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Towards appropriate sanitary inspection tools for self supply systems in developing countries

G. Oluwasanya, J. Smith & R. Carter, Nigeria

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The assessment criteria in many of the available examples of standard sanitary inspection tools are scored on a two-way 'yes or no' answer. The possibility of variations between the set out criteria in the forms and the observed sanitary faults are not provided for within the two-way answer system. The use of this type of scoring system may therefore either exaggerate or underplay particular risk factors. Onsite sanitary inspection of urban self supply wells was conducted in Abeokuta, Nigeria. The survey included the inspection of system operations and maintenance, to evaluate systems adequacy for safe water supply. This paper captures the inspection process. It explains the need for moderation of standard sanitary inspection forms to suit the peculiarities of urban self supply wells. The paper introduced a new scoring method and suggests appropriate sanitary survey format for self supply hand dug wells.

Introduction

A sanitary survey is usually an onsite review inspection of water supplies from source to point of use. The survey includes the inspection of water system operations and maintenance, to evaluate the system's adequacy for safe water production (EPA, 1999). According to Lloyd and Bartram (1991), the survey systematically lists every fault in the system as a sanitary risk factor. Identifiable points of sanitary risk in the system are then weighted equally to develop a risk score. Generally, sanitary survey forms are used. The forms contain assessment criteria for a particular type of water supply. Standardized forms for sanitary surveys are available (Lloyd and Helmer, 1990; Lloyd and Bartram, 1991; WHO, 1997; Howard, 2002; Davison et al., 2005), and most are linked to the WHO guidelines for drinking-water quality (WHO, 2004).

The assessment criteria in many standard sanitary inspection forms are scored on a two-way 'yes or no' answer. The possibility of variations between the set out criteria in the forms and the observed sanitary faults are not provided for within the two-way answer system, thereby making the assessment rigid. The scores, therefore, may not represent the correct sanitary problem, as they may either exaggerate or underplay particular risk factors.

Risk factors vary with water supply systems - public, communal or self supply systems. Self supply systems refer to local-level or private initiatives by individuals or households to improve their water supplies, without waiting for help from Government or Non-government Organizations (Carter, 2006). They include scoop holes, springs, unlined wells and rainwater collection.

The potential for growth of self supply systems is becoming a key management issue in groundwater development especially in Sub-Saharan Africa. Foster (2008) noted that the potential for growth in self supply is derived from the reality, which rapid growth of 4 – 8% pa of urban population and consequent increase in water demand present. The concept of self supply offers improved water quality, however the concern for water quality relative to accessibility and affordability is low. Self supply systems are also generally unregulated.

In Abeokuta, Nigeria, a developing urban city with population of about 250,000 people, about half the population are not served with treated public water (Oluwasanya et al, 2011). The unserved rely on mainly self supply hand dug wells for their water needs (Oluwasanya et al, 2011). To evaluate systems adequacy for safe water supply and facilitate water safety regulation of the self supply wells, a study was carried out in the area, which in part assessed the sanitary state of the water system. The sanitary survey also includes the inspection of system operations and maintenance.

This paper captures the inspection process. It explains the need for moderation of standard sanitary inspection tools to suit the peculiarities of urban self supply wells. The paper introduced a new scoring approach and suggests appropriate sanitary survey format for self supply hand dug wells.

Methods

Self supply wells assessment was done in two stages. In the first round conducted in March - April 2007, a total of 81 wells were surveyed. The second field assessment, which took place in July and August 2008, involved a smaller number (16) of wells. Assessment of a smaller number of wells in the second field exercise was done in part to validate findings from the first field study. Wells were selected based on accessibility, sanitary status, water uses, and owners/users reception of the research.

Direct observation was employed to capture the sanitary state of the wells, operations, maintenance, and water handling activities. For proof and documentation, life pictures through systematic observation and recording were taken with a digital camera. In addition, analysis of turbidity, pH, temperature and nitrate-NO_3 were undertaken on-site.

Results of particularly the nitrate-NO_3 were related with the sanitary inspection scores derived from the survey. Nitrate-NO_3 is frequently used as a marker of sewage input to groundwater resources, and as an analytical indication of human excreta and sewage in groundwater (Schmoll et al., 2006). Data analysis was carried out using non-parametric tests, as is commonly applied in the field of water resources (Helsel and Hirsch, 1992).

A sanitary survey was performed at each well when the sample was taken. Generally, sanitary inspections were a function of recording or scoring observed sanitary conditions. Observations are scored and recorded in unified formats for easy assessments (Schmoll et al., 2006). A number of standard forms have been developed for different types of water sources but none particularly for self supply systems. The sanitary survey form used therefore followed a format (SI 1) adapted from Godfrey and Howard (2005) and Lloyd and Helmer (1990). Form SI 1 was however revised (SI 2) to accommodate actual self supply realities experienced in the field.

