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Sachet drinking water in Ghana's Accra-Tema metropolitan area: past, present, and future

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Abstract

Population growth in West Africa has outpaced local efforts to expand potable water services, and private sector sale of packaged drinking water has filled an important gap in household water security. Consumption of drinking water packaged in plastic sachets has soared in West Africa over the last decade, but the long-term implications of these changing consumption patterns remain unclear and unstudied. This paper reviews recent shifts in drinking water, drawing upon data from the 2003 and 2008 Demographic and Health Surveys, and provides an overview of the history, economics, quality, and regulation of sachet water in Ghana's Accra-Tema Metropolitan Area. Given the pros and cons of sachet water, we suggest that a more holistic understanding of the drinking water landscape is necessary for municipal planning and sustainable drinking water provision.

Keywords

Africa; drinking water; Ghana; infrastructure; poverty; sachets

INTRODUCTION

Despite substantial progress toward the Millennium Development Goals' target of halving the proportion of the population without sustainable access to safe drinking water and basic sanitation, nearly a billion (10^9) people still lack safe sources of drinking water, over a third of whom live in sub-Saharan Africa (United Nations 2008). Many sub-Saharan African cities have surged in population in recent decades due to industrialization-driven urbanization coupled with high (though declining) fertility (Bloom *et al.* 2008), and projections for the next decade yield an urban-majority population for the region (United Nations 2010). Indeed, Ghana passed that threshold in 2011. In the face of such rapid and unprecedented urbanization, many governments have been unable to extend basic water and sanitation services to keep up with urban population growth, and informal settlements and

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slums have become a fixture in sub-Saharan Africa's urban landscape. The inadequate investment in water infrastructure over the past few decades has restricted – or even eliminated – piped water access for an increasingly large fraction of the urban population. This water scarcity results in further marginalization of living conditions and generates high levels of morbidity, particularly in the most densely populated, and generally poorest urban areas (UN-HABITAT 2006; Gaisie & Gyau-Boakye 2007). The drinking water landscape in Ghana's largest urban center, the Accra-Tema Metropolitan Area (ATMA), is typical of West African cities where preventable epidemics and resulting deaths continue to emerge primarily due to insufficient water and sanitation services.

Water service to ATMA is currently provided by two Ghana Water Company Ltd. (GWCL) water treatment plants on the eastern and western peripheries (Kpong and Weija Waterworks, respectively) of ATMA, but the city has grown well beyond the plants' capacities. GWCL is unable to provide water to all of Accra due to production and distribution limits, continued population growth without urban planning, and non-revenue water losses which weaken the utility further (Van-Rooijen *et al.* 2008). Subsequent water rationing and low quality ad hoc storage systems leave large portions of the population without adequate potable water. Although GWCL's service coverage is technically 80% of the ATMA, less than half of residents have a house or yard connection (Van-Rooijen *et al.* 2008), and less than 10% have a reliable in-house connection (Taylor *et al.* 2002). Most people are dependent upon water vendors when lacking a nearby connection or when rationing diverts water to higher-income neighborhoods. In Accra, where residents are already paying four times as much for water by volume than New Yorkers, slum residents are paying vendors up to eight times the local public utility prices (United Nations Development Programme 2006), and up to twenty times in dryer periods (Taylor *et al.* 2002). Barriers to connecting to the water network, such as high capital costs and lack of property rights in informal settlements, exacerbate inequalities in water network access between high- and low-income settlements (Collignon & Vézina 2000). One recent study revealed that 87% of direct access GWCL customers are well-connected officials in the public service or otherwise high-standing individuals in the private sector (Owusu & Lundehn 2006).

Where lack of infrastructure and/or rationing have left a void, entrepreneurial water vendors have stepped in to sell water in three general delivery modes: (1) by the tank, via trucked supplies, (2) by the container, straight from the vendor's own tap water supplied by GWCL, or less commonly (in Accra) from a borehole, and (3) packaged as sachets with varying degrees of filtration or disinfection. Sachet water typically consists of 500 mL polyethylene plastic bags of water heat-sealed on either end (see Figure 1a). It is a relatively new and fast-growing source of drinking water in Ghana and other West African nations. Popularly referred to as 'pure water,' sachets have gained public affinity due to low price, convenience, ubiquity, and the public perception that sachet water is of higher quality than tap water. Sachets are also notorious for constituting a major proportion of the plastic waste generated throughout the country, as consumers typically litter the plastic sleeves in streets and gutters due to lack of organized solid waste collection and removal. Clogged gutters increase the chance of flooding during the rainy seasons, which leads to subsequent loss of property and localized bouts of waterborne illness. Given the importance of sachet water as a clean source of drinking water for many underserved areas, the overall desirability of sachet water from a public health and urban planning perspective remains uncertain.

There has been little research into the transformation of drinking water delivery in developing urban centers such as Accra, and, to our knowledge, no published literature exploring how privatized, packaged water such as sachets is changing the drinking water landscape in West Africa. The word *sachet* itself does not appear in the United Nations' recent 440-page Human Development Report focusing on global water crises (United Nations Development Programme 2006). Ghana's shift toward privatized water delivery, while not thoroughly studied, was recognized by Ghana Statistical Service as it prepared for the 2010 Ghanaian Census. Among the updates to the questionnaire – following the lead of the census questionnaire in Nigeria – is a split of the traditional drinking water inquiry into two questions that solicits the primary source of drinking water in addition to the source of water for all other household uses. In anticipation of a fuller, census-driven picture of Ghana's household drinking water patterns as the 2010 census data become available in 2012, this paper profiles the growth of sachet water in Ghana's capital region, the ATMA, based on in-depth structured interviews with sachet producers, trade groups, and government agencies. We conclude by highlighting issues of drinking water provision that are likely to receive increased attention throughout the global South in the coming years.

THE ADVENT OF SACHET WATER

Water vending has probably existed as long as society itself, and the issues surrounding vended water in the developing world have received contemporary review elsewhere (Sansom 2004; Kjellén & McGranahan 2006). In urban sub-Saharan Africa, citizens lacking piped potable water have traditionally relied on both formal and informal versions of water kiosks, from which water is carried back to the home, and pushcart (or donkeycart, etc.) vendors who deliver water to communities and businesses. 'Drawers of Water' (White *et al.* 1972) has inspired much of the literature over the past few decades. This literature incorporates many pervasive themes related to vended water such as governance failures, higher costs, willingness to pay, storage challenges, quantity vs. quality tradeoffs, and adverse health outcomes (Zaroff & Okun 1984; Lewis & Miller 1987; Whittington *et al.* 1989, 1991; Cairncross & Kinnear 1991; Katko 1991; Briscoe 1993). Modern sachet water is, in essence, the latest low-cost technological incarnation of vended water, and many of the issues and challenges described in this article arise from sachets' novel product portability and the exacerbation of existing sanitation challenges as a consequence of the excess plastic litter created by the disposal of the sachets.

