

## Assessing the potential risks of burial practices on groundwater quality in rural north-central Nigeria

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### ABSTRACT

Several cultures of north-central Nigeria do not use community cemeteries. Instead, human remains are buried in and around family compounds, often in shallow and sometimes unmarked graves. At several locations, graves and drinking water wells end up too close to be presumed environmentally safe. This paper reports findings of a pilot study that explored the potential for groundwater contamination from gravesites in some rural settlements of north-central Nigeria. Preliminary results suggest that the long-standing burial practices among some cultures of rural north-central Nigeria may potentially compromise groundwater quality, which is, by far, their most important source of drinking water.

**Key words** | burial practices, gravesite leachate, groundwater contamination, north-central Nigeria

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### INTRODUCTION

Increased pressure on water reserves, from both a rapidly growing world population and climate change, threatens the future of water resources in many parts of the world (Vörösmarty *et al.* 2000; Loáiciga 2003; UN World Water Development Report 2003; IPCC 2007; Rosegrant *et al.* 2009). For some world regions, the question of water security is further complicated by certain anthropogenic practices that may potentially expose humans to serious water-related health hazards. In rural north-central Nigeria, for example and indeed elsewhere in Africa, cultural practices relating to the disposal of human remains may have significant implications for both groundwater and surface water quality. Common among these rural environments are traditional beliefs that encourage the burial of deceased family members in and around living quarters (village compounds).

For most of north-central Nigeria, cemeteries are a rare sight even in cities. This is because the cultures of most ethnic groups demand that a deceased person be returned to their ancestral village for burial. The selection of village grave sites, however, is based on longstanding traditions rather than environmental considerations. Over time, graves become scattered throughout village landscapes and, because many are not marked with a permanent

structure, some are hardly recognizable as grave sites after only a few years. Ultimately, graves and water wells often end up very close together, sometimes within a few meters of each other. From an environmental and health perspective, this close co-location of wells and graves is risky because contaminants can migrate from a grave into the shallow hand-dug drinking wells that serve as the primary source of cooking and drinking water in these villages.

In contrast to the developed world, where environmental laws are generally more stringent and burial practices tend to be highly regulated, Nigerian environmental laws are somewhat fuzzy and rarely enforced. Thus, in rural areas, local traditional/cultural burial practices often prevail even when they violate government regulations. This, I believe, stems from a general lack of scientific awareness among rural people regarding the implications of their traditional burial practices on the environment and, ultimately, human health. In fact, a careful review of the literature reveals a paucity of research on the problem that burial practices pose to groundwater purity in Africa. Elsewhere, a number of studies (e.g. Pacheco *et al.* 1991; Knight & Dent 1995; Sponberg &

Becks 2000; Hart 2005) have reported groundwater contamination around cemeteries. Pacheco *et al.* (1991) for example, monitored groundwater for bacteriological quality around three cemetery locations in Brazil and found contamination at all sites. Sponberg & Becks (2000) reported contamination of both soil and stream water downstream from a cemetery in Ohio (USA). The study found the contaminants to be consistent with chemicals used for embalment (e.g. arsenic and formaldehyde) and/or wood preservation.

Several emerging factors and dynamics in rural Africa suggest an urgent need to raise public and scientific awareness of the possible risks posed by the indiscriminate disposal of human remains on groundwater quality and public health. First, most villages in the areas where this practice persists rely on untreated groundwater, exposing them directly to pathogenic and chemical leachates that may leach from grave sites into groundwater. Second, the region is already rife with diseases. Indeed, as a region, Africa continues to suffer one of the highest death rates in the world and, correspondingly, one of the lowest life expectancies (only around 40 years; UNDP 2007). Owing to the cultural and religious belief systems that discourage postmortem examination, and the dearth of sophisticated medical facilities in many rural African societies, causes of most deaths are rarely ever established, hence, the effects of groundwater contamination on public health also remains unclear. Nigeria has no regulations regarding the composition and use of embalming chemicals, which means that effluents from graveyards may possibly contain dangerous chemicals such as arsenic that have been banned elsewhere. Geologically, the shallow and dynamic water tables, which rise dramatically in many areas during the rainy season, could facilitate the interaction between groundwater and graveyard leachates. Thus, understanding the implications of rural burial practices for groundwater quality and human health is a critical first step for raising environmental awareness among the rural people in the study region. The primary goal of this pilot study is to demonstrate that groundwater contamination is possible from the traditional burial customs of rural north-central Nigeria, and several other sub-Saharan African cultures that have similar practices.

