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DIOXIN REMEDIATION TECHNOLOGIES IN VIETNAM

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**The Consultancy Council for Science and Technology –
Office of National Steering Committee 33**

- During the Vietnam War, the US troops sprayed roughly 80 mil litres of herbicides over the South of Vietnam, mainly Agent Orange which contained dioxin. Total amount of dioxin in the above stated herbicides was 366 kg at the minimum (*Stellmann, 2003*).

- At some of the former military bases: Bien Hoa, Da Nang, Phu Cat, there remains heavily dioxin contaminated areas. During the war, this was the place where loading and washing activities of the aircraft were carried out and the barrels of herbicides were also stored there.

DIOXIN CONTAMINATED AREAS AT DA NANG AIRPORT



DIOXIN CONTAMINATION AT THE STORAGE AREA, DA NANG AIRPORT



DIOXIN CONTAMINATED AREAS IN BIEN HOA AIRBASE



THE CONTAMINATED Z1 AREA IN BIEN HOA AIRBASE



A. Loading area
Nr surfc sampls : 7
Range: 3 - 876
Mean: 261
Median: 18 ppt

Z3 (Storage area)
Nr surfc sampls : 21
Range: 152 - 238,000
Mean: 26,248
Median: 5,258 ppt

B. Perimeter area
Nr surfc sampls : 15
Range: 2 - 2,950
Mean: 482
Median: 98 ppt

C. Washing area
Nr surfc sampls : 17
Range: 2 - 218
Mean: 25
Median: 6 ppt

Drain and basin
Nr surfc sampls : 8
Range: 4 - 419
Mean: 122
Median: 101 ppt

Lakes downstream
Nr surfc sampls : 23
Range: 2 - 196
Mean: 43
Median: 34



DIOXIN CONTAMINATED AREAS IN PHU CAT AIRBASE

- **In Phu Cat Airbase:** 7,500 m³ of dioxin contaminated soil and sediment was safely contained in a landfill by the end of 2012

- **In Da Nang Airport:** 72,900 m³ of dioxin contaminated soil and sediment will be completely remediated using IPTD technology introduced by US partner starting from 2014 to 2016.



- **In Bien Hoa Airbase:** 94,000 m³ of dioxin contaminated soil and sediment was safely contained in a landfill in 2009; Around 300,000 m³ of dioxin contaminated soil and sediment has yet been remediated. Hence, around **400,000m³ of dioxin contaminated soil and sediment remains on hold for suitable remediation technologies.**

Dioxin remediation technologies

- There are no other areas where dioxin contamination is as serious as it is in the hotspots in Vietnam
- POPs remediation methods can be used for dioxin. In fact, two main methods are widely used worldwide:

1- Thermal methods (USA, Hong Kong, Japan)

- Using different types of incinerators at high temperature or vacuum type low temperature
- In situ or in pile thermal desorption destruction

*Comments: + Dioxin destruction efficiency: high, relatively complete
+ Remediation cost: high (450 – 1,500 USD/m³); exhaust requires further treatment*

2- Landfill (Italy, Taiwan)

- + Is a popular method, low cost and easy to implement
- + Risk remains as dioxin is not completely remediated

Dioxin remediation technologies having been demonstrated and applied in Vietnam

1- *Bio-remediation technology*

- Demonstration time: end of 2009 sponsored by Ford Foundation
- Cooperation between the US EPA and Vietnam Academy for Science and Technology
- Location: Dioxin contaminated area in Da Nang Airport
- Demonstration scale: 11 piles, each has a volume of 2 m³, **including**: 5 piles for aerobic treatment, 4 piles for anaerobic treatment and the other 2 piles for comparison.
- Dioxin concentration: 40,000 – 50,000 ppt TEQ
- Destruction efficiency after 6 months: 25 – 40%

Final evaluation results are not available

2- The mechano-chemical destruction technology (MCD) from New Zealand

- The first dioxin remediation technology is demonstrated in Vietnam in a methodical way sponsored by GEF via UNDP Vietnam
- Location: Bien Hoa Airbase from 31/7 to 19/9/2012
- Principles: Using mechanical energy created by the collision of steel balls at high speed to destroy the contaminants' molecule structure.