The brief history of sachet water which follows was pieced together through interviews with sachet producers, an official at the Ghana Plastic Manufacturers Association, and GWCL officials. In the 1970s and 1980s, it was common to be able to buy a cup of drinking water on the streets of Accra for 1 Ghana pesewa (100 Ghana pesewas [Gp] = 1 Ghana cedi [GH ¢]). The purchaser drank directly from a plastic or metal cup, which the vendor used to scoop water out of a larger storage vessel. This form of water entrepreneurship was aimed at poor, transient population segments, but eventually demand grew beyond this demographic. Increased demand coupled with the obvious sanitary shortcomings of such a system led to the packaging of water in small plastic bags in the 1990s. These small bags, tied by the corners at the top, generally cost Gp 1–3 for a bag containing 250–500 mL of water (generally municipal water). Hygiene remained an issue, as bags were generally filled by women and children with suspect sanitary practices (Olayemi 1999; Obiri-Danso *et al.* 2003). In the late 1990s, new Chinese machinery that heat-sealed water in a plastic sleeve effectively created the modern sachet that is currently sold on the streets of several West African nations. Filtration and chemical treatment processes (described later in this paper) were eventually built into some of the high-end machines as well (Figure 1b).

The price of a sachet in Ghana held steady at Gp 3 for many years until the redenomination of the Ghana cedi in 2007, which essentially knocked four zeros off the old cedis using a ratio of 1:10,000. Due to the shift to the new currency, receiving exact change from purchases became problematic – a situation common to much of the developing world – and the effective street price rose by two-thirds to Gp 5 where it remains today. A new *ad* *valorum* tax on sachet water was set to take effect in March 2010 in order to fund the cleanup of drains clogged by discarded sachet sleeves, but the tax was repealed by Parliament at the last minute due to concerns over civil hardship. The street price of sachets would have risen from Gp 5 to 7, but would have effectively gone to Gp 10 in most areas due to vendors' lack of change. The environmental impact of sachets has yet to be addressed as of this writing, but recent proposals have included the taxation of imported plastic used to manufacture sachet sleeves, and the development of biodegradable sachet packaging. Environmental issues related to sachet consumption are discussed later in this paper.

The appeal of the sachet seems to mirror the mass consumer appeal of small unit sizes of commodities as seen elsewhere in the developing world (Hammond & Prahalad 2004). In Ghana, where many people are living day-to-day, average household budgetary constraints often preclude the purchase of larger volumes of consumer goods such as grains, spices, and milk, and immediate needs may override the cost savings of buying in bulk. Eating meals out of the home and take-away culture is increasingly popular, and sachets can be consumed on-the-go with less concern over quality relative to tap water. Sachet marketing efforts have, just as with bottled water in the developed world, also successfully linked the image of higher status with packaged drinking water.

DRINKING WATER TRENDS IN GHANA

Recent Demographic and Health Surveys (DHS) in Ghana reveal the surge in sachet consumption, but the international water and sanitation community has thus far taken relatively little notice. Figure 2 plots the percentage of households whose primary source of drinking water is any form of piped water (in-home, outdoor, public taps) and sachet/ other sources from the three most recent Ghana DHS data sets (1998, 2003, and 2008). Among Ghana's ten administrative Regions, all generally show neutral or slightly positive trajectories in the percentage of households using piped drinking water except Greater Accra, which decreased from 84.4 to 58.2%. Filling this gap, the percentage of households primarily drinking from sachets grew to 34.5% in 2008, considerably higher than any of the other nine Regions. The Greater Accra Region had the fastest growing population in the country, growing at 4.4% annually between 1984 and 2000, and the intermittency of water delivery may be attributable both to this growth and an inadequate water infrastructure investment (Gaisie & Gyau-Boakye 2007). Census counts from 2010 are likely to show a similar pattern of mismatch between population growth and water availability.

Figure 3 shows the drastic increase in sachet consumption in Greater Accra between the 2003 and 2008 Ghana DHS. We observe the largest increases in sachet use around several low-income neighborhoods such as Nima, Kokomlemle, northern Kanda Estates (within the otherwise well-served Cantonments), Teshie Nungua Estates, and the predominantly Ga coastal strip from Gbegbeyise to Jamestown. Only the up-and-coming middle-class neighborhood of Dansoman yielded less sachet use in 2008 than in 2003. The breakdown of drinking water sources (Table 1) shows that all sources of piped water access decreased among the urban population between 2003 and 2008 (from 88.7 to 56.8%), an effect so strong that the overall Greater Accra totals mask modest increases in some categories of rural piped water access over the same period. Households were increasingly able to procure water within 15 min from home in 2008, and the median time to that water source decreased from 5 to 1 min for urban residents as sachet use increased from 5.7 to 37%. The surge in sachet use reported between the 2003 and 2008 DHS, as the novel product initially gained popularity with consumers, seems to be linked not only to convenience but in those surveys is associated with those with higher disposable income, as indicated in Table 2. This disproportionate association with wealth is probably misrepresented by the nationally-scaled wealth index calculated from the DHS, as Table 2 also shows that households surveyed in

Greater Accra are generally wealthier relative to the rest of Ghana. While additional nationally-representative data from 2006 also demonstrate that early-adopters of sachet water tended to be wealthier (Ghana Statistical Service 2006, p. 53), more recent survey data reveal that sachet consumption may be more closely linked with the urban poor. Fifty percent of households in a sample of Accra's slum neighborhoods reported using sachets as their primary drinking water source in a 2009–2010 study, and these households tended to be the poorest within these slum communities (Stoler *et al.* 2012).

Table 1 also indicates that bottled water and tanker truck delivery, which primarily enjoy a niche market among wealthy Ghanaians, continue to play a relatively insignificant role in drinking water delivery across Greater Accra. Bottled water is commonly available through street vendors and markets that cater to the rich, but it lacks broader appeal due to higher price and the ubiquity of sachet water of equal quality from the same bottlers. The slight decline in residential tanker truck water consumption may reflect the preference for sachets, or a shift by tanker operators toward commercial customers as increased traffic in Accra may have hurt the profitability of residential water delivery. Most tanker truck water is sourced from private boreholes in peri-urban areas of Greater Accra; tankers are more popular in neighborhoods beyond the ATMA where the population density is growing, but no GWCL infrastructure exists.

