Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
of waste management and occupational health and safety 3.1.4* Provide training to staff from the provincial HWDCs concerning the collection, packaging, and transportation of the POPs pesticide wastes 3.1.5* Collect, package, and transport POPs pesticide waste from hot		- Temporary safe storage of 4,951.6 tons POPs pesticide wastes`. - To the date, the 97% of identified PPW were disposed by ESM. The remaining 5000 tons of PPW are being identified and to be disposed in next phase. - National list of pesticide POPs contaminated sites		treatment of pesticide POPs wastes. – Number of trained staff from the provincial solid waste centers for treatment of	of POPs pesticide wastes from provincial solid waste centers for treatment of pesticide POPs wastes in Hubei, Hebei, Jilin, Shanxi, Hunan, Tibet and so on. 300 staff were trained. 6327.3 tons of POPs pesticides and 42,000 tons of soils	Achieved Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
spots 3.1.6* Store POPs pesticide waste safely to prevent release of POPs contaminants to the environment				pesticide POPs wastes. – Collection, packaging and transportation of 10000 tons of POPs pesticide wastes. – Temporary safely storage of 10,000 tons of POPs pesticide wastes. – Establish and maintain the inventory of	contaminated by high levels of POPs Completed the list of contaminated sites of national POPs pesticides	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				pesticide wastes.		
Output 3.2 Assessment of technologies for POPs waste disposal carried out						
3.2.1* Detailed feasibility study for final disposal units based on the waste type, destruction efficiency, emissions, residues, energy/material requirements, portability, state of commercialization, and site selection 3.2.2* Preparation of detailed Terms of Reference for	On-going On-going	- Completed for incineration technology (cement kiln) - Non-incineration technology assessment report done by IHEP and RCEES - Completed for incineration by cement kiln - TOR and technical	S S	– Report on the feasibility of the technology and site selection for destroying POPs. – Technical specification of stationary and mobile final disposal units. – List of potential vendors of technology and	Non-incineration technology assessment report. MCD technical specifications MCD technical investigation specifications Terms of reference for MCD demonstration and	Achieved Achieved Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
technology selection and Request for Proposal from vendors		specification developed (by RCEES and IHEP)		– equipment. – Terms of reference. – Request for proposal.	technical assessment.	
Output 3.3: Technology transfer promoted through PPP mechanisms						
3.3.1* Identify potential PPP arrangements for design, construction and operation of POPs waste treatment infrastructure 3.3.2* Promote cooperative relationship among technology vendors and facility	On-going On-going	-PPP with cement kilns for incineration by co-processing (Huaxin and BBMG) - For Non-incineration technology equipment supplier seminar organized -Technical specification of Non-incineration -Completed for cement kilns	MS MS	– Identification of PPP arrangements of potential construction and operation of POPs waste treatment infrastructure in China.	Feasibility study on PPP adoption in POPs waste treatment infrastructure in China.	Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
designers, constructors, and operators to achieve cost-effective options		-Not yet initiated for non-combustion		– Organized workshops to introduce technology transfer/ concept of PPP and promote the discussion of the PPP arrangements of POPs wastes. – Establishment of cooperative relationship (Joint captial) or similar cooperative relationship.	Seminar of technology of non-incineration and vendors. Contracts for MCD demonstration and technical assessment.	Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
Output 3.4: Construction, certification, operation and supervision of stationary and mobile treatment facilities arranged						
3.4.1* Environmental Impact Assessment (EIA) for one stationary and one mobile unit 3.4.2* Invite bids from potential vendors to transport POPs wastes and operate disposal facilities	On-going On-going On-going	- Facility upgraded at Huaxin Environmental Protection Engineering Co., Ltd., BBMG Mangrove Environmental Protection Technology Co., Ltd. Mobile unit: not yet initiated Stationary: Huaxin Cement and BBMG selected; Mobile unit: Not yet initiated	S MS MS	– Environmental Impact Assessment (EIA) of constructing the stationary disposal facilities for POPs wastes. – Environmental Impact Assessment (EIA) of constructing infrastructure of mobile disposal facilities.	Risk assessment of reconstruction of cement kiln [environmental impact assessment of Huaxin (Wuxue) and Jinyu mangrove (Yanxin, Zhuolu and Lingchuan] EIA of Huaxin (Wuxue) Environmental Protection Engineering Co. Yanxin Environmental Co, Zhuolu Environmental	Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
3.4.3* Prepare disposal sites for deployment of selected technology, including construction of storage facility and commissioning of equipment 3.4.4 Installation of the stationary unit at the selected site and mobile unit at selected base stations 3.4.5* Transportation of POPs waste to the POPs treatment locations in	Completed for fixed unit (cement kiln)	-Huaxin cement and BBMG invested to upgrade cement kiln; mobile unit: not yet initiated Huaxin cement and BBMG invested to upgrade cement kiln; mobile unit: process not yet initiated - 4,951.6 tons pesticide wastes are safely transported to the designated sites (Hebei and Hubei provinces) - Environmentally	MS MS HS MS HS	– Identify qualified vendors for transporting and disposing POPs wastes and the contracts. – Site preparation for waste disposal – Construction and pre-operation of storage facility – Construction and installation of the	Co, Linchuan Environmental Co. Contracts for transportation and treatment Contracts for transportation and treatment Contracts for transportation and treatment	Achieved Achieved Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
an environmentally sound manner 3.4.6 Final disposal of POPs pesticide wastes in an environmentally sound way 3.4.7 Monitoring during facility construction and operation		sound disposal of 4,951.6 tons pesticide wastes by cement kilns -Monitoring done by EPB officers and technical experts for upgrading of cement kilns: mobile unit: process not yet initiated -Investment by BBMG and Huaxin for cement kilns		stationary disposal facilities for POPs wastes – Construction and installation of the mobile disposal facilities for POPs wastes at selected site	* Dispose POPs wastes by technical innovation of cement klin in Huaxin and Jinyu group * Dispose POPs wastes by technical innovation of cement klin in Hebei Jinyu mangrove group Constructed one set of non-incineration POPs equipment (demonstration contract and report of Tsinghua University).	Achieved Exceeded Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
3.4.8 Establishment of equipment ownership arrangements				– Transport 10000 tons of pesticide wastes to the specified stationary facilities or mobile units – Treatment of 10000 tons of pesticide wastes by environmentally sound methods. – Equipment purchase, infrastructure construction, equipment installation and operation	6327.3 tons of POPs pesticide wastes and 42,000 tons of soils contaminated by high levels of POPs. Dispose POPs wastes by technical innovation of cement kiln in Huaxin group Dispose POPs wastes by	Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					technical innovation of cement kiln in Hebei Jinyu mangrove group (Yan Xin) Dispose POPs wastes by technical innovation of cement kiln in Hebei Jinyu mangrove group (Zhu Lu) Dispose POPs wastes by technical innovation of cement kiln in Hebei Jinyu mangrove group (Ling Chuan) The ownership for the pesticide POPs disposal, co-processing MSWI fly	