Ball milling stage

- Demonstration scale: 100 m³ dioxin contaminated soil
- Highest dioxin concentration: 110,000 ppt TEQ
- Lowest dioxin concentration: 341 ppt TEQ
- Highest destruction efficiency: 99.7 %
- Lowest destruction efficiency: 23.9%
- Best destruction potential for dioxin contaminated soil with concentration range of 2,000 – 10,000 ppt TEQ
- Cost: > 500 USD/ m³

Comments: Not high feasibility

(Report from the workshop “MCD technology demonstration evaluation” dated 17/1/2013 in Hanoi)

3- In Situ Thermal Desorption ISTD and In Pile Thermal Desorption IPTD

The IPTD technology is being adopted to remediate 72,900 m³ of dioxin contaminated soil and sediment in Da Nang Airport

** As planned:*

- In 2014, the first stage of remediation: 43,000 m³ of dioxin contaminated to be remediated.

- In 2016 the second stage of remediation with ~ 40,000 m³ remaining of dioxin contaminated soil and sediment will be treated.

** Cost: 84 million USD/72,900 m³ (1,152 USD/ m³)*

(exclusive of 35 Billion VND counterpart fund from the GOV)



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STUDY ON SELECTION OF REMEDIATION TECHNOLOGIES FOR DIOXIN CONTAMINATED SOIL AND SEDIMENT IN VIETNAM


- Selecting feasible technologies which are suitable to the conditions in Vietnam
- Laboratory research and on site demonstration at the contaminated areas
- Study and demonstration of **chemical and photochemical methods**: high remediation efficiency but *not feasible due to high cost and creating secondary environmental contamination.*
- Focus on study and demonstration of the two methods: **bio-remediation and land filling**

BIOREMEDIATION

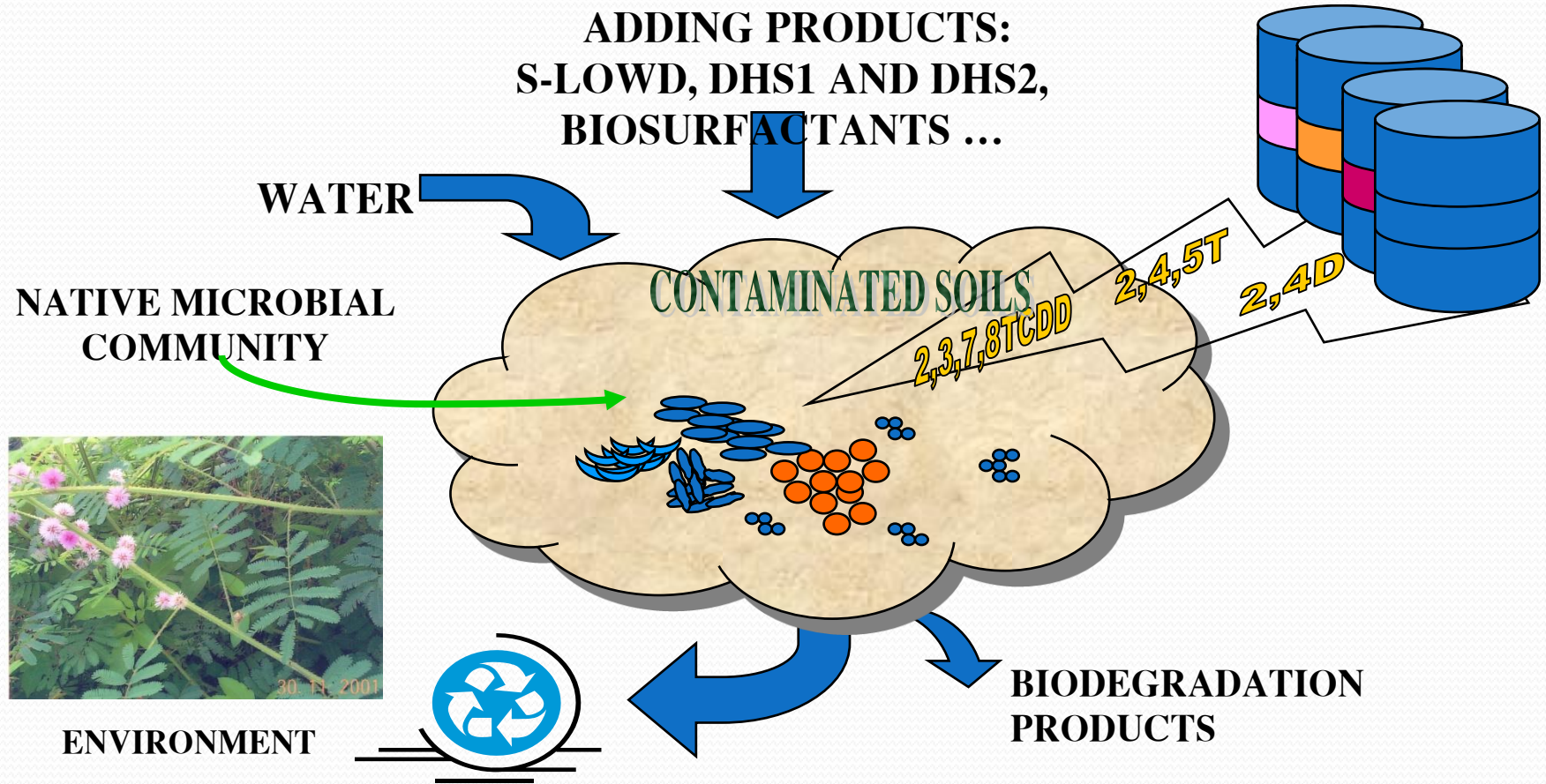
Principles: *Stimulate the development of the native microbial community* which have the ability to decompose contaminants in the environment by:

