

Full Length Research Paper

Sachet water phenomenon in Nigeria: Assessment of the potential health impacts

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Many years of neglect by government and inadequate investment in public infrastructure has left the public drinking water supply in Nigeria in an unreliable state. The society has therefore taken to several adaptive measures of alleviating this stress. One of these is dependence on sachet water, popularly referred to as 'pure water'. Although easy to serve and the price is affordable, complaints abound on its purity and other health concerns. A gradual nationwide ban was proposed by the national regulator for this packaged water but the market still witnesses tremendous growth, especially among the poor. To determine the bacteriological quality of drinking water sold in sachets in Lagos, Nigeria, one hundred samples of high - and low-demand sachet waters obtained from vendors at hot-spot locations were assessed using the multiple tube fermentation method. Based on the zero tolerance standards stipulated by the regulator, a 22% non-compliance level was recorded. Recommendations that may contribute to a policy that would allow for an integrated and holistic approach in managing the sachet water industry are discussed. The need for support of such local initiatives, especially in the drive towards achieving the much publicised Millennium Development Goals for universal water access, is also highlighted.

Key words: Sachet water, water quality, hygiene, Millennium Development Goals.

INTRODUCTION

A reliable supply of clean wholesome water is highly essential in a bid to promoting healthy living amongst the inhabitants of any defined geographical region (Mustapha and Adam, 1991). The standard industrialized world model for delivery of safe drinking water and sanitation technology is, however, not affordable in much of the developing world (Gadgil and Derby, 2003). Consequently, given the renewed global commitments towards the Millennium Development Goals (MDG) marked for 2015, the importance and contribution of locally sourced low-cost alternative drinking water schemes to sustainable access in rural and peri-urban settings of developing nations cannot be over-emphasized (UNDESA, 2004).

One such local intervention in Nigeria, where public drinking water supply is unreliable (Egwari and Aboaba, 2002), is drinking water sold in polythene sachets. In Lagos State, with up to 70% of the population deriving daily water provision from sources other than the state municipals (Coker, 2004), many people depend on water vendors to whom they pay heavily for provision of water to meet daily domestic needs. The production, marketing and consumption of sachet water have increased tre-

mendously. There are now several brands of these type of packaged water marketed in Nigeria and other developing nations (Figure 1) (Ogan, 1992; Kassenga, 2007).

Water in sachets is readily available and the price is affordable, but there are concerns about its purity. The integrity of the hygienic environment and the conditions where the majority of the water in sachets are produced has also been questioned (C.A.M.O.N, 2007). Although nationally documented evidence is rare, there are claims of past outbreaks of water-borne illnesses that resulted from consumption of polluted water in sachets (C.A.M.O.N, 2007).

The National Agency for Food and Drug Administration Control (NAFDAC) is mandated to enforce compliance with internationally defined drinking water guidelines, but regulation of the packaged water industry aimed at good quality assurance has remained a challenge to the agency (C.A.M.O.N, 2007). To control the menace of polluted water in sachets, NAFDAC declared a possible 'gradual' nationwide ban on sachet waters to allow the manufacturers of sachet water to start winding-down or change to bottle packaging (C.A.M.O.N, 2004).



Figure 1. Roadside vendors hawking chilled water in sachets.

Successful implementation of this ban has remained far from reality as the sachet water market is witnessing tremendous growth, especially among the poor and middle social class.

Few studies (Olayemi, 1999; Adekunle et al., 2003; Ashaye et al., 2001; Gyang et al., 2004) have been conducted in recent years on the quality of packaged water in Nigeria. These focussed primarily on the end-product, leaving out the processes that determine the final fate of the packaged water, as well as the people (various stakeholders involved) in whose hands lie the will and power to effect the desired change. Consequently, practicable recommendations aimed at changing the status quo have not yet emerged. This study set out to ascertain the bacteriological quality of the water in sachets, to identify contributory factors that determine the fate of the packaged water product as it moves from catchment to consumer, and to highlight unharnessed opportunities for policy improvements that would allow for sustained and improved regulation of the sachet water industry.