The first form, SI 1 drafted a total of 17 questions from Godfrey and Howard (2005) and Lloyd and Helmer (1990) sanitary inspection forms, with some of the questions rephrased (Annex 1). The scoring system was also changed from a two-way yes or no answer to a scoring scale of 1 - 5 (Annex 2) such that each question is weighted 1 – 5. One being the worst score (poor sanitary condition). Therefore the scores across all the wells could range from 17 (worst possible) to 85 (best possible).

During the first field visit, the SI 1 form was revised (SI 2) to contain eight questions, 1 – 5 scoring scale, and criteria for scoring each question (Annex 2). The eight questions represented the most relevant to self supply wells in the study area. They included questions on toilets, burial sites, solid waste dumps, source protection and operation. With SI 2, the scores across the wells ranged from eight (worst possible) to 40 (best possible).

The revision was necessary because most of the 17 questions in SI 1 were found to be inappropriate to self supply wells. For instance question 14 on the SI 1 form '*Is the dedicated pump loose at the point of attachment to the well…*?' is generally not applicable as the common mode of self supply well operation is through a drawing bucket (Annex 1). Consequently many questions could not be scored for most of the observed wells as the intended sanitary fault did not exist. The SI 2 format was tested again in the second field work.

The 1 – 5 scoring process, estimation of total score and the risk level is illustrated in Annex 2. The result of the sanitary scores derived from SI 2 reflected the observed sanitary conditions of wells better than the scores derived from SI 1. The judgement of 'better' is however subjective. It should be noted that sanitary inspection exercises generally rely on subjectivity of the observer, but guided by clear guidelines and criteria.

The idea of equal weighting of identified sanitary risk is captured in the 1 – 5 scoring method. Score weights are distributed in the vertical and horizontal dimensions. The strengths of each sanitary risk increases from 1 to 5, one being poor. The weights however remain equal within each score unit. For instance, all the faults with scores of one have equal weight of one.

Results and discussion

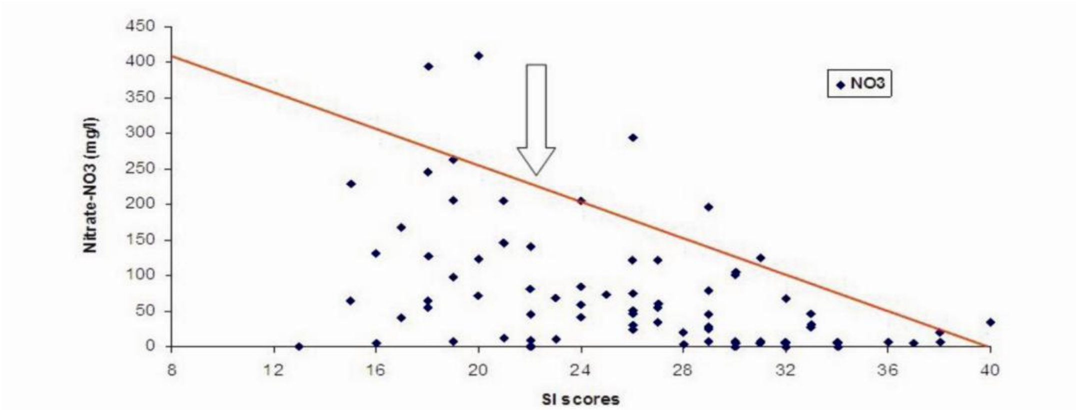
The sanitary risk levels derived for the wells are presented in Table 1. The sanitary condition of self supply wells in the study area is generally poor. Seventy five percent and 56% of the wells had sanitary risk levels ranging from intermediate to very high risk in 2007 and 2008 respectively. Implying that the number of wells with no or low sanitary risk is below average.

Table 1. Sanitary risk levels of self supply dug wells in Abeokuta, Nigeria

Risk levels	2007		2008	
	No. of wells	% No. of wells	No. of wells	% No. of wells
Very high	5	6	2	13
High	29	36	1	6
Intermediate	35	43	6	38
Low	12	15	7	44
	81	**100**	**16**	**100**

It is generally expected that sanitary inspection scores could give a good guess of the contamination condition of hand dug wells. Lloyd and Bartram (1991) made a similar inference that sanitary risk score is a useful indicator of microbial contamination. Similar claim is made of nitrate–NO_3 (Schmoll et al., 2006). To verify the general claims, the SI scores are plotted against the nitrate-NO_3 concentrations (Figure 1). High scores indicate good sanitary conditions. No conclusive relationship exists between the SI scores and the nitrate–NO_3 concentrations of the hand dug wells.