- Change the environmental factors such as oxygen and pH

- Add nutrition sources, add substances which facilitate oxidation, Dechlorination, and additives, etc

 create optimal condition for microbial community to develop and activate, increase the possibility to destroy toxic chemicals.

PRINCIPLE OF BIOREMEDIATION TREATMENT (ACTIVE LANDFILL) FOR DETOXIFICATION OF TOXIC CHEMICAL CONTAMINATED SOILS



THE RESULT OF DIOXIN DESTRUCTION USING BIOREMEDIATION TECHNOLOGY

- **Demonstrate in contaminated areas in Da Nang Airport** (in 2002):

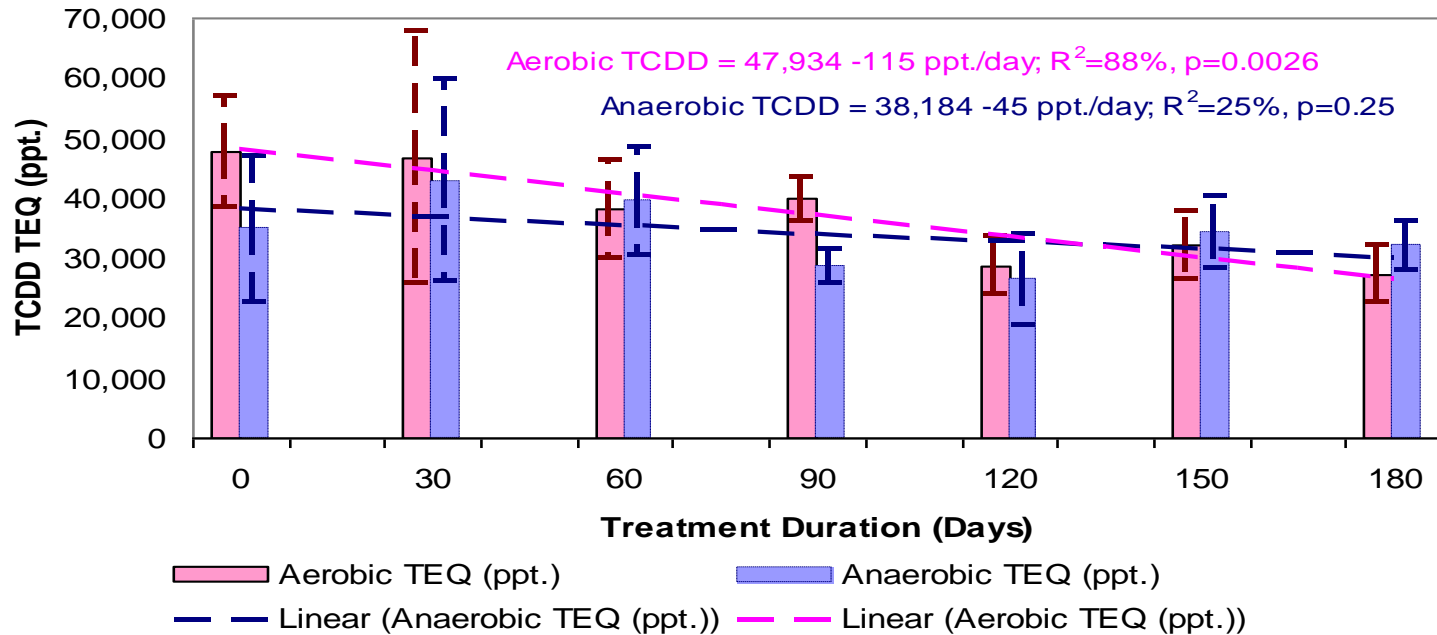
+ Demonstration scale 0.5 – 1.5 m³ of contaminated soil: Dioxin destruction efficiency after 24 months is 51% with initial dioxin concentration of 266,000 ppt; DE of 90% with initial dioxin concentration of < 100,000 ppt.

+ Demonstration scale 10 - 100 m³ of contaminated soil: Dioxin destruction efficiency after 29 months is 70% with initial dioxin concentration of ~ 30,000 ppt.

DEMONSTRATION IN DA NANG

- Cooperation between The Institute for Bio-Technology – Vietnam Academy for Science and Technology and US.EPA. Implementation: by the end of 2009 sponsored by Ford Foundation
- Carried out 4 formulas of anaerobic treatment and 5 formulas of aerobic treatment
- Scale: 2 m³ of contaminated soil
- ***The result of anaerobic treatment:***
 - + Original dioxin concentration: 40,000 ppt
 - + After 6 months: 30,000 ppt. Destruction efficiency: 25%
- ***The result of aerobic treatment :***
 - + Original dioxin concentration: 50,000 ppt
 - + After 6 months: 30,000 ppt. Destruction efficiency: 40%

TCDD Degradation in Da Nang Pilot Study All Aerobic and Anaerobic Treatments



Dioxin concentration reduction subject to time

*(Sources: Report by US.EPA and VAST at JAC meeting (JAC 5)
dated 8-9/7/2010 in Hanoi)*

LANDFILL METHOD

- Widely applied in the world, low cost
- The toxic substances are contained and isolated from the environment
- Main materials: HDPE and filter material of Enviromat from bentonite

FILTER MATERIAL (Enviromat) based on bentonite:

- + Having significant capability to absorb toxic substances
- + Sealing the isolated layer thanks to strong moisture absorbing capacity, and high swelling capability
- + Being a growing medium for micro-organism to develop and decompose toxic substances.

THE MINERAL CHARACTERISTICS OF VIETNAMESE BENTONITE

+ *The content of montnonrilonit 35-40% in the form of natrium, Having high capability of absrobance of poralised organic substances (Chlorinated compounds), having high capability of swelling*