MATERIALS AND METHODS

Sampling

To ensure adequately representative sampling, a preliminary survey was conducted before selection of the water to be analysed. Geographical zoning was done using the twenty markets spread within the study location. Inquiries were also made at randomly chosen locations, houses, retail and wholesale outlets to identify popular brand names commonly patronised in the market zones of the study area. Following this procedure, ten brands of table water were identified. A total of 10 samples for each identified brand accounted for the 100 water samples analyzed. Samples were purchased just after production directly from the factory, at the distributors' store and from the outdoor vendors (hawkers). These were labelled appropriately and transferred within 4 h to the Microbiology Laboratory, University of Lagos for subsequent analyses.

Physical examination

This involved visual examination of features external to the water itself such as the label, presence of certification number and other product information. Specific odour and appearance (colour, turbidity and presence of floating particles or extraneous materials) were also noted.

Microbiological assessment

The multiple tube fermentation test method for enumeration of total coliform bacteria and *Escherichia coli*, as recommended by the APHA (1998), was employed to determine the bacteriological quality of drinking water sold in sachets. Data obtained for the multiple tube fermentation tests were used to calculate coliform density and results were computed in terms of the MPN. For confirmation of *E. coli*, broth from positive presumptive tubes were streaked onto plates of MacConkey and Levine's Eosin Methylene Blue agar and incubated at 35°C for 24 h. Chi-square statistical analysis was subsequently used to justify significant differences between microbiological compliance levels for samples obtained at the identified points of purchase.

RESULTS

Water quality assessment

The record of the physical examination of samples is presented in Table 1. None of the identified brands met the compliance levels set by the regulator in terms of other label requirements besides the registration number. Going by the zero tolerance levels stipulated by NAFDAC for coliforms in drinking water, a cumulative figure of 22% ($n=100$) of all the identified packaged water did not meet the existing standards. *E. coli* was not detected in all packaged water samples tested in the study following further confirmatory tests of streaks from positive presumptive tubes.

Using the MPN tables, obtained MPN values for the identified brands are shown in Table 2. Based on the points of sampling and in cumulative terms, the observed level of microbiological compliance and defaults in the sampled population is presented in Figure 2. Microbiological quality deteriorated considerably as products moved farther down the distribution chain. As low as 6.67% (P1, $n=30$) showed contamination after production, 40% (P2, $n=30$) of the samples obtained from the distributors' shed were contaminated, while the highest level of contamination (45%) was observed for samples obtained from the extreme end of the distribution chain (P3, $n=40$).

Statistical analysis of data obtained revealed that compliance levels were significantly different between the samples obtained at the point of manufacture (P1) and from the distributor's shed (P2) with an X^2_c value of 9.317 at the 95% confidence level. Comparing the level of microbiological compliance between the samples at the point of manufacture (P1) and samples obtained from the hawkers (P3), the difference was again significant with an X^2_c value of 12.343. There was no significant difference

Table 1. Physical examination for labelling compliance.

NAFDAC Number	Best Before Date	Manufacturing date	Nutritional information	Batch Number	Net Volume (cl)	Producer's name and contact address
+	-	-	-	-	50	+
+	-	-	-	-	50	+
+	-	-	-	-	50	+
+	-	-	-	-	60	+
+	-	-	-	-	50	+
+	-	-	-	-	50	+
+	-	-	-	-	50	+
+	-	-	-	-	50	+
+	-	-	-	-	50	+
+	-	-	-	-	50	+

+ = displayed on sample label; - = not displayed on sample label.

Table 2. MPN values obtained for identified brands.

Brand/Sample number	Coliform count using MPN (Based on the presumptive positive tubes)									
		P1			P2			P3		
	1	2	3	4	5	6	7	8	9	10
1	0	0	0	4	1	0	1	0	0	12
2	1	0	0	0	7	1	12	1	4	1
3	0	0	0	0	0	2	0	0	4	0
4	0	1	0	0	4	1	0	21	1	9
5	0	0	0	1	0	2	1	0	16	0
6	0	0	0	1	0	2	1	0	16	0
7	0	0	0	0	1	0	8	0	0	0
8	0	0	0	0	0	1	1	0	0	0
9	0	0	0	0	0	0	0	1	0	1
10	0	0	0	0	0	0	0	0	1	0