- Ownership of equipment and scope of operation
- Ownership arrangements of equipment

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					ash containing dioxins and ball mining technique rests in respective companies and universities that are in charge of their operation and maintenance. For examples, cement kilns purchased the equipment for co-processing MSWI fly ash (containing dioxins). At least four cement plants have installed the capacity for the POPs waste disposal by	

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
					cement kilns.	
Output 3.5: Dioxin rich fly ash disposal implemented						
3.5.1 Target province selected for non-landfill pilot disposal of dioxin rich fly ash	On-going	- The technical assessment is completed -Candidate demonstration technologies are selected -the proposal for technology demonstration is completed	S	– Report of target province selection – Operation manual – Number of trained staffs from selected province – Training materials – Safely dispose 1000 tons of fly ash by	Investigation report of technology of fly ash dispose Operation procedures for water washing and co-processing of fly ash in cement kiln. 500 people were trained. Training materials	Achieved Achieved Exceeded Exceeded

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
				non-landfill technique	Disposed 9600 tons of fly ash by environmentally sound methods.	
Output 4.1: Inventory of contaminated sites prioritized						
4.1.1* Review existing national and international best practice guidelines for human health and ecological risk assessment 4.1.2* Develop a project-fit methodology, including QA/QC procedures for quantitative	Completed On-going Completed for Hebei	- Inventory of pesticides POPs waste contaminated sites were summarized. - Environmental safety assessment on the storage point of POPs wastes in Hebei and Hubei was conducted - Environmental safety assessment on some of	MS	– International peer communication about experience of the QERA of POPs contaminated sites. – Method development for evaluating the QERA of POPs contaminated sites	The reports about international communications Guidance on the investigation of contaminated sites (HJ25.1-2014); Guidance on the monitoring of	Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
environmental risk assessment (QERA) 4.1.3* Train staff in provincial solid waste management centers 4.1.4 Carry out on-site surveys following removal activities, focusing on identification of exposure scenarios	and Hubei provinces On-going	the storage points of POPs wastes in Hubei was conducted - The site risk assessment is ongoing for pesticide plant used to produce DDT and HCH in Hunan - The site risk assessment is ongoing for a storage house holding HCH and Arsenic mixed waste in Hunan - New Zealand Visit for investigation and exchange on the		under this project. – Training content, course, teachers and license. – The number of returned questionnaire. – The reports of risk assessments for POPs contaminated	contaminated sites (HJ25.2-2014); Guidance on the risk assessment techniques of contaminated sites (HJ25.3-2014). Several important training courses were organized. The risk assessment evaluation reports for POPs contaminated sites in Zhuzhou and Nantian were completed.	Achieved Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
		management of POPs and associated chemicals and contaminated sites. During this investigation, they communicated the POPs non-incineration treatment and disposal technology assessment methodology and its main progress with relevant state ministries and research institutes, and communicated the research and		sites. – Lists of the prioritization for regulating the POPs contaminated sites. – Database for reporting the QERA information of POPs contaminated sites	The list of priorization of POPs contaminated sites in Hunan province was completed. The database of POPs contaminated sites was established under this project.	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
		application progress of MCD technologies in the restoration of the contaminated soil with EDL.				
Output 4.2 Establishment and maintenance of an Internet-based information processing, display and dissemination system in place						
4.2.1 Design Internet-based system to process and display QERA results and facilitate modeling of environmental risks and remediation decision-making 4.2.2 Purchase, install, and test system,				- Data collection based on Internet. - Report - The input of data - Staffs who could maintain the system in the project offices and local environmental	MIS system was constructed.	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
maximizing use of existing hardware, software, and topographic data from the current POPs MIS 4.2.3 Input data and operate, maintain and update system 4.2.4 Conduct internet-based training and software dissemination				– protection agencies		
Output 5.1: Project management structure established						
5.1.1* Establish Project Steering Group 5.1.2* Establish the National Project	Completed Completed	Existing CICG Team established within CIO	HS HS	– The establishment of the coordinate group for implementing convention on	One coordinated group on national scale and three provincial coordinated groups	Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
Management Team under CIO 5.1.3* Recruit Chief Technical Advisor (CTA), a National Technical Advisor (NTA), policy experts, and technical experts in POPs waste management, evaluation, and program development 5.1.4* Establish local project management offices in target provinces	Completed Completed Completed	NTA (From RCEES) recruited. No CTA recruited PMOs established in Hubei and Hebei provinces Training conducted in Hubei and Hebei	S S S	national and local scales. – Team construction for POPs management. – The construction for the essential office facilities. – Team construction of national experts – Establish three project management office on local scale	were constructed. Completed. Completed Completed Three project management offices on provincial scale were constructed. Five times coordinating	Achieved Achieved Achieved Achieved Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
5.1.5* Hold management training classes for national and local project management staff		provinces		– The management of contracts associated with POPs waste project. Training courses about the method, tool and basic knowledge	group meeting were organized.	
Output 5.2 An M&E mechanism designed and implemented according to GEF M&E procedures						
5.2.1 & 5.2.2* Hold the Inception Workshop and Report 5.2.3 Measure impact indicators on an annual basis	Completed On-going On-going	Inception workshop held on 20 August 2009 and attended by more than 100 participants- Report available Discussed in annual reports	HS MS S	– Project launch seminar. – Workplan – Input of data and	Completed Eight annual project reports have been completed Ongoing	Achieved Achieved Achieved Achieved,