## THE STUDY AREA

The study area is located in Benue State of north-central Nigeria between latitudes  $6^{\circ} 25'$  and  $8^{\circ} 8' N$ , and longitudes  $7^{\circ} 47'$  and  $10^{\circ} E$  (Figure 1). Burial customs here are representative of many other rural societies of Nigeria. The study location lies within the fertile Benue Valley, a relatively flat terrain averaging between 100–250 m above mean sea level. It is drained largely by the Benue River and its major tributary, the Katsina Ala River, along with their several other smaller tributaries.

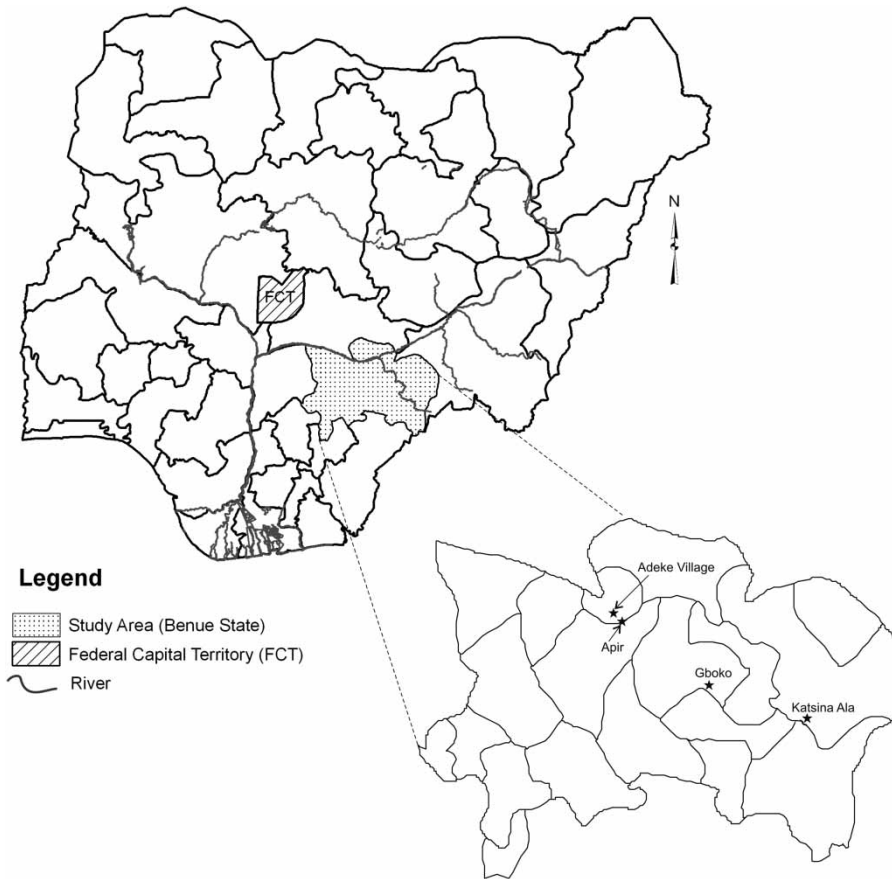
The entire Benue Valley is characterized by a tropical sub-humid climate defined by two distinct seasons – the wet (rainy) and the dry. The wet season runs from April to October. The annual rainfall total ranges from 1,200–1,500 mm. During the wet season, the water table in shallow aquifers is greatly elevated so that it stands at less than 2 m of the surface in most wells. The dry season lasts from November to March, during which severe water shortages are experienced in most places as domestic wells and springs dry up. At this time many rural families resort to a few perennial streams and ponds for their water needs.

Moderately high day-time temperatures and fairly high humidities characterize the wet season, particularly along the river valleys. Generally, mean monthly temperatures fluctuate between 28 and 35 °C (Agwu *et al.* 2009).