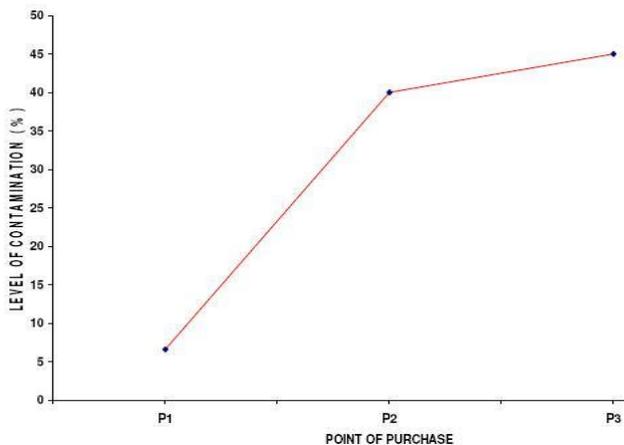


Figure 2. Cumulative levels of microbiological compliance and defaults in the sampled population.

between the microbial quality of P2 and P3 at the 95% confidence level (X^2_c value of 0.175).

DISCUSSION

NAFDAC regulations require food labelling to be informative and accurate (USDA, 2006). The minimum labelling requirements for regulated items involve a declaration of the product's brand name or common name that must appear in bold letters, a complete "location" address of the manufacturer, the production "batch" number, date of manufacture and best use before/expiry date, metric volume and, most importantly, NAFDAC registration number must be included on the product label. Despite the fact that all sampled brand water paraded the mandatory NAFDAC certification numbers, none met the compliance levels set by the regulator in terms of other label requirements. In a similar study by Kassenga (2007) on the microbiological quality of packaged water in Tanzania, up to 54% of the surveyed brands did not comply with the labelling requirements.

The observed level of compliance (22%) with the zero tolerance coliform stipulation by NAFDAC correlates with previously published reports (Ogan, 1992; Waburton et

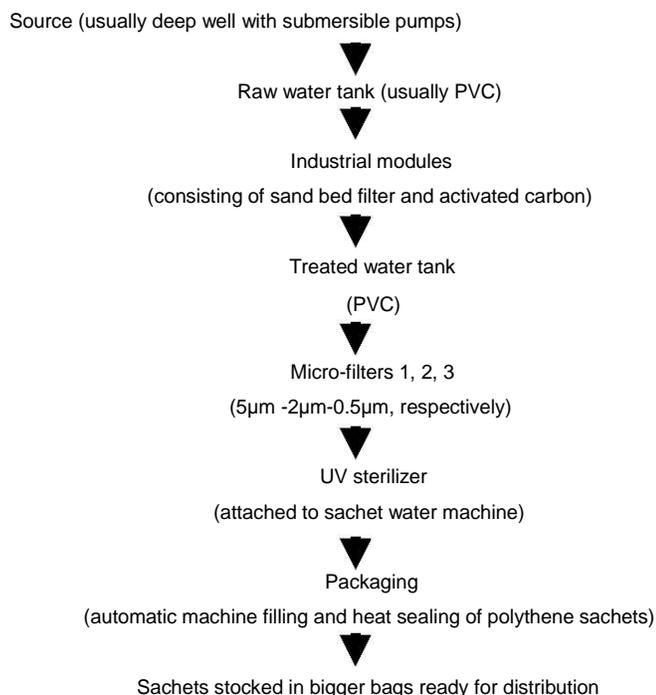


Figure 3. Typical water treatment process in sachet water factories.



Figure 4. Improper storage condition of water in sachets.

al., 1992) and may constitute a potential threat to public health. Non-detection of *E. coli* in this study might in part be due to poor recoveries associated with traditional crude methodologies available in the developing world (Santiago-Mereado and Hazen, 1987; Gawthorne et al., 1996). Alternatively, it could be that the disinfection method used in the manufacturing process eradicated the bacteria. On-site visits to the factories of identified products revealed a combination of treatment schemes (Figure 3) were used during the production of water in sac-

hets. These processes present multiple barriers that prevent pathogen presence in the final product.