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
5.2.4 Prepare Annual Project Reports and Project Implementation Reviews 5.2.5 Hold annual tripartite review meetings 5.2.6 Hold biannual Steering group meetings 5.2.7 Carry out mid-term external evaluation 5.2.10 Carry out annual project financial audits 5.2.11 Carry out biannual visits to	On-going On-going On-going On-going Completed	PIRs and annual reports produced Tripartite meeting held on 26 Feb 2013 Meeting held as planned Midterm evaluation on-going Beijing Kuntaironghe Certified Public Accountants Co., Ltd. entrusted to undertake financial audit for the third year Field visits undertaken	S S S S S S	information into the MIS system – Recognition and remediation of problem and errors – Guidance on the techniques and policies of project coordination group – Summarization of experiences and recommendations	Ongoing Ongoing Ongoing Ongoing – The MIS has been	annual tripartite meeting held each year. Achieved Achieved, annual audits carried out each year Achieved

Activities	Status at mid-term	Progress at mid-term	Mid-term Rating	Targets of activities and outputs at project end (such as people trained, regulations or standards developed, firms reached, technologies introduced, etc)	Progress at project end	Rating at exit and Comments
selected field sites 5.2.12* Establish a project management information system (MIS), including a project website		by PM accompanied by PMT (CIO/FECO) Project website: http://www.china-pops.org/: Seems that English version of website not working.		– Problems and suggestions by the field investigations – The construction of MIS system and their applications – Project information, experiences and lessons delivered by the internet	installed, tested, and used for promoting the use of existing hardware, software, and topographic data from the current POPs. Websites introduced	Achieved Achieved

Annex 7: Project expenditures, China POPs project (June 2018)

	Budget	Expenditure
Outcome 1 Strengthened legal and regulatory framework for environmentally sound management (ESM) and disposal of POPs waste	852,400.00	750,760.54
Outcome 2: Improved institutional capacity at all levels of POPs waste disposal management	924,000.00	800,718.59
Outcome 3: Environmentally sound disposal of targeted POPs pesticide waste and dioxin rich incinerator fly ash	7,063,600.00	7,115,971.59
Outcome 4 Qualitative environmental risk assessment (QERA) site prioritization	642,500.00	605,933.86
Outcome 5. Project management, monitoring and evaluation	476,500.00	661,038.08
GRAND TOTAL	9,959,000.00	9,934,422.66

Annex 8: Terms of reference

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

TERMS OF REFERENCE

Independent terminal evaluation of project

[Title]

UNIDO Project ID: 104147
GEF Project ID: 2926

April 2018

Contents

I. PROJECT BACKGROUND AND CONTEXT

1. Project factsheet[14][15]

Project title	[Title]
UNIDO ID	104147
GEF Project ID	2926
Region	Asia and the Pacific
Country(ies)	China
Project donor(s)	GEF
Project implementation start date	4/4/2009
Expected duration	5 years
Expected implementation end date	30 June 2018
GEF Focal Areas and Operational Project	GEF Operational Program on POPs – OP 14
Implementing agency(ies)	UNIDO
Government coordinating agency	China Ministry of Environmental Protection (MEP)
Executing Partners	MEP/Foreign Economic Cooperation Office (FECO)
UNIDO RBM code	GC33 (Implementation of MEA)
Donor funding	9,973,000 (excluding PPG)
Project GEF CEO endorsement / approval date	15/12/2008
UNIDO input (in kind, USD)	In kind 100,000
Co-financing at CEO Endorsement, as applicable	MEP (cash & in-kind) MOF (cash) Local EPBS (cash & in-kind) Pesticides owners and other private sectors (cash & in-kind)
Total project cost (USD), excluding support costs and PPG	42,073,000
Mid-term review date	March 2014
Planned terminal evaluation date	May 2018

(Source: Project document)

2. Project context

China has urgent need of an on the ground program for managing stockpiles of obsolete POPs pesticides and associated contaminated wastes in an environmentally sound manner. China's large agricultural sector with its heavy

[14] Data to be validated by the Consultant

[15] Different data for implementation start date: July 2009 according to mid-term review and October 2011 according to UNIDO Open Data Platform as of August 2017

dependence on agro-chemicals resulted in about 574,000 tons of POPs pesticides being manufactured up to 2004 when production was banned. Although POPs pesticides production has been prohibited by domestic regulations, the lack of a targeted national program providing capacity building and technical assistance to manage these chemicals has resulted in significant stockpiling of obsolete POPs pesticides.

Based on the research and surveys conducted in conjunction with the preparation of this 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. In the past, plant owners and end users have been largely unregulated and responsible for managing their own POPs pesticides, which 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.