While the booming sachet water industry diverts an unknown quantity of water from the municipal system, often depriving or limiting access of those further down the network, it effectively extends improved water coverage deeper into informal settlements and slums, and alleviates the need in those places for a method of safely storing drinking water. The deterioration in water quality from source to storage container in the developing world is well-documented (Wright *et al.* 2004), as are the associated adverse health outcomes (Gundry *et al.* 2004). Recent work in Accra has shown that the use of sachet water by low-income households may provide an inadvertent health advantage over stored tap water despite the higher cost of sachet water and general health disadvantages associated with poverty (Stoler *et al.* 2012). Whether or not sachets ultimately perpetuate poverty by allowing Ghana's government to shirk their water provision duties remains an open issue. It is further complicated by historical evidence of citizens' willingness to pay for water in sub-Saharan Africa (Whittington *et al.* 1991; Rogerson 1996).

THE SACHET INDUSTRY

Several family-owned small-scale sachet producers provided detailed access to their machinery in June 2010, demonstrating that the production of sachet water is relatively simple. A water pump draws directly from a piped connection of municipally-treated water (or occasionally from a storage tank or borehole), and sends it through some form of filtration media, and then into the sachet machine which fills a fixed volume (typically 500 mL) of a plastic roll, then heat-seals and slices the edge to create the individual sachet. Sachets typically drop into a basket on the floor and are quickly hand-packed into bags of thirty (i.e. 15 L by volume). These bags – the unit size for virtually all sales and accounting metrics – may be stored on pallets before being loaded onto trucks and delivered either to wholesalers or directly to market. The sachet machines used in West Africa are generally made in China and marketed under several brands, the most common being the Koyo machine pictured in Figure 1b. The filtration media, external to the sachet machine, are often bolted to the wall and usually comprise some combination of carbon and sand filters of different pore sizes for trapping different particles and organisms. Older machines are sometimes retrofitted with an ultraviolet filter to kill remaining bacteria and viruses; newer machines incorporate this feature internally. In addition, some sachet producers who deliver directly to market will add a cooling module so sachets are already cold when packed.

The vast majority of sachets sold in ATMA contain water from the GWCL municipal system, and sachet producers pay GWCL for that water as would any user legitimately connected to the system (as opposed to pirated connections). GWCL water comes from two surface water treatment plants: Weija Waterworks in the west, situated on the Densu River and drawing raw water from Weija Lake; and Kpong Waterworks in the east, which receives water from the Akosombo Dam at Lake Volta. The average daily water supply to ATMA is 372,218 m^3, with 174,364 m^3 (46.8%) coming from Weija, 196,322 m^3 (52.7%) from Kpong, and 1,531 m^3 (0.4%) from boreholes (often drilled to 50 m) in Dodowa, North ATMA (Lievers & Barendregt 2009). Weija water is chemically hard and widely regarded as having poorer taste than the 'sweeter' Kpong water, hence most water packaging operations are situated in the eastern half of ATMA.

Sachet water is not viewed as a threat by GWCL, even while the majority of sachets are filled with water diverted from municipal production. While GWCL is responsible for urban potable water, the proportion of water used for drinking water relative to all other household and uses is very small. GWCL downplays the transfer of water from taps to sachets; while the average flatbed delivery of sachets may contain thousands of units, the load only represents four to eight cubic meters of water relative to over a million cubic meters produced by GWCL annually (Van-Rooijen *et al.* 2008). GWCL is instead more acutely focused on minimizing non-revenue water losses (Lievers & Barendregt 2009). Since the urban poor are less likely to be paying customers, GWCL has less to gain through infrastructure improvements (new mains or meters) in low-income areas, even as piracy and malfunctioning meters persist.

Sachets are produced by both large corporations and small family businesses often regarded as 'cottage industries.' Corporate producers are few in number and generally located in Tema, closer to the Kpong water treatment plant where GWCL water service is most reliable. The primary large-scale (corporate) players are (alphabetically): Everpure, Ice Cool, Mobile, Standard Water, and Voltic. (Insights on corporate production were gleaned from personal interviews with senior executives at two of these large-scale sachet producers.) These companies position sachets differently within their respective product lines; for example, sachets are Mobile's primary product, whereas Voltic controls 85% of the bottled water market and grew its sachet business more recently. These corporations each produce up to a million bags of sachets per month during the dry season and half a million per month in the rainy season, figures that may rise if cheap plastic continues to remain available. Kpong water is generally treated with carbon filtration (to remove organic sediment), sand filtration (protozoa and bacteria), and ultraviolet light (viruses). Weija water and most borehole water receive additional reverse osmosis treatment to remove excess salts.

These competitors have recently banded together to fight against government threats of new excise taxes on sachet water and to combat the general public backlash against pollution from discarded sachets. Thus, the issues surrounding sachet water, especially for the big commercial firms, have not focused on water quality, but rather on the problem created by the disposal of the plastic wrapping. Because these large corporate producers are properly registered with the government and have the resources for ongoing quality assurance, the issues they face regarding water availability, packaging, and waste are typical of any beverage manufacturer including juicers and breweries.

The number of small-scale producers and brands is unknown, but still on the rise according to anecdotal information obtained from industry trade groups and government representatives familiar with sachet registration rosters. No single government agency or industry group is able to account for more than a few hundred producers, but most believe there are several hundred more that are unregistered, together accounting for over a thousand brands (industry estimates approach 3,000 as noted below), and no reliable figures exist. Strong seasonal demand, continued water rationing within ATMA, and low barriers to entry result in a fluid industry with producers frequently entering and exiting. Small-scale producers are typically family enterprises drawn to the industry because it is a relatively simple business to run, does not require extensive education, and has low initial investment. These businesses are littered throughout the ATMA and produce sachets with brand names marketed either for broad appeal, or more frequently toward specific ethnic neighborhoods.

The first author conducted structured interviews in June 2010 with several small-scale producers about barriers to entry, the competitive landscape, and the economics of the business. The low barriers to entry are striking: an entrepreneur can be up and running for just over GH¢ 5,000 (about US$ 3,300 or £ 2,000) which would cover the purchase of a used sachet machine and water pump, an initial set of carbon and sand filters, and the payment of all required registration and licensing fees. The most significant variable cost – plastic rolls for primary packaging – is quickly recouped as bags of sachets go to market (often the very same day). Other variable costs include changing the filters every week or two (depending on volume), labor for packing and distribution, and a GWCL water invoice. These businesses usually produce a single brand, but will occasionally serve as an outsourcer and fill sachets for other brands in the wet season when lower demand renders excess filling capacity. Demand peaks during Accra's two dry seasons (generally December to April, and then July to August), and sachet filling machines will commonly remain in production day and night. Sachet fillers do not generally perceive a lot of competition among each other, though some make an effort to keep prices lower than larger producers to entice distributors. The profits are substantial enough for all involved to make a handsome living; small-scale producers can earn several thousand cedis per month.

