

Assessment of Pesticides in Soil from Obsolete Stores: A Caribbean Case Study

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INTRODUCTION

The presence of contaminated sites from storage of obsolete pesticide stockpiles were identified in six countries following FAO Pesticide Stock Management System (PSMS) inventorying, namely; Trinidad and Tobago, Suriname, St. Kitts and Nevis, Dominican Republic, Dominica and Barbados. The system includes inventory forms and a database utility that is designed specifically for inputting inventory data and producing reports that can be used for a variety of purposes related to data evaluation. The public health and environmental risk associated with site contamination from obsolete pesticides has yet to be assessed. Notably, the environmental risk may far exceed the direct health hazard. Soil and water contamination is a grave concern as the exposure pathways allows for larger geographic distribution and increases the exposure routes. Although the region has had some experience in site characterisation and risk assessment of chemical contaminated sites, fragmentation exist in the institutional framework, as many organizations are involved with sometimes conflicting objectives. Perform preliminary site assessments of obsolete pesticide contaminated soils to assist in ranking and identification of pilot remediation sites.

METHODOLOGY AND RESULTS

Countries completed online inventories of obsolete pesticide stocks using the FAO PSMS. FAO Technical Guidelines such as the Environmental Management Tool Kit (EMTK) Series were then used to generate an estimate of the environmental and public health risks. Rapid environmental assessments were conducted by national competent authorities following procedures including forms from FAO (2016). This was followed by preliminary site investigations by an expert team to sites where soil contamination was reported (Table 1). Site assessments were conducted at obsolete pesticide storage sites in St. Kitts and Nevis, Dominica, Barbados, Trinidad and Tobago and Suriname. Table 1 also identifies the specific sites within country along with the EMTK site assessment and prioritization. Results of the EMTK analysis and prioritization identified the Fond Cole and Camden Base sites in Dominica and Trinidad and Tobago respectively as the only critical sites. Dicofol and Actellic were identified as the obsolete pesticides at the Fond Cole site. These pesticides are moderately persistence in soils, with low volatility and leaching (Table 2). Preliminary site investigation

Country/District	Site/Store	Pesticide	Fp	Fe	Site Prioritization	Samples
Suriname: Commewijne	Marienburg obsolete storage	Chlorpyrifos, HCH (Hexachlorocyclohexane)	204,800	64	Problematic Site (environment)	1*
Suriname: Nickerie	Airfield Alibux Wageningen	HCH (Hexachlorocyclohexane)	ND	ND	ND	1
Suriname: Commewijne	Pepperpot	Cupravit (Copper Oxychloride)	3716	58	Problematic Site (environment)	1
Dominica	Fond Cole Sanitary Landfill	Dicofol, Actellic (Pirimiphos-methyl)	352,000	65	Critical site	1*
Nevis	New River Estate	Malathion	718,796	43	Problematic Site (pesticide)	1*
St. Kitts	Department of Agriculture	Buctril (Bromoxynil)	2093	41	Non-priority	1
St. Kitts	Sugar Manufacturing Association	Buctril (Bromoxynil)	81,845	54	Problematic Site (environment)	1
Barbados	Grantley Adams International Airport	Carbaryl, Endrin	107,265	55	Problematic Site (environment)	1*
Trinidad and Tobago	Camden Base (Airstrip)	Imidacloprid, Fenobucarb	54,306,536	58	Critical Site	0

Table 1: Location and site assessment of obsolete pesticide stocks for countries where soil contamination was reported

revealed that the exposure pathways are mainly associated with leaching and water contamination as the site has high sand content (69.7%)

and correspondingly low cation exchange capacity ($6.05 \text{ cmol}^+ \text{ kg}^{-1}$) (Table 3). Of the soils analysed for respective pesticides, reported values were all below the method detection limit (Table 4). The EMTK tool A (Environmental risk assessment) and tool B (Prioritization of stores) was relatively effective in identifying the environmental hazard posed by obsolete pesticide stocks. It was less effective in prioritizing the sites. When combined with preliminary site assessment data, a more accurate ranking was possible.