While *E. coli* was not identified in the sampled population ($n=100$), its absence may, however, be insufficient to justify the purity of the analyzed packaged water. Although the presence of these organisms can be traced to faecal contamination, faecal-oral illness, however, is not caused by enteric bacteria alone. Faecal-oral illness could also result from infection with pathogenic viruses, protozoa and helminths (Asbolt, 2004), which have different environmental behaviours and survival characteristics to bacteria, and are now increasingly transmitted through drinking water (Anon, 1999; Kindhauser, 2003).

Thus, it may be argued that the test used primarily for warnings of faecal contamination in the developing world gives very little information on the presence or absence of a health risk (WHO, 1993; Gawthorne et al., 1996). Attempting to assess routinely viruses and protozoans of public health concern in the developing world is currently expensive. This calls for more scientific research aimed at developing low-cost technologies for detection of these pathogens in drinking water.

Given that the highest levels of contamination were observed for the brands obtained from the distributor's shed and the hawkers, the results suggested that the most probable port of post-treatment microbial contamination of packaged waters is largely during distribution and not within the factory premises. In the study location, reduced cost prices associated with bulk purchase remain a major incentive for excessive direct purchases from the manufacturers despite the unavailability of sufficient storage facilities and space. These quantities are often beyond the normal disposing ability of the distributors. Often sighted in the study location were packaged water products stored under direct sunlight and unhygienic conditions (Figure 4).

Coupled with the possibility of back-seepage into bags that are not well-sealed, the regrowth potential of microorganisms becomes significantly increased owing to the high ambient temperatures of up to 33.1°C (WWIS, 2007). In tropical settings, ambient temperatures are closer to that required for optimum growth for human pathogens (Prescot, 1999). Bacterial regrowth in packaged water has been demonstrated by Gonzalez et al. (1987), Bischofberger et al. (1990), Hunter et al. (1990), and Nsaze and Babarinde (1999). Furthermore, with so many shanty-towns and appalling sanitary facilities in the study location, the risk of contracting helminthic and other parasitic infections is heightened as these packets spend ample time in contact with ova-harboring soil during improper storage.

Apart from environmental contaminants, contamination from improper vendor handling also poses threats to the health of the ignorant consumers who drink often-times without any proper cleaning of the sachets. The common procedure is to wipe the sachet with the back of the hand (often times dirty) and then tear an end open with the

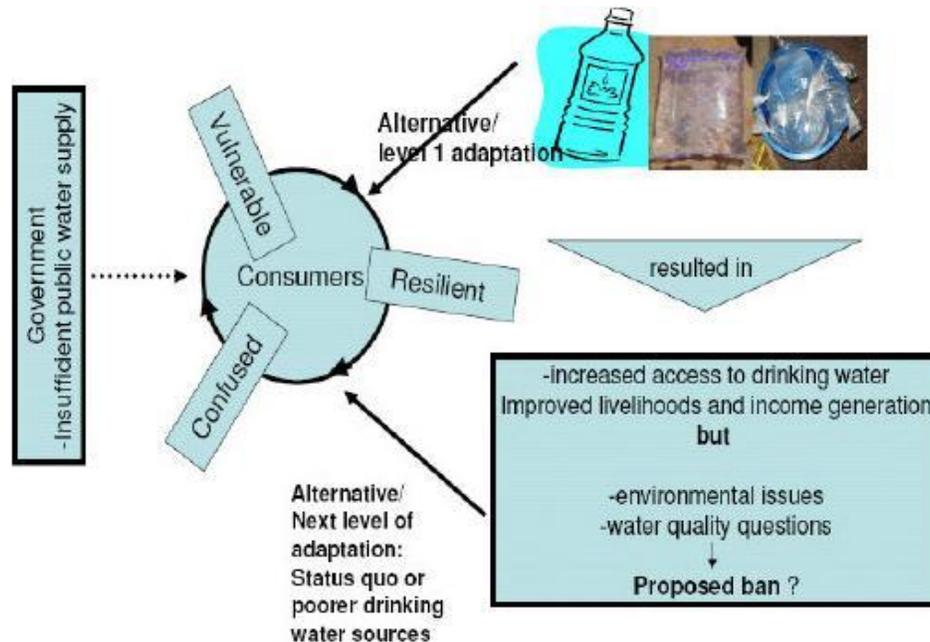


Figure 5. Fate of consumers with changing policies and insufficient public water supplies.

teeth. Previous studies (al-Lahham et al., 1990; Bonner et al., 2001; Daniels et al., 2002; Olsen et al., 2001; Viedma Gil de Vergara et al., 2000; Michaels, 2002) have identified handling as the source of infection in food- and water-borne diseases in several countries and for different types of microorganisms. Regardless of the level of treatment given to the water in sachets within the factory location, food handlers in the distribution line remain potential flaws by impeding safe transfer of the desired quality to the consumer, thus constituting a potential threat to public health.