Sachet filling operations are generally located in neighborhoods with stable water access (see Figure 4), and then they target neighborhoods that are subject to greater water rationing or have no access at all (both within and outside of ATMA, but generally within Greater Accra). The best water supplies are generally located around Tema, which is closer to Kpong Waterworks; along Spintex Road, an industrial corridor that runs west from Tema to Tetteh Quarshie Interchange; along a second corridor north of Legon through Madina and Dome; and in the former colonial quarters of Accra that now comprise higher-status neighborhoods such as Airport Residential Area, Cantonments, and Osu. When the water supply is interrupted, small producers will often have polytanks filled with water from Tema to keep the business going. These water reserves are expensive and erode most profits, but they keep customers happy until local water service is restored. Some sachet businesses locate additional machines closer to Tema, where water service is more regular due to its newer infrastructure coupled with strong industrial demand, and then truck the water back into Accra. A growing criticism of sachet fillers by the citizenry is that the mechanical pumps destabilize water pressure and availability for customers downstream in the water network who may expect regular water service. GWCL recently piloted a new 'bottom-up' method of quantifying customer satisfaction with their water service through household interviews and water quality tests, and such a strategy (more broadly implemented) may root out inconsistencies between GWCL service expectations and customer realities that are affected by sachet operations. A significant obstacle is the unknown number of sachet producers who are unregistered or pirating GWCL water. Neither industry groups nor government regulatory bodies have a comprehensive registry of sachet producers, and the data in Figure 4, drawn from proprietary sachet industry data for 350 producers, may be the best available geographical representation of sachet-filling activity in ATMA.

Many sachet brands are not traditional businesses, but wholesalers who outsource all production functions. Plastic rolls are purchased pre-printed with the desired brand and contact information, filled at a sachet producer with excess capacity (who may or may not be registered), and then delivered by pickup truck to market. This form of 'gray market' wholesale sachet business owns no machinery, has no premises to inspect, and is extremely difficult to track since any phone inquiries (it is customary for producers to print a contact phone number on the sachet) by regulating authorities tend to prompt the vendor to replace their mobile phone's SIM card. Such wholesaling, with particularly low barriers to entry, has become both lucrative and popular, and adds a whole new cat-and-mouse element to regulation efforts and the general tracking of sachet production. It also potentially creates localized service discrepancies that undermine customer confidence in GWCL.

The transiency of industry participants – particularly among those looking for short-term financial gains – results in lower compliance rates among smaller players and less knowledge about registration requirements. Estimates of the size of the industry might be made by contacting the suppliers, but there are many dealers of the filling machines, and hundreds of plastics manufacturers supplying the industry. Local networks facilitate these business connections, and there are no comprehensive vendor registries, though some trade organizations have successfully organized hundreds of manufacturers in a given sector (generally the sachet, beverage and plastic industries). Mutual self-preservation initially prompted the organization of these trade organizations in the face of public backlash against the waste generated by discarded sachet sleeves (discussed below). Groups such as the Association of Ghana Industries, National Association of Sachet Water Producers, Accra Ice & Pure Water Association, and the Ghana Plastic Manufacturers Association have made the only known attempt to quantify the economic impact of their activities on the Ghanaian economy. These industry groups collectively estimate that there are over 2,700 sachet producers (99% of whom are local Ghanaian businesses) using over 3,500 machines. (Data provided by a former official of the National Association of Sachet Water Producers [NASWAP]). Plastic roll manufacturers are estimated to number around 75 operating more than 650 machines, though this sector comprises over 90% foreign direct investment. The two sectors combined claim to directly employ about 150,000 nationally with an estimated 320,000 dependents, while providing indirect employment for several hundreds of thousands of Ghanaians through affiliated activities such as packing, vending, and distribution.

SACHET WATER QUALITY

As noted earlier, sachet water can be viewed as the latest, low-cost technological incarnation of vended water in developing cities. Technology has allowed vended water to evolve even further in the developed world, and a recent body of literature highlights the challenges in maintaining quality control of machine-vended water (i.e. filling personal containers) in the US and Europe (McSwane *et al.* 1994; Chaidez *et al.* 1999; Hunter & Barrell 1999; Schillinger & Du Vall Knorr 2004). The vast majority of published literature on sachet water addresses product quality, and this section reviews that body of work. Searches in PubMed, Science Direct, Google Scholar, and Academic Journals databases were conducted between June and July 2010 using combinations of keywords such as 'sachet water', 'quality' and 'Africa' to identify potential articles; reference lists were used to locate additional resources. Articles were included if any diagnostic test was performed to determine levels of any substance that affects drinking water quality, even if the primary focus of the paper was not sachet water. Over 200 articles were reviewed and thirty (twenty-three from Nigeria, six from Ghana and one from India) are summarized in Table 3.

Recent research on sachet water has primarily focused on sub-standard quality and potential disease transmission, with some elaboration on health impact. Despite scientific interest in microbiological quality of sachet water that dates back to at least the mid-1990s (see Oloke 1997, for an early example), there is a striking paucity of research on the topic. As evident in Table 3, very few studies have incorporated a study design with a sufficient sample size, geographic coverage, or general scientific rigor needed for broad conclusions about quality, even at a local scale. Most of this literature also appears in African journals that are not linked to major databases like PubMed, which slows the dissemination of findings and subsequent rousing of interest in these issues, particularly with international organizations that may have the resources to investigate further. While the lack of thorough sachet research is surprising, it is understandable given the emerging state of the sachet economy and absence of any ‘impact’ publications in Western academic literature. This brief review includes only English-language publications, but as English is the national language of both Nigeria and Ghana, the representative literature from this region was likely captured. In fact, Table 3 may represent the most comprehensive compilation of sachet-related literature available. It is notable that the sachet literature is limited to West Africa, as the phenomenon seems to have been born in Nigeria and quickly adopted in Ghana. DHS data and anecdotal reports indicate that sachet water is now prevalent in all nations contiguous to Nigeria and Ghana (Côte d’Ivoire, Burkina Faso, Togo, Benin, Niger, and Cameroon). The literature on bottled drinking water quality has a slightly broader geographic base with early reports from Nigeria (Ogan 1992; Olayemi 1999), as well as recent work in Zimbabwe (Okagbue *et al.* 2002), South Africa (Ehlers *et al.* 2004), and Tanzania (Kassenga 2007). Due to higher expense, bottled water remains a luxury for higher socioeconomic status households and is not a significant source of drinking water in West Africa. Recent DHS data show that the only areas of West Africa where more than 1% of the population use bottled water as a primary drinking water source are urban regions of Liberia and Nigeria (3.6 and 6.9%, from 2009 and 2008 respectively) (Macro International Inc 2011).