The absence of adequate capacity and infrastructure for environmentally sound management (ESM) and disposal of POPs pesticide wastes in China poses significant risks to human health and the environment. In most POPs pesticide manufacturing plants and end user sites, there are no storage facilities specifically designed for obsolete pesticides and pesticide wastes. Large amounts of obsolete POPs pesticides are not therefore often stored in proper conditions, such as outdoor storage, simple enclosure, or open-air disposal with municipal solid waste, all of which constitute a serious threat to human health. This serious risk of environmental contamination and human exposure is further exacerbated by natural disaster, such as the flooding and earthquakes, which China has recently experienced.

Current practices for hazardous waste disposal have been dominated by incineration and therefore generate secondary pollution such as dioxins and furans. It is estimated that fly ash containing a high level of dioxin from incineration of hazardous wastes and medical wastes amounts to 11,000 tons per annum. Incineration plants generally dispose of this dioxin rich fly ash in open dumps or non-sanitary landfills mixed with municipal wastes, thereby increasing the potential POPs pollution risk to water resources.

The Chinese government acceded to the Stockholm Convention on May 23, 2001. The Tenth National People's Congress Standing Committee ratified the Stockholm Convention on June 25, 2004. Under Article 6(1) (c), China is required to manage POPs wastes in an environmentally sound manner. However, surveys and reports have shown that lack of institutional, technical, and financial capacity inhibits the sound management of obsolete POPs pesticides and associated wastes.

The project document provides detailed information on the POP types, quantities and manufacturers, as well as on the regulatory environment in the People's Republic of China.

3. Project objective and expected outcomes

The project's overall objective is to implement environmentally sound management (ESM) and disposal of 10,000 tons of accumulated POPs pesticide wastes and 1,000 tones dioxin rich incinerator fly-ash in fulfilment of China's obligations under the Stockholm Convention. If not addressed, the presence of these geographically dispersed accumulations of POPs wastes constitutes a significant source and ongoing pathway risk to environmental receptors, particularly groundwater and surface water resources, with concomitant negative impact on human and ecosystem health.
The immediate objectives of the project are to:

- Strengthen the legal and regulatory framework for environmentally sound management (ESM) and disposal of POPs waste;
- Improve institutional capacity at all levels of POPs waste disposal management;
- Remove POPs pesticide wastes dioxin rich incinerator fly ash from targeted contaminated sites, and transport them to disposal unit;
- Dispose of wastes in an environmentally sound manner
- Complete qualitative environmental risk assessment (QERA) site prioritization.

Expected Outcomes:
According to the project document, five substantive outcomes were envisaged to achieve the project objectives:
Outcome 1: Strengthened legal and regulatory framework for environmentally sound management (ESM) and disposal of POPs waste. Current laws and regulations do not specifically address POPs pesticide wastes and dioxin-rich fly ash, and were not designed in view of China's obligations under the Stockholm Convention. The project will work with legislative and regulatory agencies to modify existing laws and regulations and, where necessary, develop new regulatory approaches to specifically address POPs pesticide wastes and dioxin-rich fly ash.
Outcome 2: Improved institutional capacities at all levels of POPs waste disposal management. POPs pesticide waste and dioxin-rich fly ash generators and contaminated site owners are often unaware of the potential environmental, legal, and human health risks that their current and past operations entail. In addition, waste generators and owners lack the managerial and technical capacity to manage POPs wastes in an environmental sound manner.
Outcome 3: Environmentally sound disposal of targeted POPs pesticide waste and dioxin rich incinerator fly ash. Activities under this outcome will include training and technical support for identification and characterization of POPs wastes at target sites, collection of those wastes, containment for safe storage and transportation, transportation of wastes to designated treatment facilities, and survey of hot spot sites to confirm their successful remediation.
Outcome 4: Qualitative environmental risk assessment (QERA) site prioritization. Activities under this outcome will include training and technical assistance to

establish an inventory of contaminated sites, prepare human health and ecological risk assessment, carry out site surveys, identify POPs exposure scenarios and concentrations, perform GIS analysis, collect necessary data, and complete a quantitative environmental risk assessment, and train CIO staff to maintain the system and transfer it to EPBs. The result of China's first soil pollution survey jointly launched in July 2006 by MEP and the Ministry of Land and Resources will be fully considered in the QERA.

Outcome 5: Project management, monitoring and evaluation. Establishment of a Steering Group composed of national and local stakeholder agencies, establishment and staffing of the project management team at the national and local levels, recruitment of national and international consultants, execution of a management training program for project staff (particularly at the local level), and ongoing monitoring and reporting of project activities.

These outcomes were planned to be achieved through the production of 14 outputs.

4. Project implementation arrangements

UNIDO is the GEF Implementing Agency (IA) for the project. A project focal point was to be established within UNIDO to assist with project execution. This focal point was to include dedicated core staff, supplemented by support from professional and support staff colleagues on a part-time as needed basis, including in particular senior staff engaged in the management and coordination of UNIDO's POPs program. UNIDO makes these services available as part of its in-kind contribution to the project.

The project management structure as designed is provided in Figure 16.

