organizations. Additionally, the Benue State Rural Water and Sanitation Authority (BERUWASSA) has included these construction techniques into their training programs for local artisans, who will be empowered with the ability to implement these technologies in their communities.

A representative from Logo LGA, Benue State on a field visit to a community in Oju LGA. Following their visit, Logo will introduce the technology into their communities

Conclusions

Implementation of pilot projects in Benue and Bauchi States in Nigeria have led to the construction of improved pit latrines that substantially reduce the risk of collapse due to poor soil conditions and shallow groundwater. While these technologies remain in the pilot stage, their ease of installation and apparent resilience following construction have already renewed enthusiasm for sanitation in communities involved in the study. Coupled with the implementation of best practice measures mentioned above, households stand a far greater chance of establishing sustainable sanitation options.

Further documentation is available on these technologies, which details the pilot project undertaken in Nigeria and

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New Sanitation Technologies
for Communities with Poor Soil

Technical solutions for areas with shallow groundwater and frequent soil collapse.

Sanitation in Areas of Poor Soil Quality

Sanitation facilities are essential to the provision of clean water in developing communities and the foundation of the WaterAid community led total sanitation (CLTS) approach. In communities where shallow groundwater or poor soil quality prevents the construction of conventional pit latrines, adequate sanitation is often elusive. This briefing note presents concepts and technologies that have been developed to facilitate development of effective sanitation programmme in communities with challenging hydro-geologic conditions.

Introduction

Adequate sanitation is key to the health of any community. In Nigeria, this cornerstone of the CLTS program is often addressed through the construction of deep pit latrines. Superstructures comprised of mudblock or grass are built atop pits dug to a depth of up to 4 meters. In most cases, these pits are unlined when they are covered with slabs and Superstructures.

Many communities throughout the country have experienced widespread instances of latrine failure. In each instance, the collapse of the unlined pit walls instigates a collapse of the structure built above. Where the problem is found, it is almost always pervasive. Severely impacted communities often abandon critical aspects of CLTS, and revert to open defecation practices.


A typical pit latrine in Benue State, Nigeria

Instances of pit collapse are not confined to a given region or soil type. They are extensive in at least three states in which WaterAid Nigeria operates, and transcend any single climate or landscape. Pit latrines fail in the soggy soil of communities in the southern state of Benue; similar issues are encountered in the dry sand of Bauchi and Jigawa states, deep in the Sahel region of the country.

Mechanics of Soil Collapse

In southern states, pit collapse is most often experienced at the peak of the rainy season. The saturated soil is commonly less stable than its dry counterpart, and shallow groundwater often rises well above the pit floor. The standing water within the pit drives erosion of the unlined walls.

This erosion ultimately undermines the stability of the soil above, which sinks or falls into the pit. Any structure built above is subsequently compromised: concrete will crack and mudblock will tumble. The failure of the superstructure may occur gradually or catastrophically, depending on the composition of the soil, weight of the building materials, and extent of erosion beneath.

In the arid north, sandy soil loses cohesion when water is introduced into the pit through the slab hole or through the soil walls. Water infiltration, caused by rain or use of water nearby to bathe, will erode the walls and cause collapse of the slab above. In most cases, these events are often experienced within a year of construction.

Response

WaterAid Nigeria recently undertook a study of hydro-geologic issues in communities throughout the country in October and November of 2007. From the study, insight was gained into the mechanics of soil collapse and several low-cost solutions were developed that promise to facilitate the reintroduction of sanitation programs in the affected communities.
The remainder of this briefing note describes the solutions developed in response to the study. The final section also discusses approaches toward

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the technologies discussed above, must be established within the target community. Strategies for ensuring proper capacity development are discussed in the final section of this note.

Building Capacity

Through the pilot project conducted in Nigeria, it was observed that community participants developed the necessary technical skills quickly, and were able to repeat the basic steps required in constructing the arborloo and low impact lining with no formal supervision. It was however critical to develop an understanding of the technical concepts and build enthusiasm for the new approaches to sanitation.

Designs for the prototype technologies were first presented by WaterAid to its partners in the Water and Sanitation Units (WASU) in the local governments of Benue State. Many options were presented, and with the consultation of representatives from the selected pilot communities they selected the approaches that were deemed most appropriate.
Plans were then put in place to pilot the selected technologies: the low impact lining and the arborloo. For the arborloo, local sanicenters were presented with a design for a lightweight dome slab as discussed above. Several slabs were cast according to these specifications and provided to communities that elected to pilot the arborloo approach to sanitation.

