Alternative Sanitation in Protracted Emergencies

Molly Patrick[1], Jennifer Murphy[2], Patricia Akers[2], Travis Brown[2], Yegerem Tsige[3], Ahmed Adow[4], Mohammed Abdirashid[4], David Githiri[3], Vincent Hill[2] and Thomas Handzel[1]

[1]CDC Center for Global Health, [2]CDC National Center for Emerging and Zoonotic Infectious Diseases, [3]United Nations High Commissioner for Refugees, [4]Norwegian Refugee Council

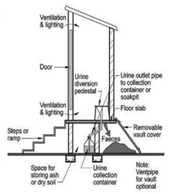
Background and Rationale

Alternative Sanitation in Emergencies

- There is an increasing need for sanitation alternatives in humanitarian emergencies, which often occur in areas with difficult soil/ground conditions, flooding, or lack of space.
- In these settings, traditional, below-ground sanitation systems, such as pit latrines, may be technically and financially impractical

Urine-diversion dry toilets (UDDT)

- UDDTs are an above-ground sanitation system designed for dry excreta management
- Urine diverted at squat plate, storage vault(s) inactivate waste over 6-12-month period



Study Location

Hiloweyn Camp, Dollo Ado, Ethiopia

- Established 2011
- Somali refugees
- Official estimates (2014): ~7,900HHs
- Rocky soils and localized flood-risk

UDDT Program (~1,000 UDDTs; 1,800HHs)

- 2012-2013: Single-family UDDT (Phase 1 pilot; n=140)
- 2014: Shared-family UDDT (Phase 2-3 scale-up; n=765)
- 2015: Shared-family UDDT (Phase 4; n=65)

Objectives

Given scale-up of UDDT program in Hiloweyn, objectives were to:

- Measure the acceptability of UDDTs over time
- Measure the performance of the UDDTs over time
  - The WHO guideline values for use of treated feces in agriculture [<1 viable helminth (i.e., *Ascaris*) ovum and <1000 *E. coli* per gram total solids] used as conservative performance measure
  - Key environmental parameters associated with microbiological inactivation tested (temperature, moisture content, pH)

Acceptability

Objectives:

- Determine if adoption of UDDTs changes over time
- Determine if UDDTS are consistently and correctly used and by whom
- Determine if attitudes and preferences of UDDTs are more positive than for other forms of sanitation available
- Determine the factors contributing to satisfaction with sanitation system among users and non-users of UDDTs

Methods:

- Two, cross-sectional surveys, 18-months apart
- Sample size: 420 households
- Stratified sampling design from Phase 1-3 UDDTs and from latrine users (4 groups)
- Simple random sampling of households
- Questionnaire: demographics, sanitation practices, sanitation preferences and UDDT observation
- Wald chi-square (p≤0.05), multivariable logistic regression modelling

Results:

- Surveyed HHs: 397 HH baseline; 414 endline

UDDT Use and Condition:

	Percent (95% CI)		
Variable	Baseline (n=285)	Endline (n=303)	p
Reported current use (past 24 hours)	**98.2 (96.7-99.8)**	**96.7 (94.7-98.7)**	**0.235**
Reported consistent use (every day)	**88.8 (85.1-92.5)**	**93.4 (90.6-96.2)**	**0.048**
Add ash after every use	**85.3 (81.1-89.4)**	**97.0 (95.1-98.9)**	**<0.0001**
Presence of ash bucket	97.9 (96.2-99.6)	91.1 (87.9-94.3)	0.0003
Ash in the bucket	81.4 (76.9-86.0)	67.0 (61.7-72.3)	<.0001
No foreign objects in urine pipe	77.2 (72.3-82.1)	88.4 (84.8-92.1)	0.0003
No wet waste in active vault	58.6 (52.8-64.3)	73.3 (68.2-78.3)	0.0002

- Correct and consistent use high at both surveys
- However, at least one non-user per HH: 64.9% to 74.6% (p=0.012) from baseline to endline (*child < 5 years)*
- Cleanliness and structural indicators improved from baseline to endline

Satisfaction with Sanitation Type:

Reported Satisfaction	Percent (95% CI)		p
	Baseline	Endline	
Latrine users	(n=107)	(n=108)	
Primary Latrine Users	66.4 (57.3-75.5)	88.9 (82.9-94.9)	**<0.0001**
UDDT users	(n=285)	(n=303)	
All UDDT Users	62.8 (57.2-68.4)	97.0 (95.1-98.9)	**<0.0001**

- No difference between UDDT and latrine satisfaction at either survey(p=0.28)
- 88.9% (95% CI 84.9-93.0) of single-family UDDT users reporting satisfaction vs. 75.2% (95% CI 70.7-79.7) of shared UDDT users (only significant at baseline)

Factors Associated with Satisfaction (UDDT):

Variable	Odds Ratio	Wald X^2	p
Previous sanitation type in Somalia			
Previously used pit latrine vs pour-flush (ref)	4.158	6.29	0.0121
Previously used field vs pour-flush (ref)	2.411	8.48	0.0036
Years in the camp (Increase in satisfaction per year)	2.261	30.877	<0.0001
Shared (ref) vs not	1.762	4.28	0.0385
Time of use of UDDT (increase in satisfaction per year)	1.713	9.0576	0.0026
Clean (ref) vs unclean	2.819	17.07	<0.0001

- Years in the camp and cleanliness highly associated with satisfaction

Performance- Baseline

Methods:

Sampling from single-family UDDT (n=21)