It is noteworthy that not every study has found sachet water quality to be troublesome (Egwari *et al.* 2005; Olowe *et al.* 2005), though there is an obvious bias toward reporting of positive test results for pathogens or contaminants. The wide variety of impurities, despite the anecdotal nature of some inquiries, may just be the tip of the proverbial iceberg as sachet consumption increases across West Africa. Ironically, while water quality continues to be the primary topic of interest, sachets have the potential to be a transformative public health intervention – albeit as an unintended consequence – for low income households by eliminating the need for unsafe water storage vessels. The deterioration of water quality during transport and storage is established in public health literature (Clasen & Cairncross 2004; Wright *et al.* 2004; Gundry *et al.* 2006), and as noted earlier, the potential for high-quality sachet water to improve health outcomes by eliminating these contamination pathways has been suggested empirically. At the same time, there remain many regulatory challenges to ensuring high sachet quality; these are discussed later in this paper.

Additionally, while research continues into the health effects of phthalates and other chemicals thought to leach from plastic bottles in the US and elsewhere (see, for example, Sax 2010), no related studies of such effects in sachet water were identified in the literature review shown in Table 3. Sachet bags frequently experience direct sun exposure both during distribution on pickup truck flatbeds, and while for sale in open markets or on the heads of street vendors; higher temperatures are a risk factor for not only increased microbial growth, but the release of contaminants from some plastics. The potential health effects attributable to plastic packaging remains unknown, and may be particularly important for sub-standard plastics used in gray-market sachet production.

REGULATION

Content for this section is drawn from personal interviews with a senior executive at the Ghana Standards Board (GSB) on 8 June 2010, and with a senior executive at the Food and Drugs Board (FDB) on 10 June 2010. Both requested anonymity.

Regulation of sachet water in Ghana primarily rests with the country's FDB and the GSB. The FDB operates from a public health perspective, and has several primary concerns related to sachet water: quality of the plastic packaging, quality of the ink printed on the sachet (consumers commonly tear the packaging with their teeth before consumption), and of course the water quality itself. The GSB focuses on standards development for trade, and its attention to sachet water primarily concerns the enforcement of use of the GSB certification seal, the most recognizable mark of quality assurance in Ghana, on registered products.

While FDB registration is officially mandatory for any product brought to market in Ghana, the rapid growth and unknown scope of both formal and informal sachet water production, combined with a lack of resources for adequate enforcement of these regulations in Ghana, render FDB registration somewhat voluntary. Sachets also fall into a class of goods for which GSB certification (to use their quality seal on packaging) is explicitly voluntary. If a product has health and safety implications, the FDB may impose mandatory GSB certification, but since most sachet water is produced by GWCL and already meets international (and therefore GSB) standards, mandatory certification is not currently viewed as necessary. If significant volumes of sachets were being filled at questionable sources such as untested rivers or boreholes, the FDB would consider further regulation. The ongoing regulatory challenges faced by both agencies are largely a product of the nature of the sachet sector rather than bureaucracy.

The FDB conducts post-market surveillance including unannounced premises inspections (usually at least once each year) and product quality audits. Registration can be revoked at any time for non-compliance, and ongoing surveillance is critical as producers are known to submit inauthentic water samples during the application process. To bolster quality assurance efforts, Ghana National Service Officers assigned to the FDB are sometimes used for product surveillance, including recording brands and manufacturing addresses to crosscheck registration of sachets already on the market. When dealing with violators, the priority is advocating for registration, but repeat offenders can be shut down, especially those found to be endangering public health by selling poor quality water.

In order to expand industry knowledge of the registration process, the FDB organizes training sessions for sachet producers, but efforts to organize through trade organizations have been more successful. Unregistered wholesalers with no fixed business location are more difficult for the FDB to track. These businesses are mostly cottage industries, and if they are filling sachets with a registered producer then the offense is considered minor (the FDB perceives low public health risk). The FDB has an initiative underway to implement print registration numbers on the sachet packages (along with the GSB seal) so that registration can be tracked more efficiently.

In addition to standards development and metrology, the GSB also participates in certification, testing, and inspection of commercial activities. GSB certification is mandatory to use the GSB certification seal on product packaging. Producers must provide an end-to-end production scheme showing controls in the production process. The GSB conducts an initial facilities inspection, followed by laboratory testing to confirm initial product quality, and then there are occasional audits where records are requested to show ongoing quality assurance (filters being changed, cleaning schedules, etc.).

Many sachet packages contain fake or absent vendor addresses and standards seals, a pattern previously documented in Nigeria (Gyang *et al.* 2004; Nwosu & Ogueke 2004; Olaoye & Onilude 2009). In early 2010, GSB initiated a joint task force with the Accra Metropolitan Assembly to investigate unregistered packaged water producers. This intensified surveillance is specifically aimed at curbing standards abuse by producers of sachet and bottled water that is more pronounced than in other industries. Once caught, more than half of illicit producers remedy the delinquent certification. Many plead ignorance of GSB regulations, an excuse which may or may not be legitimate.

The larger problem is the wholesalers who own no business assets; the water providers filling their sachets may or may not be certified, and if they are, wholesalers often bypass certification and use the same seals on their packaging. The GSB conducts public education campaigns, ranging from seminars and workshops to commercials and talk show appearances, to educate consumers about the GSB mark and reinforce its value. The GSB does not require prosecution of violators; warnings are given and every effort is made to gain compliance and continue commerce. Standards enforcement used to be mandatory, which encouraged more counterfeiting of the GSB mark.

Although registration is compulsory by law and the FDB has enforcement authority, it is still regulated loosely and tends to still be a voluntary act on the part of the sachet producer. Both the FDB and GSB acknowledge that a major challenge to registration compliance is public knowledge of the various processes. Because registration entails many hurdles, entrepreneurs familiar with the various procedures often generate additional income as unofficial ‘consultants’ to new sachet industry entrants. This knowledge gap serves as an excuse for both lax compliance by producers and lax enforcement by regulators, and efforts to maximize compliance are stalled as the sachet industry continues to add new producers. With registration revenues still climbing, no official estimate of the size of the sachet industry, and no major sachet-related public health scandals, there is less perceived urgency to aggressively pursue noncompliance.