* *Area of external surface: 14.3 m²/g*

* *Area of internal surface: 28.0 m²/g*

* *Individual surface area: 42.3 m²/g*

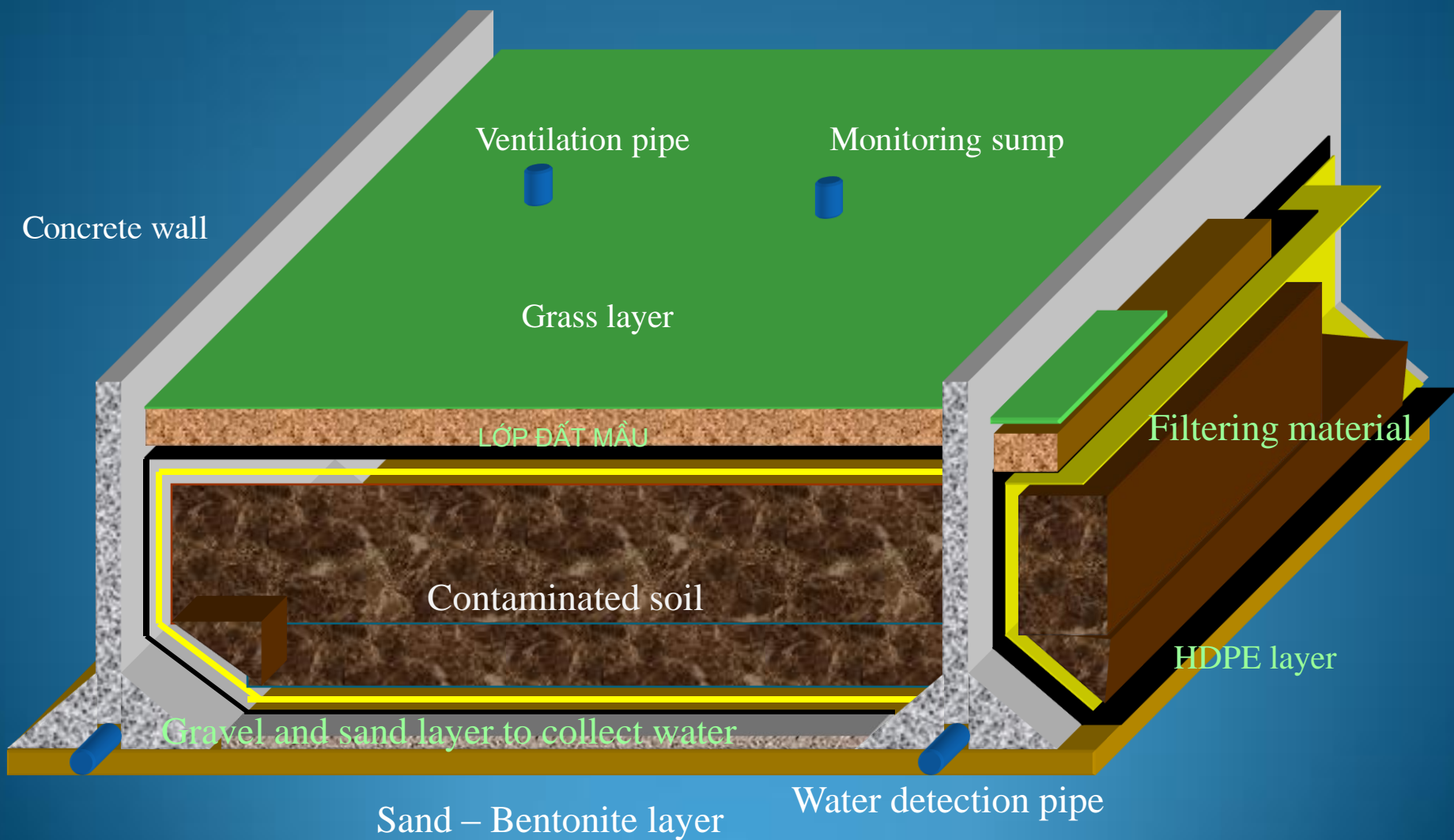
* *Average hole diameter: 51.5 A⁰*

+ *Ion exchange capacity: 60 - 80 mEg/100g*

+ ***Swelling capacity: 600 - 800%***

+ ***Dioxin absorbance capacity: >99.75%***

A MODEL OF ACTIVE LANDFILL FOR DIOXIN CONTAMINATED SOIL



APPLICATION OF LANDFILL METHOD

- **In 2009:** Contained 94,000 m³ of dioxin contaminated soil in Bien Hoa Airbase
- **In 2012:** Contained 7,500 m³ of dioxin contaminated soil and sediment in Phu Cat Airbase



The landfill for dioxin contaminated soil in Phu Cat Airbase in 8/2012

Active landfill

Is the combination of bio-technology and landfill method.