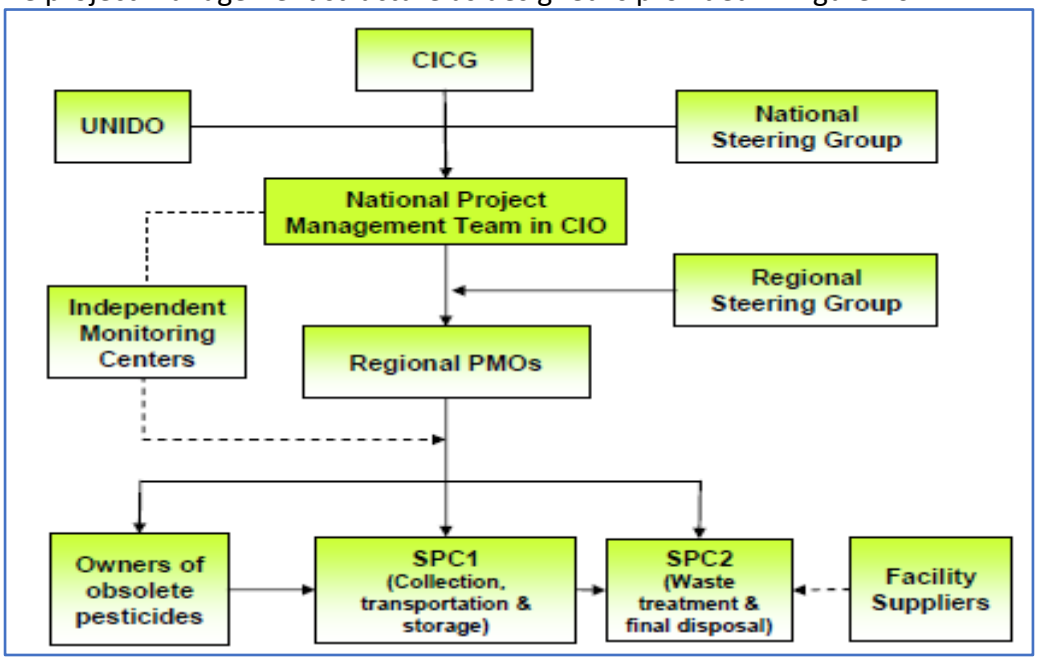

Figure 16. Project Organogram

The **Convention Implementation Coordination Group (CICG)**. China established the National NIP Development Leading Group in September 2003. This Group became the National Leading Group for Implementation of the POP Convention when China ratified the Convention on 13 August 2004, which was formally approved by State Council in April 2005 and renamed the National Technical Coordination Group (TCG) for Implementation of the Stockholm Convention, or Convention Implementation Coordination Group (CICG). The CICG provides (i) review of significant policies related to POPs management and control, (ii) guidance and coordination for POPs management activities and Convention implementation. The CICG consists of the following 13 agencies:

i. Ministry of Environmental Protection (MEP)
ii. Ministry of Foreign Affairs (MOFA)
iii. National Development and Reform Commission (NDRC)
iv. Ministry of Finance (MOF), which is the GEF Focal Point in China
v. Ministry of Commerce (MOCom)
vi. Ministry of Science and Technology (MOST)
vii. Ministry of Agriculture (MOA)
viii. Ministry of Public Health (MOH)
ix. Ministry of Housing and Urban-Rural Development (MOHURD)
x. General Administration of Customs (GAC)
xi. State Electricity Regulatory Commission (SERC)
xii. General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ)
xiii. State Administration of Work Safety (SAWS)

UNIDO coordinates all POPs activities of all UN, multi- and bilateral POPs activities in the country, jointly with the Ministry of Environmental Protection (MEP) through the annual Technical Coordination Group (TCG) meetings. This includes World Bank, UNDP, UNITAR, UNEP and others.

Convention Implementation Office (CIO). The CIO is part of MEP and is responsible for coordinating the day-to-day management of the Stockholm Convention implementation in China.

National, Provincial and Municipal Steering Groups. The project was to establish a national steering group by drawing upon resources from related ministries or commissions in charge of development and reform, environment, health, construction, and pricing to provide the project team with political guidance and inter-ministerial coordination support. To facilitate the extensive demonstration and replication activities at provincial and municipal levels, the National Steering Group is to encourage and assist provincial and municipal governments in the establishment and operation of their own corresponding steering groups.

National Project Management Team (NPMT), composed of staff from MEP, NDRC, MOHURD and other relevant agencies. MEP is to designate a coordinator/team leader. The Project Management Team is responsible for the day-to-day management and execution of the project, and oversees local project management offices.

Project Expert Team (PET). The project was to recruit an international **Chief Technical Advisor (CTA)**, a **National Technical Advisor (NTA)**, policy experts, waste management industry experts, chemists, monitoring & evaluation experts and other technical experts. These experts form a Project Expert Team to assist the CIO and NPMT.

Regional Project Management Offices (PMOs) are responsible for coordination of project activities that transcend provincial boundaries. The project involves a large number of obsolete pesticides owners, incinerator fly ash owners and dedicated treatment and disposal facilities operating across municipal and provincial lines. Regional PMOs are to be composed of staff from relevant provincial governmental agencies.

Private sector stakeholders and other potential project participants were meant to be recruited and integrated into the project, including waste owners, waste transporters and treatment and disposal facilities, private sector contractors and end-users.

5. Main findings of the Mid-term review (MTR)

The relevance of the project to China's National Program of Disposal Facilities Construction for Hazardous Wastes and Medical Wastes Treatment (NPDFCHWMW) was deemed high. The project also was supporting China to meet the objectives as set in its National Implementation Plan (NIP) and in complying with the Stockholm Convention.

Effectiveness of the project was considered highly satisfactory:

- The regulatory framework has been strengthened for the sound management of obsolete POPs pesticides and wastes
- Guidelines for ESM of obsolete POPs pesticides stocks and wastes had been developed
- Capacity had been built for the destruction of POPs and other hazardous wastes in the Hubei and Hebei provinces through significant investment of private partners (Huaxin Environment Company and Jinyu Mangrove Environmental Protection Company) to upgrade cement kilns.
- At midterm, 4,951.6 tons of POPs pesticides and wastes had already been packed, transported and soundly disposed of at the upgraded cement kilns.

However, delays had been encountered for delivery of the mobile unit for destruction of POPs pesticides and wastes using non-combustion technology.