ENVIRONMENTAL IMPACT

The most volatile issue concerning sachets in ATMA – and most other sachet-consuming regions – is the accumulation of plastic waste. An estimated 270 tons of plastic waste is generated every day in Ghana, with 85% coming from non-biodegradable plastic bags containing drinking water and ice cream (IRIN 2004). The plastic waste is ubiquitous in busy areas of Accra and Tema, and inadequate solid waste collection and removal services means that these sleeves typically end up thrown in gutters, sewers, and drains. The accumulation of plastic clogs water drainage pathways and exacerbates flood conditions in low-lying neighborhoods. For many low-income neighborhoods, flooded drains ultimately lead to increased risk of exposure to untreated sewage, animal waste, and runoff from urban agriculture.

GWCL advocates instituting a deposit on sachet wrappers to create value for the plastic, which could then be recycled. Likewise, corporate stakeholders advocate recycling programs for the creation of jobs, though recycling programs have not been profitable in Ghana due to low cost of plastics material, and by 2005 only an estimated 2% of plastic was being recycled (IRIN 2004). A Recycling Task Force was formed in 2004 to improve the nation’s plastic recycling capacity and explore new uses of recycled plastic in industrial manufacturing, but little progress has been made. The Trashy Bags Company, a non-profit recycler of plastic wrappers in Dzorwulu, Accra, has raised public awareness about the plastic waste issue by recycling used sachet wrappers into consumer goods such as shopping bags, fashion accessories, and even clothing. While Trashy Bags has created many local jobs and served as a voice for environmental sanitation, it barely dents the volume of plastic waste generated in Accra. Blowplast Industries Limited, formed in 2006, has recently begun paying cash for plastic wrappers in Accra at a rate of Gp 10 per kilogram of waste delivered to their plant. Blowplast sells recycled products below market rates, but has not yet published aggregate statistics on the amount of waste processed. The company contributes substantially to educating the public on recycling and is setting an important precedent.

Several sachet taxes have been proposed by Ghana's Parliament – though none have been implemented – to pay for environmental cleanup efforts. Efforts to divert new taxes from sachets to imported plastics were scrapped after significant lobbying by other industrial plastics consumers whose operations are not related to sachets, but would have been adversely impacted. The best hope for reducing waste may rest with the effort to produce a biodegradable sachet package. Wells Plastics Limited (Staffordshire, UK) has developed a photoinitiated oxo-biodegradable plastic additive that causes polyethylene to break down in three to four months – a period longer than most bags of sachets remain in stock in the dry season –and has been in advanced test stages since 2010. (Product testing documentation was provided in June 2010 by the Accra Plastic Waste Management Project.) This is just one of several prototypes that are expected to be brought to market in 2012.

CONCLUSION

While Accra's population continues to grow at about 3% per year, both its growth rate and share of Ghana's total urban population are declining (United Nations 2010). Future ATMA population growth of over 1 million residents (by 2025) is expected to be focused in peri-urban communities just beyond contemporary metropolitan boundaries. The evolving drinking water landscape yields some important implications for water provision in these areas to avoid fostering the growth of new and existing slums. Peri-urban communities in Greater Accra are generally served by boreholes and tanker trucks, but these services are unlikely to sustain the water demand associated with current population growth projections. While rural drinking water provision is often driven by place-specific factors such as unwieldy travel distances to fresh water, existence of non-potable well water, or the avoidance of guinea worm, urban drinking water consumption in Ghana is increasingly being shaped by privatization of drinking water in lieu of adequate municipal water provision.

Sachet water has risen from obscurity to become one of the most important drinking water sources in Accra in just a few years, and the dominant drinking water source in many low-income neighborhoods. Failures in governance attributed to the Accra Metropolitan Assembly have forestalled serious policy discussion on the future of sachets, and most sachet industry participants, regulators, and consumers alike now believe sachets are here to stay in Ghana. The plastic waste menace, dubious sachet quality control, and social justice concerns over water as a human right spur talks of a ban on the plastic sleeves – or on plastic bags altogether – which has precedent in sub-Saharan Africa (Simpson 2007). At the same time the urban poor may reap an unintended health advantage as sachets replace the consumption stored water that is often cross-contaminated in the home (Stoler *et al.* 2012), while in Ghana's rural north, the Upper West Regional Iodated Salt Committee recently appealed to sachet producers to add iodine to sachet water to combat low iodated salt consumption. As the future of sachet water continues to be tugged in multiple directions, the appeal of sachet water continues to spread throughout West Africa.

Urban populations in sub-Saharan Africa continue to grow, but are projected to be less centralized in megacities over the next several decades (United Nations 2010). Urban drinking water infrastructure is already insufficient in most West African cities, a pattern that has been documented in East Africa for decades (Thompson *et al.* 2000). If full municipal coverage becomes unrealistic in newer satellite cities, decentralized drinking water solutions traditionally targeted at rural communities may become an urban necessity. Development agencies stand to benefit by addressing the sachet phenomenon in the effort to meet Millennium Development Goals for urban water and sanitation sustainability in the region.

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Figure 1.
(a) Sachet water purchased from a street vendor, and (b) typical Koyo sachet filling machine at a small production facility in Accra.

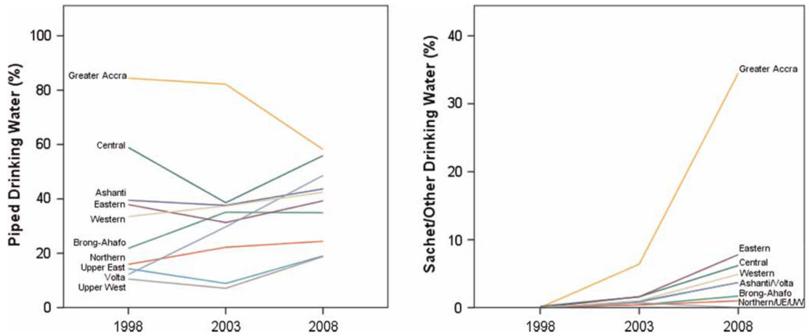

Figure 2.

Percentages of households using piped drinking water vs. sachet/other water as the primary source of drinking water by DHS survey year for Ghana's ten administrative Regions.