Communities that elected to pilot the low impact lining were asked to excavate a deep pit and collect materials required to build the lining. Representatives from WaterAid and the local WASU were invited to the community on a specified date soon after, at which time program engineers from WaterAid demonstrated the construction approach to the community. WASU representatives were asked to participate in the construction process, in order to build their own technical capacity.

The construction process was followed by an open forum with participating members of the community. They were asked to provide feedback on the construction process and their impression of the installed technology. With the aid of the community Water and Environmental Sanitation Committee (WESCOM), the program engineers developed a bill of quantities and cost estimate for each technology. Once they had participated in the construction of a low impact lining, the local government WASU was directed to spearhead similar installations in other communities. Once these had been installed, WaterAid program engineers inspected the pits in order to ensure the capability of WASU representatives to oversee construction in communities unfamiliar with the new technology.

Following construction of pilot pits in a given local government area (LGA), WASU representatives from nearby LGAs were invited to the original communities to view the new technologies, and discuss their implementation with the local WASU and WESCOM. The new local government WASUs were then instructed to spearhead similar activities in their own jurisdictions. WaterAid program engineers continued visits to the field in order to ensure proper transfer of knowledge between local governments and communities.

Construction techniques were also added to the WaterAid Manual of Standards and Specifications, a comprehensive technical guide provided to WaterAid partners in local governments and civil society

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Local artisans secure a flexible hoop at the top of a hardwood pit in Balzur Community Tafawa Balewa LGA, Bauchi State (left), The cage is subsequently encased in mud treated with latrite and a collar beam is formed at the top.

those that naturally develop in bamboo cages. As a result, the clay packing becomes increasingly critical. If available funds exist, bitumen can be added to increase the resilience of the packing material. The installation procedure of the hardwood lining is similar to that of the bamboo option indicated above.

<u>Mudblock Lining</u>

In very arid communities, groundwater levels remain well below the floor of latrine pits. In such instances, a lining of stacked mudblock will suffice. The diameter of the excavated pit should be set such that the final diameter (once the mudblock lining is in place) matches the standard set by the local WESCOM.

The mudblock should be stacked in a staggered ring pattern. Builders should maintain a 2-3 centimeter gap between adjacent blocks in order to allow infiltrating water to drain easily into the surrounding soil.

Due to the tendency of mudblock to dissolve when submerged in water for prolonged periods of time, this option is not recommended for environments where users will observe standing water in their latrine pits. Moreover, users should ensure the slab is properly covered at all times to prevent infiltration of rainwater.

Good Practice

The risk of pit collapse due to poor soil quality and shallow groundwater can be mitigated through measures of good practice during construction and use of the facility. Regardless of chosen technology, community members should be made aware of several steps they can take to reduce the likelihood of failure:

- When choosing a location for the pit latrine, avoid places where rainwater runoff is high, groundwater is shallow, or water-intensive activities (such as bathing) take place nearby.
- Only construct deep pit latrines during the dry months, when groundwater levels are below the floor of the pits under construction.
- Hardwood floors and slabs should be built significantly larger than the width of the pit, in order to ensure that the weight of the slab and the user is distributed to soil away from the pit edge.
- The risk of collapse is greatly reduced through the construction of a superstructure from lightweight materials. Instead of mudblock, community members should be encouraged to use grasses, hardwoods, and bamboo.
- All deep pit latrines should be sheltered from rain through the use of a cover (such as a piece of plywood) or a roof.

These measures of good practice, as well as the construction approach for

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Partners and program engineers inspect a community latrine that collapsed in Benue State after a failure in the pit below (left), a collapsed pit in Jigawa State (right).

capacity building, which includes the training of WaterAid partners and local artisans. Additional technical documentation on the solutions presented is listed at the end of the note.

New Technologies

WaterAid's response to the issue of pit collapse must involve a number of versatile approaches, which collectively reach households of various income levels in all affected regions. The resulting technological approaches have been developed as construction techniques that can be implemented using a wide range of available materials. In most cases, required materials can be found locally at minimal cost.

Two primary techniques have been applied in communities around Nigeria. A basic concept known as an arborloo has been adopted from similar sanitation programs in South Africa and Haiti, and is introduced first. This technique is followed by a discussion of a low impact pit lining, which includes a number of construction approaches that are currently under pilot testing in various regions of Nigeria.

The Arborloo

Many communities are limited in their ability to excavate deep pits by rocky terrain and shallow groundwater. The arborloo is a sanitation approach that involves the use of shallow pits and a lightweight superstructure that can be easily moved atop a new pit nearby when the original pit is full.