Involvement of the major stakeholders at midterm had been highly satisfactory. At national and provincial levels, the relevant ministries and departments (e.g. Health, Environment, EPBs, etc.) are members of steering groups. At provincial level, waste centres and private partners (cement kilns) are key partners of the project. Experts from leading academic and research Chinese institutions (e.g. Tsinghua University, CRAES, RCEES, IHEP, etc.) have been recruited to provide technical expertise or service.

The project was being efficiently executed by CIO/FECO and adequately

supervised and guided by UNIDO. And at midterm, project implementation had been cost-effective owing to a number of factors and chances of sustainability were deemed high. The overall rating for the project based on the evaluation findings was Highly Satisfactory

Recommendations included:

- All identified contaminated sites should be properly safeguarded and the population living in the vicinity should be adequately informed in order to minimize / eliminate risk of exposure.
- Assist the local authorities to put in place a mechanism and long-term strategy for the remediation of the contaminated site near the pesticide factory in Hunan.
- A no cost two-year extension should be given to allow for the completion of activities for delivery of the mobile unit for which the Mechano-Chemical Dechlorination (MCD) technology.
- Ensure that planned co-financing materializes.
- Summarize successful replication experiences and lessons as basis for project implementation in other provinces for the second phase.
- Ensure that regulations and guidelines for ESM of obsolete POPs pesticides stocks and wastes and other hazardous wastes are enforced at all levels.

6. Budget information

Table 1. Financing plan summary

USD	Project Preparation	Project	Total (USD)
Financing (GEF / others)	Click here to enter text.	9,973,000	**9,973,000**
Co-financing (Cash and In-kind)	Click here to enter text.	32,100,000	32,100,000
Total (USD)	Click here to enter text.	**42,073,000**	**42,073,000**

Source: Project document / progress report

Table 2. Financing plan summary - Outcome breakdown[16]

Project outcomes	Donor (GEF/other) (USD)	Co-Financing (USD)	Total (USD)
1. Strengthened legal and regulatory framework for environmentally sound management(ESM) and disposal of POPs waste	852,600	2,069,650	**2,922,250**
2. Improved institutional capacity at all levels of POPs waste disposal management	953,100	1,841,175	**2,794,275**

[16] Source: Project document.

Project outcomes	Donor (GEF/other) (USD)	Co-Financing (USD)	Total (USD)
3. Environmentally sound disposal of targeted POPs pesticide waste and dioxin rich incinerator fly ash	7,074,000	26,400,825	**33,474,825**
4. Qualitative environmental risk assessment (QERA) site prioritization	584,700	1,051,100	**1,635,800**
5. Project management, monitoring and evaluation	508,600	737,250	**1,245,850**
Total (USD)	**9,973,000**	**32,100,000**	**42,073,000**

Source: Project document / progress report

Table 3. Co-Financing source breakdown

Name of Co-financier (source)	In-kind	Cash	Total Amount (USD)
Central Government (MEP) Central Government (MOF)	6,180,000	220,000 3,900,000	6,400,000 3,900,000
Local EPBs	6,370,000	1,030,000	8,168,779
Private sectors	8,320,000	5,980,000	12,228,386
UNIDO	100,000		100,000
Total Co-financing (USD)	**20,970,000**	**11,130,000**	**32,100,000**

Source : Project document

Table 4. UNIDO budget execution (Grant 200000228)

Items of expenditure	2012	2013	2014	2015	2016	2017	2018	Total expenditure
Contractual Services	8,606,980	599,000						9,205,980
International Meetings	28,950					-1,667		27,283
Local travel	26,457	45,275	13,483	-1,939	19,699	24,449	2,655	130,079
Nat. Consult./Staff	14,960	5,821	-24					20,758
Other Direct Costs	28,087	39	15	-137		-371		27,634
Staff & Intern Consultants	231,192	28,363	-2,812			100,638	47,880	405,261
Train/Fellowship/Study	9,717							9,717
Grand Total	**8,946,344**	**678,498**	**10,662**	**-2,076**	**19,699**	**123,049**	**50,535**	**9,826,712**

Source: UNIDO Project Management database as of 25 January 2018

II. Scope and purpose of the evaluation

The purpose of the evaluation is to independently assess the project to help UNIDO improve performance and results of ongoing and future programmes and projects. The terminal evaluation (TE) will cover the whole duration of the project from its starting date in 4/4/2009 to the estimated completion date in 30/6/2018.

The evaluation has two specific objectives:

(i) Assess the project performance in terms of relevance, effectiveness, efficiency, sustainability and progress to impact; and
(ii) Develop a series of findings, lessons and recommendations for enhancing the design of new and implementation of ongoing projects by UNIDO.

III. Evaluation approach and methodology

The TE will be conducted in accordance with the UNIDO Evaluation Policy[17] and the UNIDO Guidelines for the Technical Cooperation Project and Project Cycle[18]. In addition, the GEF Guidelines for GEF Agencies in Conducting Terminal Evaluations, the GEF Monitoring and Evaluation Policy and the GEF Minimum Fiduciary Standards for GEF Implementing and Executing Agencies will be applied.

The evaluation will be carried out as an independent in-depth evaluation using a participatory approach whereby all key parties associated with the project will be informed and consulted throughout the evaluation. The evaluation team leader will liaise with the UNIDO Independent Evaluation Division (ODG/EIO/IED) on the conduct of the evaluation and methodological issues.

The evaluation will use a theory of change approach and mixed methods to collect data and information from a range of sources and informants. It will pay attention to triangulating the data and information collected before forming its assessment. This is essential to ensure an evidence-based and credible evaluation, with robust analytical underpinning.

The theory of change will identify causal and transformational pathways from the project outputs to outcomes and longer-term impacts, and drivers as well as barriers to achieve them. The learning from this analysis will be useful to feed into the design of the future projects so that the management team can effectively manage them based on results.