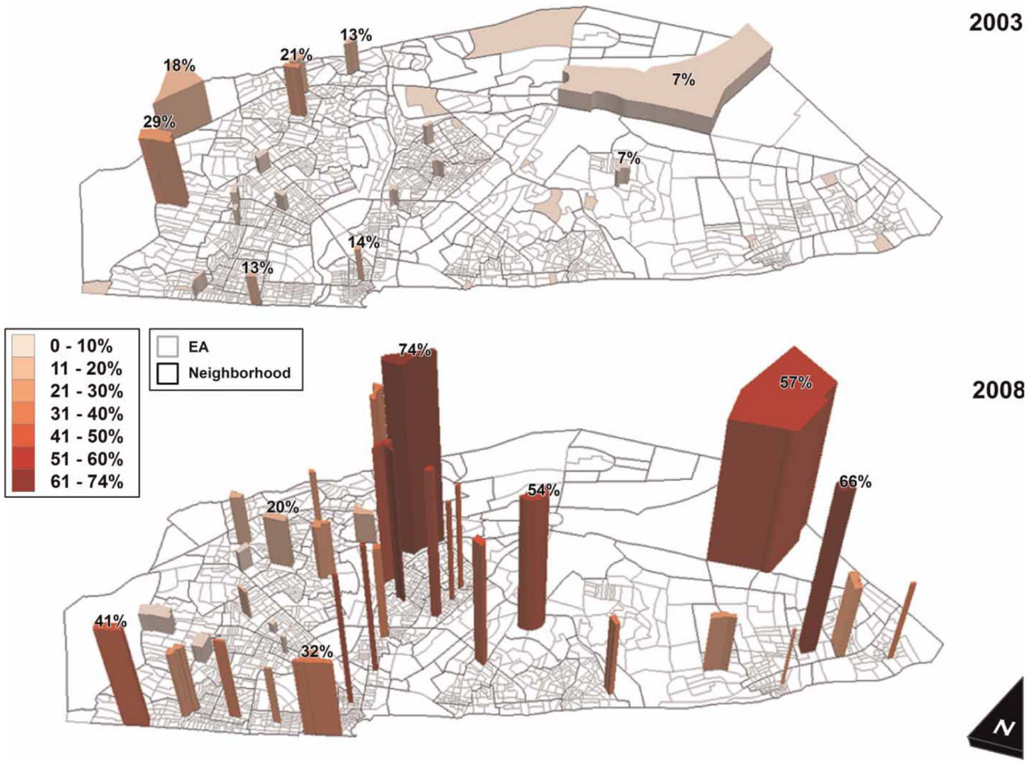

Figure 3.
Percentages of households using sachets as the primary source of drinking water (by enumeration area cluster) within the Accra Metropolitan Area, from the 2003 and 2008 Ghana DHS.

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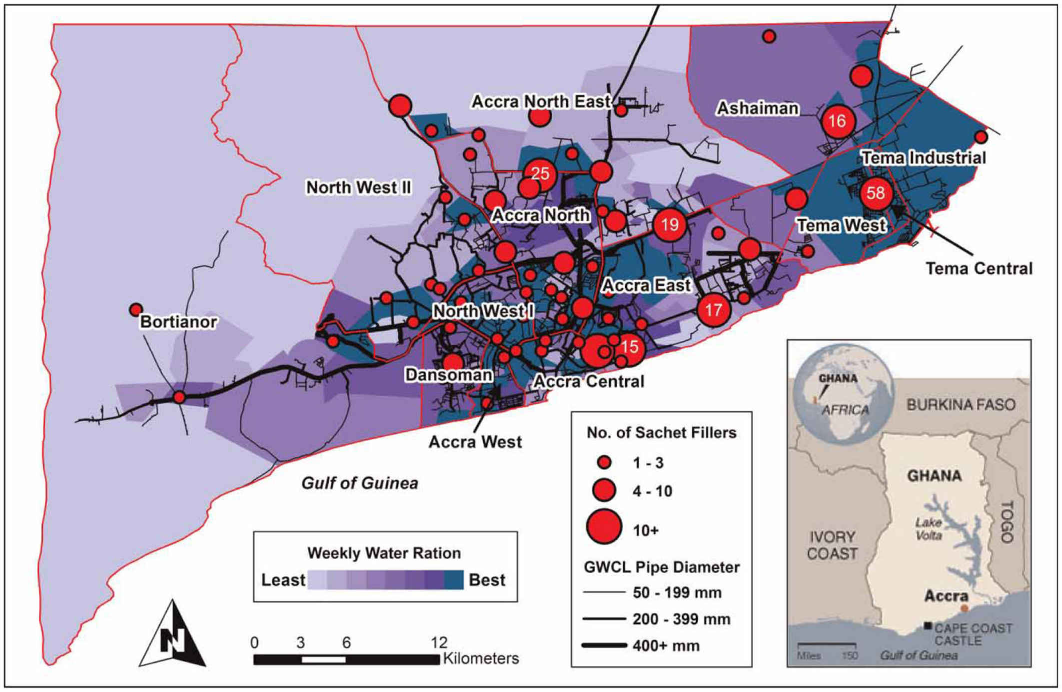

Figure 4.
Neighborhood distribution of ATMA sachet filling businesses registered with the Sachet Water Producers Association in 2010, shown with GWCL rationing scheme and pipe infrastructure.

Table 1

Percent distribution of Greater Accra households by water characteristics, according to residence, Ghana DHS 2003 and 2008

	2003			2008		
Characteristic	**Urban**	**Rural**	**Total**	**Urban**	**Rural**	**Total**
Source of drinking water[a]						
Piped into dwelling	20.4	11.4	19.3	16.4	14.6	16.2
Piped into compound/plot	31.1	5.7	27.9	20.3	1.6	18.2
Public tap	37.2	34.3	36.9	20.1	53.1	23.9
Open well in yard/plot	0.0	1.0	0.1	–	–	–
Open public well	0.1	10.5	1.4	0.7	0.5	0.7
Protected well in dwelling/yard/plot	0.1	1.0	0.2	1.1	3.6	1.4
Protected public well	0.3	1.0	0.4	–	–	–
River, stream	0.1	21.0	2.7	–	–	–
Pond, lake	0.1	4.8	0.7	–	–	–
Tube well or borehole	–	–	–	0.1	3.6	0.5
Unprotected spring	–	–	–	0.0	0.5	0.1
Rainwater	0.1	1.0	0.2	0.1	2.6	0.4
Tanker truck	4.2	5.7	4.4	2.2	0.5	2.0
Bottled water	0.1	0.0	0.1	2.0	0.5	1.9
Sachet water	5.7	2.9	5.4	37.0	18.8	34.9
Other	0.3	0.0	0.2	–	–	–
Total	100.0	100.0	100.0	100.0	100.0	100.0
Time to water source[b]						
Percentage <15 min	91.0	72.8	87.3	94.2	87.9	93.4
Median time to source (min)	5.0	10.0	6.0	1.0	11.0	1.0

[a] n=841 for 2003, n=1,673 for 2008.

[b] n=393 for 2003, n=1,671 for 2008.