Name	Group	Half-life (days)	Koc (Sorption Coefficient)	GUS Leaching Potential	Solubility (mg/l)	Vapour pressure at 25°C (mPa)	Henry's Law Coeff. ($\text{Pa m}^3 \text{ mol}^{-1}$)
Dicofol	Organochlorine	80 (MP)	6064 (NM)	0.36 (L)	0.8 (L)	0.25 (LV)	2.45×10^{02} (NV)
Chlorpyrifos	Organophosphate	386 (VP)	5509 (NM)	3.36 (H)	1.05 (L)	1.43 (LV)	0.478 (MV)
Endrin	Organochlorine	4300 (VP)	10000 (NM)	0.00 (L)	0.24 (L)	2.00×10^{07} (LV)	1.48×10^{01} (MV)
Actellic (pirimiphos-methyl)	Organophosphate	39 (MP)	1100 (SM)	1.03 (L)	11 (L)	2.00×10^{03} (LV)	6.08×10^{05} (NV)
Malathion	Organophosphate	0.17 (NP)	1800 (SM)	-1.28 (L)	148 (M)	3.1 (LV)	1.00×10^{03} (NV)
Carbaryl	Carbamate	16 (NP)	300 (MM)	2.02 (TS)	9.1 (L)	0.0416 (LV)	9.20×10^{05} (NV)
Cupravit (copper oxychloride)	Inorganic Compound	10000 (VP)	NA	NA	1.19 (L)	0.00001 (LV)	NA
HCH (Hexachlorocyclohexane)	Organochlorine	980 (VP)	1270 (SM)	3.95 (H)	8.52 (L)	4.4 (LV)	1.48×10^{06} (NV)
Buctril (bromoxynil)	Hydroxybenzotriazole	0.63 (NP)	302 (MM)	-0.34 (L)	38000 (H)	0.12 (LV)	8.7×10^{07} (NV)
Imidacloprid	Neonicotinoid	191 (VP)	225 (MM)	3.74 (H)	610 (H)	4.0×10^{07} (LV)	1.7×10^{10} (VN)
Fenobucarb	Carbamate	18.5 (NP)	1068 (SM)	1.23 (L)	420 (M)	48 (HV)	NA

NP, MP and VP represents non, moderately and very persistent; NM, SM and MM represents non, slightly and moderately mobile; L, M, H and TS represents low, moderate, high and transition state; LV and NV represents low volatility and non-volatile. NA means "not available"

Table 2: Properties of obsolete pesticides related to the environmental fate. Data sources from <http://sitem.herts.ac.uk/aeru/ppdb/en/index.htm>

Country	pH	EC	TOC	TKN	C/N	CEC	Sand	Silt	Clay
		mS cm^{-1}	%	%		$\text{cmol}^+ \text{ kg}^{-1}$	g kg^{-1}		
Barbados	8.06	1.03	2.48	0.28	8.86	12	517	209.9	273
Dominica	7.63	0.25	0.33	0.05	6.60	6.05	697.3	218.1	84.6
St. Kitts and Nevis	8.42	0.48	2.94	0.02	147.00	10.8	654.9	230.2	114.9
Suriname	7.90	0.29	1.02	0.16	6.38	6.92	778.7	123.7	97.6

Table 3: Selected soil properties of study sites

Country	Pesticide	Concentration ($\mu\text{g kg}^{-1}$)
Barbados	Endrin	< 5*
	Carbaryl	ND
Dominica	Actellic (pirimiphos-methyl)	< 2.5*
	Dicofol	< 5*
St. Kitts and Nevis	Malathion	< 2.5*
	Buctril (Bromoxynil)	ND
Suriname	Chlorpyrifos	< 2.5*
	HCH (Hexachlorocyclohexane)	ND
	Cupravit (copper oxychloride)	ND

Table 4: Concentration of obsolete pesticides in soils from contaminated sites

Atypically, soils across countries showed similar chemical and physical properties; alkaline pH, non-saline with low CECs and being composed mainly of sand sized separates. These properties may partly explain the low pesticides levels detected in the samples. Tested pesticides were non-volatile (Table 2), which support minimal loss during storage and processing. A combination of the EMTK tool kit and site investigation assisted assessment and prioritization of pesticide contaminated sites. Concentration of analyzed pesticides in soils were below detection limits. The fate of obsolete pesticides may be beyond the immediate soil matrix and require further assessment.

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