1. Data collection methods

Following are the main instruments for data collection:

(a) **Desk and literature review** of documents related to the project, including but not limited to:
- The original project document, monitoring reports (such as progress and financial reports, mid-term review report, output reports, back-to-

[17] UNIDO. (2015). Director General's Bulletin: Evaluation Policy (UNIDO/DGB/(M).98/Rev.1)

[18] UNIDO. (2006). Director-General's Administrative Instruction No. 17/Rev.1: Guidelines for the Technical Cooperation Programme and Project Cycle (DGAI.17/Rev.1, 24 August 2006)

office mission report(s), end-of-contract report(s) and relevant correspondence.
- Notes from the meetings of committees involved in the project.

(b) **Stakeholder consultations** will be conducted through structured and semi-structured interviews and focus group discussion. Key stakeholders to be interviewed include:
- UNIDO Management and staff involved in the project; and
- Representatives of donors, counterparts and stakeholders.

(c) **Field visit** to project sites in the People's Republic of China.

2. Evaluation key questions and criteria

The key evaluation questions are the following:

(b) What are the key drivers and barriers to achieve the long-term objectives? To what extent has the project helped put in place the conditions likely to address the drivers, overcome barriers and contribute to the long-term objectives?

(c) How well has the project performed? Has the project done the right things? Has the project done things right, with good value for money?

(d) What have been the project's key results (outputs, outcome and impact)? To what extent have the expected results been achieved or are likely to be achieved? To what extent the achieved results will sustain after the completion of the project?

(e) What lessons can be drawn from the successful and unsuccessful practices in designing, implementing and managing the project?

The evaluation will assess the likelihood of sustainability of the project results after the project completion. The assessment will identify key risks (e.g. in terms of financial, socio-political, institutional and environmental risks) and explain how these risks may affect the continuation of results after the project ends. Table below provides the key evaluation criteria to be assessed by the evaluation. The details questions to assess each evaluation criterion are in annex 2.

Table 5. Project evaluation criteria

#	Evaluation criteria	Mandatory rating
A	**Impact**	**Yes**
B	**Project design**	**Yes**
1	• Overall design	Yes
2	• Logframe	Yes
C	**Project performance**	**Yes**
1	• Relevance	Yes
2	• Effectiveness	Yes
3	• Efficiency	Yes
4	• Sustainability of benefits	Yes
D	**Cross-cutting performance criteria**	

#	Evaluation criteria	Mandatory rating
1	• Gender mainstreaming	Yes
2	• M&E: ✓ M&E design ✓ M&E implementation	Yes
3	• Results-based Management (RBM)	Yes
E	**Performance of partners**	
1	• UNIDO	Yes
2	• National counterparts	Yes
3	• Donor	Yes
F	**Overall assessment**	Yes

Performance of partners

The assessment of performance of partners will ***include*** the quality of implementation and execution of the GEF Agencies and project executing entities (EAs) in discharging their expected roles and responsibilities. The assessment will take into account the following:

- Quality of Implementation, e.g. the extent to which the agency delivered effectively, with focus on elements that were controllable from the given GEF Agency's perspective and how well risks were identified and managed.
- Quality of Execution, e.g. the appropriate use of funds, procurement and contracting of goods and services.

Other Assessments required by the GEF for GEF-funded projects:

The terminal evaluation will assess the following topics, for which ***ratings are not required***:

a. **Need for follow-up**: e.g. in instances financial mismanagement, unintended negative impacts or risks.
b. **Materialization of co-financing**: e.g. the extent to which the expected co-financing materialized, whether co-financing was administered by the project management or by some other organization; whether and how shortfall or excess in co-financing affected project results.
c. **Environmental and Social Safeguards**[19]: appropriate environmental and social safeguards were addressed in the project's design and implementation, e.g. preventive or mitigation measures for any foreseeable adverse effects and/or harm to environment or to any stakeholder.

[19] Refer to GEF/C.41/10/Rev.1 available at: http://www.thegef.org/sites/default/files/council-meetingdocuments/ C.41.10.Rev_1.Policy_on_Environmental_and_Social_Safeguards.Final%20of%20Nov%2018.pdf

3. Rating system

In line with the practice adopted by many development agencies, the UNIDO Independent Evaluation Division uses a six-point rating system, where 6 is the highest score (highly satisfactory) and 1 is the lowest (highly unsatisfactory) as per Table 6.

Table 6. Project rating criteria

Score		Definition	Category
6	Highly satisfactory	Level of achievement clearly exceeds expectations and there is no shortcoming.	SATISFACTORY
5	Satisfactory	Level of achievement meets expectations (indicatively, over 80-95 per cent) and there is no or minor shortcoming.	
4	Moderately satisfactory	Level of achievement more or less meets expectations (indicatively, 60 to 80 per cent) and there are some shortcomings.	
3	Moderately unsatisfactory	Level of achievement is somewhat lower than expected (indicatively, less than 60 per cent) and there are significant shortcomings.	UNSATISFACTORY
2	Unsatisfactory	Level of achievement is substantially lower than expected and there are major shortcomings.	
1	Highly unsatisfactory	Level of achievement is negligible and there are severe shortcomings.	

IV. Evaluation process

The evaluation will be conducted from April to June 2018. The evaluation will be implemented in five phases which are not strictly sequential, but in many cases iterative, conducted in parallel and partly overlapping:

i. Inception phase: The evaluation team will prepare the inception report providing details on the methodology for the evaluation and include an evaluation matrix with specific issues for the evaluation; the specific site visits will be determined during the inception phase, taking into consideration the findings and recommendations of the mid-term review.
ii. Desk review and data analysis;
iii. Interviews, survey and literature review;
iv. Country visits;
v. Data analysis and report writing.