- Baseline #1: 6 closed vaults (8-months storage) + 4 active vaults
- Baseline #2: 15 closed vaults (1.3 years storage)

Results:

Physical/Chemical Parameters

- Temperature: Range 31-34 ^{o}C
- Moisture Content: Average moisture content active vault 12%, closed vault average 1-3%
- pH: Average pH constant at ~9

Microbial Parameters

- *E. coli*: not measured baseline #1; 70% (n=10) met WHO guideline at baseline #2
- *Ascaris* Viability: No viable or non-viable *Ascaris* in baseline #1 (active or closed vaults); 8 of 15 had only non-viable *Ascaris* detected (very low levels)

Interpretation:

- Extremely low levels of *Ascaris* (viable or non-viable) prevented use of this approach to assess efficacy of inactivation over time →Longitudinal Study developed

Longitudinal Study

Methods:

Sampling from shared-family UDDT (n=20)

- "Tea bags" (20 µm mesh) prepared (Jensen 2009)
- *Ascaris* Bag: Waste + *Ascaris* ova (for *Ascaris* viability)
- Indicator Bag: Waste only (*E. coli* and environmental parameters)
- One bag tested immediately (t=0); three bag embedded into the center of each UDDT (Figure)
- Testing at 6, 9, and 12-months

Results:

Physical/Chemical Parameters

- Temperature: Average temperature ranged from 32-36^{o}C (max: 41^{o}C)
- Moisture Content: Average moisture content decreased from 9% to 3% from 0 to 12 months (max: 20%)
- pH: Average pH constant at ~9 (max: 10.9)

Microbial Parameters

- *E. coli*: UDDTs that met the WHO guideline increased from 30% to 95% from 0 to 12 months
- *Ascaris* Viability: After 6-months of storage, there was a >2.8-log10 reduction (>99.8%) in *Ascaris* viability

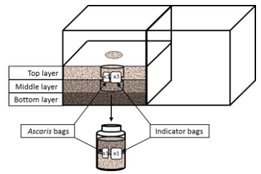
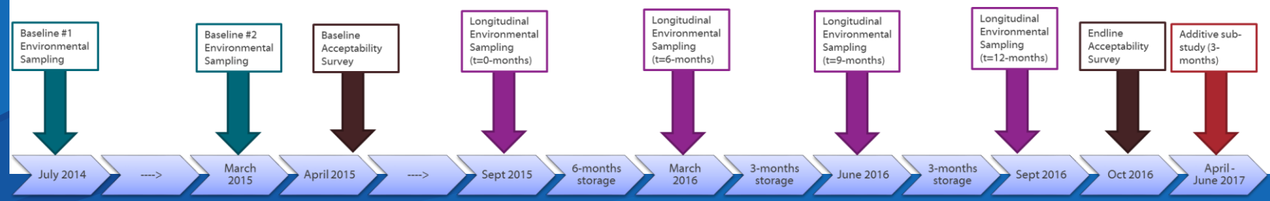


Figure. Diagram of sampling location within UDDT for longitudinal study

Additive Sub-Study

- UDDT waste treated with the 0.5%, 2%, and 5% (w/w) concentrations of commercially available hydrated lime
- Moisture content set at 20%; pH > 12 [0.5% pH ~8 by 1-week, 2% and 5% remained at pH >12]
- *E. coli*: 0.5%, 2%, and 5% lime treatments met the WHO guideline immediately (t=0)
- *Ascaris* Viability: 2% and 5% treatment: >2.7 log10 reduction after 1 week of storage; 0.5% treatment: >2.9 log 10 reduction after 4 weeks of storage
- Control: >2.4 log10 reduction after 6 weeks of storage



Conclusions

- Adoption and current, consistent and correct use of the UDDTs was high (increased with time of use)
- UDDT users not more or less satisfied than latrine users
- Sanitation services generally well managed in the camp
- Hot, extremely dry environment in Hiloweyn likely representing an ideal location for a desiccation technology
- Overall, UDDTs were successful in microbial inactivation over a 12-month storage period (not all met guidelines)
- Appropriate precautions (e.g.,PPE) needed for waste handling after 12-month storage and at secondary storage site location (lime at 2-5% if feasible and safety precautions can be ensured)

Recommendations

- Additional research in 1) different cultural settings, 2) different environmental conditions (e.g., more temperate and humid environments), and 3) earlier in emergency phase
- Explore modifications to enable child < 5 years to use
- Additional experiments on lime additive use under range of environmental conditions (e.g. higher moisture content)

Lessons Learned

- KAP or other sanitation-specific surveys to understand previous practices may assist with targeted implementation strategies for different demographic groups (e.g. previous sanitation access)
- Programming needed to allocate sufficient resources to educational sessions to emphasize consistent cleaning and correct use practices early in the introduction of UDDTs (+ provision of cleaning kits to HHs)
- Time of use significantly impacts satisfaction level of UDDTs, so may be more appropriate for protracted emergencies vs acute phase
- UDDTs may meet WHO guideline for reuse in hot, arid environments, after 12-months storage
- Promoting conditions which desiccate stored waste (e.g. additive use) and secondary treatment [pH (≥12)] may help improve UDDT performance
- Strong management and oversight required such that proper use of the UDDTs is maximized (e.g., to prevent liquid from entering the waste vault) and safe handling and disposal can be ensured

Project Partners

UNHCR The UN Refugee Agency

NRC NORWEGIAN REFUGEE COUNCIL

OXFAM

Center for Global Health

Division of Global Health Protection