The landfill works as a bioreactor: dioxin is decomposed under the free but strict aerobic and anaerobic conditions.

Advantages:

- Is an environmental friendly technology, easy to adopt, and not requiring complicated equipment
- Low cost: 150 - 200 USD/ m³
- Does not produce exhaust and wastewater

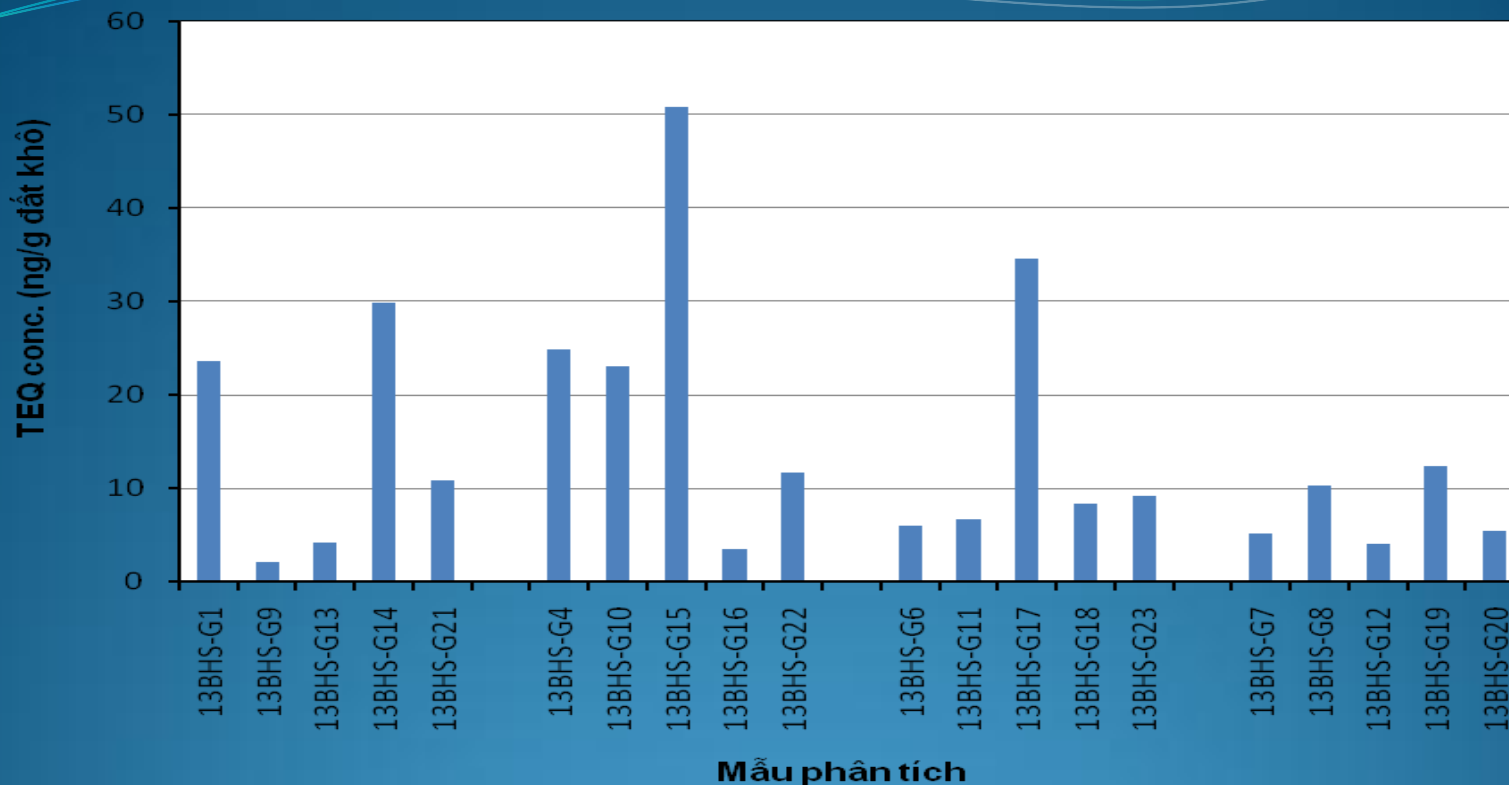
THE RESULT OF ACTIVE LANDFILL DEMONSTRATION IN BIEN HOA AIRBASE

(Cooperation between the Institute for Bio-Technology and the High
Command for Chemistry in 2009)