Regulating the sachet water industry

There is a need for a switch from the traditional end-product focused regulatory approach currently employed by the national regulator to one that involves the people who play active roles as manufacturers, consumers and handlers in the packaged water industry. Regulatory activities that promote core hygiene values such as hand washing, general cleanliness of storage environment and vendor containers and proper handling culture will produce the desired improvements rather than a tenacious focus on end-product monitoring (Kirby and Gardiner, 1997; Guzewich and Ross, 1999).

While the identification of an ideal indicator organism remains challenging, a recommended regulatory strategy is to define indicators for each of the specific roles such as in source assessment, validation of the drinking water treatment process, operational and routine monitoring, in addition to end-product verification. Breakdowns in any of these barriers to disease transmission affect the quality of

the raw water or treated water and ultimately endanger the integrity of the system (Berger, 1981; Oloke, 1997).

Given the intermittent supply and low coverage of utility networks in many locations, there is a great prospect for alternative sources of water provision such as sachet water if the stated MDG targets are to be met in the developing world (Kjellén and McGranahan, 2006). On the international scene, the many 'exclusion criteria' and 'official indicators for MDG assessment seem to relegate packaged water along with other vended sources as unimproved. Agreed that the target of the MDG is achieved as people switch to piped water connections, or to free public stand pipes, boreholes or rainwater cisterns within a kilometre of their home (WHO UNICEF, 2000), a big challenge is the time framework for which this will become a reality in the developing world. Apparently, it might not be realistic a goal in the foreseeable future given the insufficiency of capital, cost (operation and maintenance) and commitment evident in the study location and other urban settlements of low and medium income countries where water supply functions are sub-optimal. It should be noted that these labelled 'unacceptable options' in the form of local provisions could make a bigger difference to the well-being of the most deprived populations than striving for ideal solutions such as universal piped water connections.

Also, by oppressing packaged water in a bid to protecting public health, authorities could be making it more difficult for deprived residents to obtain water which could lead to more grievous conditions as people may revert to poorer sources (Figure 5). Given the prevailing poor coverage levels, any proposed ban on such water in sachets,

as was envisaged by the regulatory agencies in the study location, may not necessarily be a socially desirable option.

Agreeably, it may not simply be about disregarding packaged water as unimproved. Instead, questions need to be raised by the international community and national governments about how possible strategies aimed at improving the status quo could be identified. More attention should be given to interventions that could increase the effectiveness of the treatment, distribution and disposal system; and how this can make a positive contribution to the widely publicised MDG.

Conclusion

Based on the bacteriological quality of assessed water samples, the study has attempted to examine the public health implication of packaged water products in Nigeria. Most packaged water apparently is of good quality, but some are contaminated. It should, however, not be automatically assumed that packaged water in sachets is generally safe. Although the technologies used in this water industry present barriers that prevent pathogen presence in the final product, the quality of the packaged water is compromised significantly as it moves from the manufacturer to the consumer. Regulatory activities that promote core hygiene values (e.g., hand washing, general cleanliness of storage environment and vendor containers) and a proper handling culture could produce the desired improvements rather than a tenacious focus on end-product monitoring, which does not always give a complete picture in terms of microbiological risk assessment. Also, an extreme shift towards implementation of the proposed ban on water in sachets may not be socially desirable. Thus, while seeking to protect public health in the developing world, there is need for regulatory and health agencies to maintain a balanced position that concurrently improves social welfare and access to drinking water. Obviously, in concert with international agencies such as the World Health Organization, this would involve considerable support for locally sourced initiatives such as the nation's packaged water, which apparently covers for institutional inadequacies in public water supply in Nigeria and other parts of the developing world.

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