When placed atop a shallow, unlined pit, the arborloo is intended to serve a household for a short period lasting from one to three months. The limited depth of the hole minimizes risk of collapse and permits use of the technology in areas with shallow groundwater and rocky terrain, where deep pits are difficult to excavate.

Once the pit in use has been filled by the household, a new pit is excavated beside the arborloo. The lightweight superstructure is then lifted easily and placed atop the new pit. The arborloo is then ready for use again. The task of digging the new pit and moving the arborloo requires minimal effort and can be accomplished in a short period of time.

The original pit, filled with excreta, is covered with a layer of ash and a portion of soil removed from the new pit. Over time the contents of the pit will decompose, and after 1 year it can be excavated again as the family returns the arborloo to its original location. The compost removed from the pit can be used or sold as fertilizer for crops or gardens. This practice has the added benefit of familiarizing households with the process of fecal decomposition.

The arborloo approach to sanitation

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can be introduced to any community regardless of income levels or available materials. The superstructure can be built of anything lightweight, including grasses, softwoods, bamboo, or other indigenous vegetation. In Benue, an arborloo superstructure comprised of woven palm fronds was constructed at a cost of roughly US$12, and can serve as a household sanitation facility there for years before it needs to be replaced.

An arborloo, constructed of woven palm fronds at the WaterAid office in Makurdi.

Typical latrine floor slabs can also be made lightweight and portable. In cooperation with WaterAid, a local sanicenter in Benue recently began producing cement dome slabs with a diameter of 80 centimeters (in contrast to the standard 120 centimeters) to reduce its weight. Additionally, holes were cast on opposing sides of the slab to facilitate the use of rope handles.

Conventional slabs comprised of hardwood planks or branches can also be made portable by lashing the wooden pieces together as they are laid down. Rope handles can likewise be added and the hardwood slab can be subsequently transported atop new pits easily.

A lightweight dome slab cast in Oju LGA.
Hole pairs will be used for rope handles.

Arborloos are particularly advantageous in communities where income levels are generally low. If households are given the capacity to produce their own slab and superstructure from materials readily available in the surrounding environs, the technology can be provided to a household at no cost.

WaterAid Nigeria is also initiating the introduction of kiddieloos to communities in Benue State. Similar to the arborloo, the kiddieloo is a lightweight slab laid atop a shallow pit, however no superstructure is added. This facility serves as a public latrine for children, who often lack concerns about individual privacy.

Low Impact Pit Lining

Deep pits can be made sustainable in communities with poor soil conditions or shallow groundwater through the introduction of a lining system comprised of indigenous materials. Like the arborloo, a low impact lining is a concept adaptable to various regions by accommodating a wealth of different materials.

The specific construction approach for a low impact lining depends on the nature the materials selected; however the performance of the resulting system is universal. The structural lining includes physical elements strong enough to retain the soil as it settles toward the pit. Additionally, the lining prevents erosion of the soil walls by water that either rises into the pit from the ground or infiltrates from the surface above.

Two similar but distinct lining systems were installed in communities of Benue and Bauchi states. They likewise address the issue of pit collapse in both tropical and arid regions, and selection of lining materials in each area was undertaken with sensitivity to their availability in the surrounding environs.

Bamboo Lining

In Benue, the availability of bamboo led to its selection as the primary structural element. The bamboo stalks were cut to a length 25 centimeters greater than the depth of an excavated pit, and one end of each bamboo rod was sharpened with a cutlass. The sharpened end of each rod was then driven into the floor of the excavated pit adjacent to the soil wall with a hammer, until the top of the rod was made level with the surface of the ground.

Each rod was driven individually, placed up against the previous rod driven, as the construction team moved in a concentric circle until they returned to the first rod. At the top of the bamboo cage, a piece of flexible softwood was installed as a compression hoop and tied to each rod with rope.

To ensure effectiveness of the new lining, voids between the soil wall and bamboo were packed with water-resistant clay comprised of mud and latrite. This packing serves as a barrier that stops erosion of the soil walls and protects the bamboo from termites.

The top of the bamboo cage and flexible hoop are cast into a mudblock capping beam. Once the beam has dried, a slab and superstructure can be added by the user.

Hardwood Lining

The scarcity of bamboo in arid regions such as Bauchi compelled the pilot project team to select alternative materials for the cage structure. Here, local hardwood sticks were substituted. Sufficiently strong, the sticks provide an adequate substitute, however their natural form is often less straight than bamboo stalks.

Voids between driven hardwood sticks are often substantially larger than

Community sanitation committee members drive bamboo rods in Obijago Community, Obi LGA (left), a softwood hoop is installed and secured with rope (right).