- Scale: 3,384 m³ of dioxin contaminated soil
- Remediation duration: Since April 2009
- Remediation results:
 - + **Original average dioxin concentration: ~ 10,000 ppt TEQ**
 - + **Average dioxin concentration after 27 months: 52 ppt TEQ***
 - + **Average dioxin concentration after 40 months: 14.12 ppt TEQ****

** The demonstration result was accepted by the Panel under the Vietnam Academy for Science and Technology dated 2/5/2012*

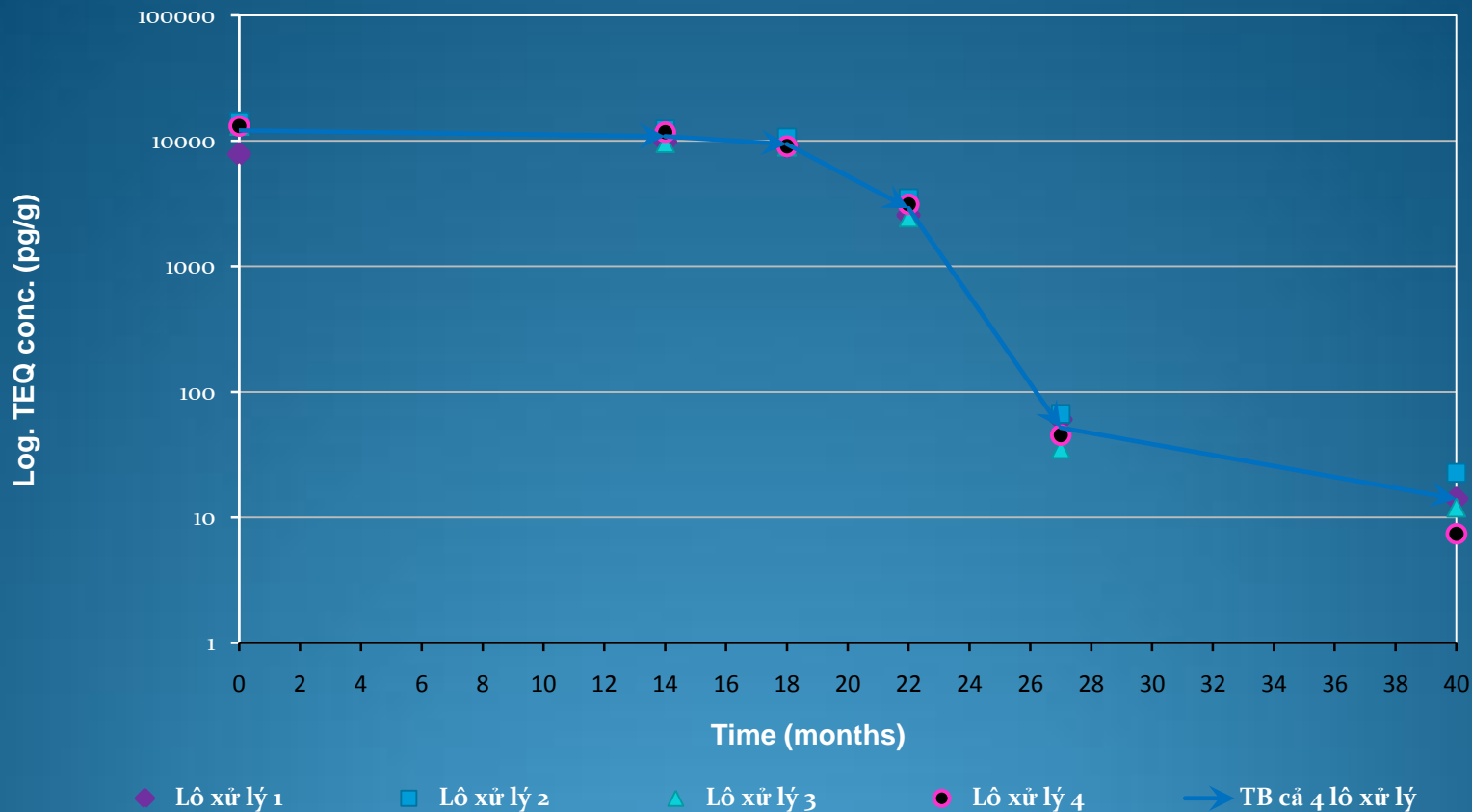
*** Was evaluated by the Panel of science and technology at National level dated 28/6/2013*