V. Time schedule and deliverables

The evaluation is scheduled to take place from April to June 2018. The evaluation field mission is tentatively planned for 14-25 May 2018. At the end of the field

mission, there will be a presentation of the preliminary findings for all stakeholders involved in this project in China. The tentative timelines are provided in Table 7.

After the evaluation field mission, the evaluation team leader will visit UNIDO HQ for debriefing and presentation of the preliminary findings of the terminal evaluation. The draft TE report will be submitted 4 to 6 weeks after the end of the mission. The draft TE report is to be shared with the UNIDO PM, UNIDO Independent Evaluation Division, the UNIDO GEF Coordinator and GEF OFP and other stakeholders for receipt of comments. The ET leader is expected to revise the draft TE report based on the comments received, edit the language and form and submit the final version of the TE report in accordance with UNIDO ODG/EIO/EID standards.

Table 7. Tentative timelines

Timelines	Tasks
3 April – 3 May 2018	Desk review and writing of inception report
Before 11 May 2018	Briefing with UNIDO project manager and the project team based in Vienna through Skype
Week 14 and 21 May 2018	Field visit to China
18-19 June 2018 20 June 2018	Debriefing in Vienna Preparation of first draft evaluation report
20 June – 6 July 2018	Internal peer review of the report by UNIDO's Independent Evaluation Division and other stakeholder comments to draft evaluation report
30 July 2018	Final evaluation report

VI. Evaluation team composition

The evaluation team will be composed of one international evaluation consultant acting as the team leader and one national evaluation consultant. The evaluation team members will possess relevant strong experience and skills on evaluation management and conduct together with expertise and experience in innovative clean energy technologies. Both consultants will be contracted by UNIDO.

The tasks of each team member are specified in the job descriptions annexed to these terms of reference. The ET is required to provide information relevant for follow-up studies, including terminal evaluation verification on request to the GEF partnership up to three years after completion of the terminal evaluation.

According to UNIDO Evaluation Policy, members of the evaluation team must not have been directly involved in the design and/or implementation of the project under evaluation.

The UNIDO Project Manager and the project team in the People's Republic of

China will support the evaluation team. The UNIDO GEF Coordinator and GEF OFP(s) will be briefed on the evaluation and provide support to its conduct. GEF OFP(s) will, where applicable and feasible, also be briefed and debriefed at the start and end of the evaluation mission.
An evaluation manager from UNIDO Independent Evaluation Division will provide technical backstopping to the evaluation team and ensure the quality of the evaluation. The UNIDO Project Manager and national project teams will act as resourced persons and provide support to the evaluation team and the evaluation manager.

VII. Reporting

Inception report

This Terms of Reference (ToR) provides some information on the evaluation methodology, but this should not be regarded as exhaustive. After reviewing the project documentation and initial interviews with the project manager, the Team Leader will prepare, in collaboration with the national consultant, a short inception report that will operationalize the ToR relating to the evaluation questions and provide information on what type of and how the evidence will be collected (methodology). It will be discussed with and approved by the responsible UNIDO Evaluation Manager.
The Inception Report will focus on the following elements: preliminary project theory model(s); elaboration of evaluation methodology including quantitative and qualitative approaches through an evaluation framework ("evaluation matrix"); division of work between the International Evaluation Consultant and national consultant; mission plan, including places to be visited, people to be interviewed and possible surveys to be conducted and a debriefing and reporting timetable[20].

Evaluation report format and review procedures

The draft report will be delivered to UNIDO's Independent Evaluation Division (the suggested report outline is in Annex 4) and circulated to UNIDO staff and national stakeholders associated with the project for factual validation and comments. Any comments or responses, or feedback on any errors of fact to the draft report provided by the stakeholders will be sent to UNIDO's Independent Evaluation Division for collation and onward transmission to the project evaluation team who will be advised of any necessary revisions. On the basis of this feedback, and taking into consideration the comments received, the evaluation team will prepare the final version of the terminal evaluation report.
The ET will present its preliminary findings to the local stakeholders at the end of the field visit and consider their feed-back in preparing the evaluation report. A

[20] The evaluator will be provided with a Guide on how to prepare an evaluation inception report prepared by the UNIDO ODG/EVQ/IEV.

presentation of preliminary findings will take place at UNIDO HQ after the field mission.

The TE report should be brief, to the point and easy to understand. It must explain the purpose of the evaluation, exactly what was evaluated, and the methods used. The report must highlight any methodological limitations, identify key concerns and present evidence-based findings, consequent conclusions, recommendations and lessons. The report should provide information on when the evaluation took place, the places visited, who was involved and be presented in a way that makes the information accessible and comprehensible. The report should include an executive summary that encapsulates the essence of the information contained in the report to facilitate dissemination and distillation of lessons.

Findings, conclusions and recommendations should be presented in a complete, logical and balanced manner. The evaluation report shall be written in English and follow the outline given in annex 4.

VIII. Quality assurance

All UNIDO evaluations are subject to quality assessments by UNIDO Independent Evaluation Division. Quality assurance and control is exercised in different ways throughout the evaluation process (briefing of consultants on methodology and process of UNIDO Independent Evaluation Division, providing inputs regarding findings, lessons learned and recommendations from other UNIDO evaluations, review of inception report and evaluation report by UNIDO's Independent Evaluation Division).

The quality of the evaluation report will be assessed and rated against the criteria set forth in the Checklist on evaluation report quality, attached as Annex 5. The applied evaluation quality assessment criteria are used as a tool to provide structured feedback. UNIDO Independent Evaluation Division should ensure that the evaluation report is useful for UNIDO in terms of organizational learning (recommendations and lessons learned) and is compliant with UNIDO's evaluation policy and these terms of reference. The draft and final evaluation report are reviewed by UNIDO Independent Evaluation Division, which will submit the final report to the GEF Evaluation Office and circulate it within UNIDO together with a management response sheet.