### Cultural perspective on burial in the study area

The study area is home to the culturally rich Tiv-speaking people of north-central Nigeria. The Tivs number slightly over 4 million, making them one of Nigeria's major ethnic groups. Agriculture is the major occupation among Tiv rural dwellers. The Tivs are known for their tenacity and respect for tradition. Although European contact, especially the influence of Christianity and other outside influences, has weakened some indigenous cultural practices of the Tivs, the tribal group has continued many of its ancient traditions, including their ancient burial practices.

Before European contact, cemeteries were unknown in Tivland, where the location of a grave was determined



**Figure 1** | Study area map.

based on the circumstances surrounding each death (Gundu 1998). Although colonial administrators established a cemetery in each urban settlement in Tivland, such sites were rarely used by the tribe. By Tiv tradition, a deceased family member must be buried in his/her ancestral village irrespective of the place of death. Only a child (usually less than 10 years old) may be buried elsewhere, depending on the distance the family resides away from their village. The Tivs adhere strictly to this practice to the extent that even corpses of deceased members residing in foreign countries must be returned home for burial. The cultural and spiritual underpinnings of Tiv burial traditions are however beyond the scope of this article. An interested reader is directed to Gundu (1998) for a full account. Of closer significance to this study are the factors that determine the selection of grave sites in Tiv villages.

Owing to the longstanding practices and beliefs in Tiv villages, it is common to find isolated graves in different corners of a compound (Figure 2). Although two or more graves may be located near each other, such proximity is based on immediate practical concerns and does not suggest that the Tiv possess a concept similar to Western notions of a cemetery. A compound head (the eldest extended family member) usually selects the site of a grave. Factors considered in the location of a grave include the type of death, age of the deceased, social status, as well as some spiritual considerations. For example, a deceased child is usually buried by the roadside adjacent to the main compound. Until recently, someone who died from an accident (considered a curse) would be buried far away from the compound usually, near a stream (Gundu 1998). Adult men are usually buried around their households. Others, especially



**Figure 2** | Typical village compounds with graves beside them.

those possessing a relatively high status, may be buried in the centre of the compound.

The Tiv grave is generally a rectangular pit with depth varying between 0.75 to 1.2 m, usually excavated by non-professional diggers. In general, there are no regulated standards regarding the depth of a grave or its finishing. However, historically, the depth of a grave is determined by the age and social persona of the deceased (Gundu 1998). Thus, a child or a less wealthy person may be buried in a shallower and or poorly-finished grave. Due to European influences however, the practice of grave marking (erection of beacons) is increasing. Prior to colonial contact, graves were simple pits closed to form mounds; there were hardly any grave makers and the grave was for all practical purposes not intended to be a permanent structure (Gundu 1998). Without permanent markers several graves were no longer recognizable after only a few years.

This study is motivated by concerns that stem from the combination of these factors.

## METHODOLOGY

Because this was a pilot study, only a few representative sites were selected for data collection. Groundwater samples were collected from drinking wells at four rural settlements and townships, including Adeke Village, Apir, Gboko, and Katsina Ala (K/Ala) (see Figure 1). All sampled wells were the hand-dug type because they are the most commonly used by the people. Boreholes are uncommon since the majority of the populace cannot afford them. A well was selected for sampling if it was in close proximity to one or more graves (<25 m away), with occasional sampling of distant wells as controls. Figure 3 shows two examples of grave location relative to drinking wells in the study area.

At each site, a hand-held GPS unit was used to record the coordinates of both the wells and the graves. Next, the surface diameter of the well and the depth to the water table were measured. Finally, water samples were collected and stored in sterilized bottles. Collection and storage of water samples was done following appropriate procedures required for specific laboratory analyses. A total of 33 samples were collected for analyses.

To test for bacterial contamination, a bacto-hydrogen sulphide test kit was used. In this test, hydrogen sulphide was added to the water sample and left for a 24-hour period. A sample turning black was indicative of bacterial contamination. At this exploratory stage of the research, no further analysis was done to isolate the type of bacteria. Finally, samples were sent to the laboratory to test for nitrates, glycerol, formaldehyde, and phenols – all chemicals that could be suggestive of graveyard leachate.