Dioxin concentration of 20 samples after 40 months of remediation

(lowest sample: 2,1 ppt TEQ; highest sample: 50.78 ppt TEQ)

(Sources: Report by the Dioxin lab – VEA at the National Scientific and technological Panel dated 28/6/2013)



Chronological chart for dioxin reduction

(Sources: The Institute of BioTechnology – Vietnam Academy for Science and Technology)

THE CONCLUSIONS BY THE NATIONAL PANEL FOR SCIENCE AND TECHNOLOGY DATED 28/6/2013

1- Application of bio-remediation technology for a lot of soil (3,384 m³) in Z1 area within a duration of 40 months reduced dioxin concentration to a relatively acceptable standard for crop plantation subject to Vietnamese regulation QCVN 45:2012/BTNMT

2- The Panel recommends the Ministry of Science and Technology to create favourable condition for the research authors to cooperate with Ministry of Defence in providing the technology adoption in a larger scale.

SECRETARY OF THE PANEL

Từ Bình Minh

CHAIRMAN OF THE PANEL

Đặng Vũ Minh

(Vietnamese regulation, QCVN 45:2012/BTNMT: The maximum of dioxin allowable for annual crop is 40 ppt TEQ)

Disadvantages of the active landfill technology

- Long decomposition duration
- The capability to decompose soil contaminated with dioxin at the concentration above 10,000 ppt TEQ has yet been assessed
- Remediation of Arsenic and other heavy metals are not available

The comparison of dioxin remediation technologies

Technology	Clean-up limit	Destruction efficiency	Dioxin and Arsenic In the environment	Remediation cost
IPTD	150 ppt TEQ	>95%	<ul style="list-style-type: none"> - Exhaust: required to achieve 0.1 ng-I TEQ/Nm³ - Waste water : required to achieve 10 pg/l subject to TCVN 9737:2013/BTNMT 	1,152 USD/m³
MCD (Mechano-Chemical Destruction) của New Zealand	-	70 - 80%	<ul style="list-style-type: none"> - Exhaust, dust: have yet been controlled - Wastewater achieves TCVN - Arsenic in treated soil has yet achieved Vietnamese regulation 	> 500 USD/m³
Active landfill	14,12 ppt TEQ after 40 months with original concentration lower than 10,000 ppt TEQ	99 %	<ul style="list-style-type: none"> - Does not discharge exhaust, wastewater - The remediation result for soil contaminated with dioxin at concentration over 10,000 ppt TEQ is not available and so is for the Arsenic result 	150 - 200 USD/m³
Landfill	-	-	<ul style="list-style-type: none"> - Not yet remediate - Risk of contamination spreading remains 	80-100 USD/m³

Proposal for selection of feasible dioxin remediation technologies for Bien Hoa Airbase

While waiting for new technologies to meet the standard for complete remediation of dioxin at Bien Hoa Airbase, the combination of the two technologies is recommended:

1- ISTD or IPTD: With dioxin contaminated soil with concentration over 10,000 ppt TEQ

2- Active landfill: With dioxin contaminated soil with concentration lower than 10,000 ppt TEQ

*Thank you for your
attention!*