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Table 2

Distribution of Greater Accra households using sachets as the primary drinking water source by national wealth quintile, Ghana DHS 2003 and 2008

	Primary source of drinking water							
	2003 (*n*=842)[a]				2008 (*n*=1,673)[b]			
Wealth index quintile	**Sachet (%)**		**All other (%)**		**Sachet (%)**		**All other (%)**	
Poorest	0	(0.0)	4	(100.0)	0	(0.0)	10	(100.0)
Poor	0	(0.0)	22	(100.0)	2	(5.0)	38	(95.0)
Middle	0	(0.0)	56	(100.0)	27	(18.1)	122	(81.9)
Rich	6	(2.5)	234	(97.5)	139	(30.8)	313	(69.2)
Richest	39	(7.5)	481	(92.5)	416	(40.7)	606	(59.3)
Total	45	(5.3)	797	(94.7)	584	(34.9)	1089	(65.1)

[a] Pearson χ^2=13.25, p=0.010.

[b] Pearson χ^2=58.14, p<0.001.

Table 3

Summary of published literature addressing sachet water quality

Reference	Setting	*n*	Quality measure	Outcome
Abiola (2010)	Ibadan, Nigeria	20	Fecal coliforms (FC); lead	95% FC free; 100% high lead concentrations
Addo *et al*. (2009)	Teshie-Nungua, Accra, Ghana	30	Total coliforms (TC) and FC	100% high TC counts; 20% contained FC
Adenkunle *et al*. (2004)	Ibadan, Nigeria	78	TC, other bacteria, chemical parameters	6.4% bacterial growth; elevated aluminum, fluoride, and cyanide
Ajayi & Adesida (2009)	Akure, Nigeria	15	Chemical parameters, activity concentrations of ^{40}K, ^{226}Ra and ^{228}Ra	100% exceeded UNSCEAR and WHO limits for uranium and thorium series
Ampofo *et al*. (2007)	Southern Ghana	179	TC, FC, *Salmonella*, *Clostridium* and *Bacillus* spp.	40.2% elevated TC; 8.4% FC; 3.4–8.4% various bacterial spp.
Ante *et al*. (2007)	Kaduna, Nigeria	60	TC, chemical analysis	100% exceeded WHO TC guidelines; 45% exceeded local TC standards
Ashaye *et al*. (2001)	Ibadan, Nigeria	8	Physicochemical properties	Low total dissolved solids; variable mineral content
Banu & Menakuru (2010)	Pallavaram, Chennai, India	7	Physicochemical properties, bacterial isolates	100% *Klebsiella pneumoniae* and *Proteus mirabilis*; antibiotic resistance; metal tolerance
Dada (2009)	Lagos, Nigeria	100	TC, *Escherichia coli*	22% elevated TC; 0% *E. coli*
Dodoo *et al*. (2006)	Cape Coast, Ghana	180	TC, *E. coli*, physico-chemical analysis	Elevated TC in 45% of brands, *E. coli* in 14%
Egwari *et al*. (2005)	Lagos, Nigeria	8	Enteric pathogens, *E. coli*	Sachet contents negative, but surfaces 100% contaminated
Ejechi & Ejechi (2008)	Niger Delta Region, Nigeria	500	TC, FC	18–26.7% elevated TC; 4–6% contained FC
Ezeugwunne *et al*. (2009)	Nnewi, Nigeria	90	TC, FC, bacterial isolates	36% *E. coli*; 19.4% *Streptococcus faecalis*; 19.4% *K. pneumoniae*; 25% *Staphylococcus aureus*
Ifeanyi *et al*. (2006)	Port Harcourt, Nigeria	5	TC, *E. coli*, heavy metals	100% elevated TC, iron, zinc, manganese, lead
Kwakye-Nuako *et al*. (2007)	Accra, Ghana	27	Four parasitic organisms, other inorganic materials	77.8% contained one or more protozoan pathogens
Ngozi *et al*. (2010)	Abakaliki, Ebonyi state, Nigeria	250	*E. coli*, *Enterobacter* and *Klebsiella* spp.	4.4% *E. coli*, 1.6% *Enterobacter* spp., and 1.2% *Klebsiella* spp.
Ngwai *et al*. (2010)	Amassoma, Nigeria	30	TC, FC, heterotrophic, thermotolerant and spore- former bacteria, *E. coli*	100% high levels of heterotrophic, spore- former, and thermotolerant bacteria; no *E. coli;* some *Klebsiella*
Nwachukwu & Emeruem (2007)	Aba and Owerri, Nigeria	60	TC, various heterotrophic bacteria, *Staphylococcus* spp.	All brands grew bacteria with wide resistance to eight common antibiotics
Nwosu & Ogueke (2004)	Owerri Metropolis, Nigeria	15	TC, FC, *E. coli*	60% high TC; 40% FC; 20% *E. coli*
Obiri-Danso *et al*. (2003)	Kumasi, Ghana	88	TC, FC, heavy metals	4.5% elevated TC; 2.3% FC; iron within WHO standards, no lead or manganese
Okafor & Ogbonna (2003)	Southeast Nigeria	300	Nitrite and nitrate content	25% of brands contained elevated nitrite concentration
Okeri *et al*. (2009)	Benin City, Nigeria	10	Trace metals	Safe levels of copper, iron, manganese and zinc; no chromium or lead
Okioga (2007)	Tamale, Ghana	15	TC, FC	47% elevated TC; 6.7% FC

Reference	Setting	*n*	Quality measure	Outcome
Okpako *et al*. (2009)	Calabar, Nigeria	4	Four fungi spp.	75% contained at least two fungi spp.
Oladipo *et al*. (2009)	Ogbomoso, Nigeria	n/a	Fourteen bacteria isolates	All sachets tested contained bacteria, including *Bacillus* and *Pseudomonas* spp., *Enterobacter aerogenes* and *P. mirabilis*
Olaoye & Onilude (2009)	Western Nigeria	92	TC, FC, 11 bacterial isolates	100% elevated TC; 2.2% FC; 3.3–18.5% other isolates; no lead or manganese
Olowe *et al*. (2005)	Osogbo Metropolis, Nigeria	3	TC, FC, bacterial isolates, chemical parameters	All elevated bacterial levels
Onifade & Ilori (2008)	Ondo State, Nigeria	30	TC, FC, *E. coli*, other bacterial isolates	60% exceeded WHO TC standard; 6.7% *E. coli*, 7 other pathogens detected
Orisakwe *et al*. (2006)	Eastern Nigeria	41	Heavy metals and chemical parameters	Excess lead (12.2%), cadmium (19.5%), copper (5%)
Oyedeji *et al*. (2010)	Ile-Ife, Southwest Nigeria	60	TC, FC, *E. coli*	100% elevated TC; 20% *E. coli*