## RESULTS AND DISCUSSION

Of the 33 samples collected, 27 (82%) tested positive for bacterial contamination. Among these, two samples out of the control group of four wells were bacterial contaminated but both had no phenol content, which may suggest that the proximity of wells to grave sites might play a role



**Figure 3** | Example well location relative to graves.

in the contamination. At this pilot stage however, no further analyses were performed to isolate the bacteria types, hence, the contamination cannot be attributed directly to gravesite leachate. Isolation of bacteria type is critical for attribution because other sources of bacterial contamination are possible. For example, because >90% of the wells are hand-dug, they have large diameter openings (>0.5 m), many often with inadequate coverings such that rodents and other reptiles may fall and decompose in them, leading to bacterial contamination. Moreover, water is drawn manually with ropes tied onto buckets in ways that are not very hygienic (see Figure 4). Nonetheless, the evidence of bacterial contamination, irrespective of

the sources, raises health concerns and needs to be evaluated in greater detail.

Table 1 summarizes the results of laboratory analyses for water chemistry. Due to financial constraints at the time of the study, only 14 of the 33 samples, including two from the control group, were analyzed for nitrates, phenols, and formaldehyde. All the samples were collected from wells located 25 m or less from gravesites, except for the control samples. The nitrate concentration in all 14 samples ranged from 0.001–0.034 mg/L, far below the Nigerian Standard for Drinking water Quality (NSDWQ) set limit of 50 mg/L (SON 2007). Figure 5 shows the results for the phenol concentration in the water samples. Going

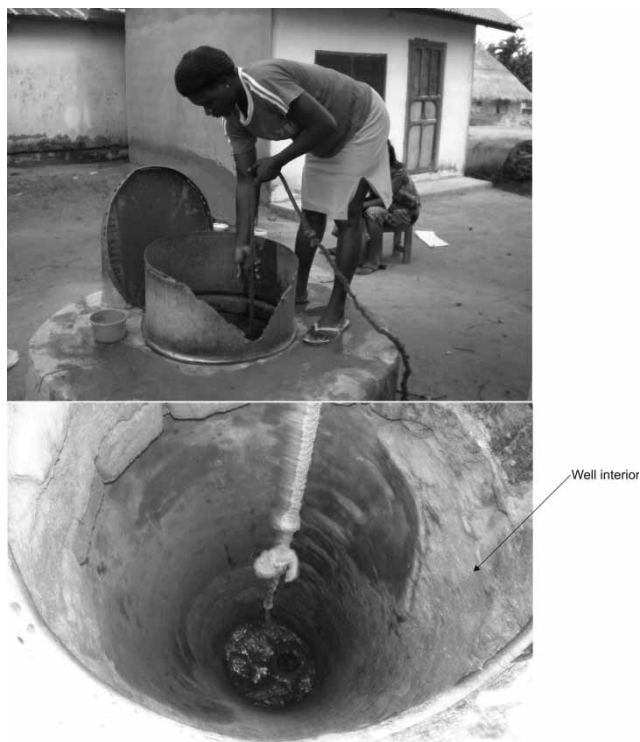


Figure 4 | Drawing water from a hand-dug well.

by the NSDWQ set limit of 0.001 mg/L, more than half (57%) of the 14 samples are significantly phenol contaminated. The wells around Gboko show comparatively

Table 1 | Summary of water quality analyses

Sample	Well-grave distance (m)	Phenol (mg/L)	Nitrate (mg/L)	Formaldehyde (mg/L)	Bacteria Indication
Gboko 1	21.4	0.4	0.22	0	+
Gboko 2	23	0.7	0.026	0	+
Gboko 3	56.7	0	0.01	0	-
Gboko 4	11.2	2.6	0.01	0	+
Gboko 5	23.5	1.4	0.01	0	+
Gboko 6	25	1.0	0	0	+
Gboko 7	22	0	0.001	0	+
Apir 1	12.3	0	0.013	0	+
Apir 2	15	0	0.007	0	+
Apir 3	16	0	0.024	0	+
Adeke	9.7	0.4	0.01	0	+
K/Ala 1	7.5	0.9	0.034	0	+
K/Ala 2	49.6	0	0.03	0	+
K/Ala 3	15.2	0.1	0.03	0	+

higher phenol concentration than the rest of the sites. It will be interesting to see if the phenol concentration trend in the analyzed samples is representative of the entire study area. The occurrence of phenol in the well samples may be related to the impacts of gravesites because phenol is used in embalment. However, further

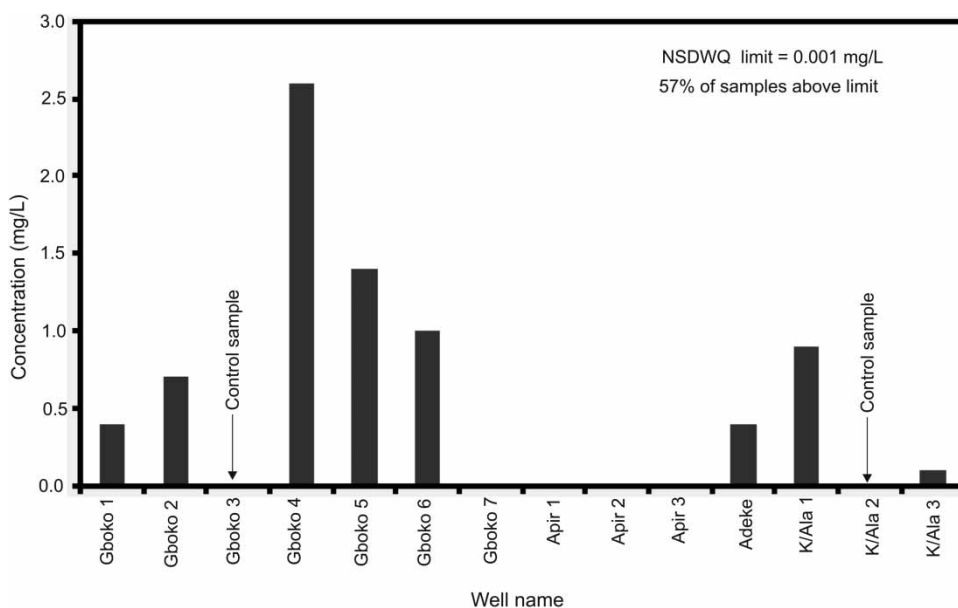


Figure 5 | A graph showing phenol concentration in wells.

investigation is needed to make the connection. For all 14 samples, no formaldehyde, a major embalming chemical, was detected. It must be noted however that these results may be limited because they stem from a pilot investigation that focused on a few selected sites and utilized the basic methods of analyses. A more robust study is needed to obtain a better picture of the impacts that gravesites may have on groundwater quality in the entire study region. Nevertheless, the results obtained meet the study objective, which was to establish that groundwater contamination from gravesite leachate was possible. Subsequently, a broader investigation involving a larger number of wells in varied geologic settings and the analyses of more chemical and also physical parameters of water quality will be pursued. The next phase will also involve both microbial analyses and geoelectrical surveys that will help determine if groundwater contamination at a location is attributable to gravesite leachate.

Meanwhile, it is the author's strong opinion that the local populace must be educated about the environmental and health implications of their long-standing burial tradition. The need for protecting their groundwater resources against obvious pollution sources must be thoroughly communicated. As one measure, the state government could introduce legislation that prohibits the location of burial sites within a given distance of drinking wells. For most developed countries cemeteries are prohibited within a 15–25 m radius of water supplies. A similar regulation could be adopted in these villages. However, in the context of the rural cultures, the enforcement of such regulation might require that locals shift from their long-standing burial tradition and adopt the western culture of cemeteries. Use of cemeteries (or small family burial plots) can free up space for groundwater development far enough from graves that the risk of graveyard contamination is greatly reduced.

## CONCLUSION

This pilot study was carried out to explore the potential implications of the cultural burial practices among rural societies of north-central Nigeria on groundwater quality. Water samples were collected in several hand-dug wells

used for drinking purposes that are located close to graves where human remains have been buried. The goal was to determine if groundwater contamination from embalming and or wood preservation chemicals used for coffins, or from bacteria in decomposing human corpses, is a possibility. A microbial analysis showed that most of the wells are contaminated with bacteria although there is no evidence at this point to link the contamination to graveyard leachate. Water chemistry analyses found phenol concentrations to be significantly higher than the drinking water limit, which may be suggestive of graveyard influence. While preliminary, these results suggest that there is potential for groundwater contamination in the vicinity of gravesites in the study area and thus point to a critical problem that must be addressed with urgency.

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