However, rather than focusing on the apparent lack of relationship between the SI scores and the nitrates-NO_3 values, it may be worth noting a possible relationship highlighted below the diagonal line in Figure 1. The diagonal line of the triangle may be presenting the maximum expected nitrate-NO_3 value for a particular sanitary score. This possible relationship also suggests that the likely level of contamination may be predicted from SI scores in the absence of actual water quality testing.



N = 81; NB: The actual possible relationship may be found below the red diagonal line and the arrow; SI scores range from 8 (worst possible) to 40 (best possible)

Figure 1. Variation of sanitary inspection scores of well area with nitrate-NO_3 contents of hand dug wells

Source: Field data

A similar possible relationship was inferred by Nussbaumer in 2008 (Nussbaumer, 2008). Nussbaumer detected very little relation between faecal contaminations (Thermotolerant coliforms) and sanitary scores but derived maximum expectable thermotolerant coliform concentrations for a certain sanitary score. The recurrence of a likely relation between sanitary scores and microbial contaminations indicated by nitrate-NO_3 levels or coliform counts is worth being given further attention in research. The relationship may prove a useful key in drinking water quality modeling.

Sanitary survey scoring approaches

The known yes or no scoring method may be appropriate and generally sufficient in places where construction designs and materials, and activities around water systems are regulated. Usually in such countries, onsite survey of water systems is used to either supplement a full sanitary survey or is a mandatory regulatory requirement in various overlapping water systems protection acts or rules. For example to ensure public health safety, EPA (1999) reports that it is a regulatory requirement for community and non-community water systems to have a periodic onsite sanitary survey under the Total Coliform Rule (TCR) (54 FR 27544-27568, 29 June 1989). Onsite inspection is also suggested under the Surface Water Treatment Rule (SWTR) of the United States Environmental Protection Agency (USEPA).

Experience with this study however shows that 'yes or no' sanitary scoring approach assumes a rigid correspondence between the assessment criteria and the observed sanitary faults. Hand dug wells, which are generally expected to be completed with hand pump, for instance, are not. Well covers exist in varying degree of materials and covering range (Photographs 1 and 2). In the study area, there is also no known regulation for especially self supply well design, source and water safety. Water source construction, user activities and source handling of self supply sources are typically a function of source ownership, investment capabilities and water use priorities. In which case construction quality, design and source handling varies. The extent of variation in any of observed sanitary faults do not therefore usually fit a 'yes or no' assessment score method, but arguably captured in the 1 – 5 scoring approach.

Photograph 1. Fully covered well with gaps within planks, and see-through openings between cover and head wall

Photograph 2. Partially covered well; the perforated bowl cover used for the covering of the un-covered part is placed next to the well

Examples of self supply dug wells showing varied degree of covering; Source: Field data

Sanitary survey and emerging paradigms

Many of the existing sanitary survey forms, particularly the ones that are linked with the WHO Guidelines for Drinking-water Quality are becoming dated. The commonly cited sanitary forms in Lloyd and Helmer (1990) and Lloyd and Bartram (1991) are used or adapted in many recent studies like Godfrey and Howard (2005) and WHO documents (WHO, 1997; 2004). The United States EPA document, a guidance manual for conducting sanitary surveys of public water systems also dates back over 10 years (EPA, 1999).

New concepts have emerged in the water and sanitation sector within the last 10 years. Water safety plans is an acclaimed paradigm in water quality management to ensure safe water provision of any water systems (Godfrey et al., 2002; WHO, 2004; McCann, 2005; Breach and Williams, 2006; Garzon, 2006). The role of Self supply systems in urban water supply management is also increasingly recognized (Foster, 2008; Munkonge and Harvey, 2009; Osbert and Sutton, 2009; Workneh et al., 2009). A tool like the sanitary survey format is critical and tangential to water systems assessment and hazards identification. The experience with the sanitary inspection exercise presented in this study shows the need for regular update of universally accepted tool of scientific and research importance. The sanitary survey scoring format particularly applies. Constant review of such tools is also necessary to develop formats to suit emerging concepts and paradigms.

Sanitary survey review: where to draw the line

A call for caution is expedient in the canvass for sanitary survey tool review. It is important to understand where to draw the line to avoid complexities or introduction of ambiguities. The revised sanitary inspection form that is presented in Annex 2 for instance does not include questions on the number and condition of latrines or soil characteristics, which arguably would impact on the risks of contamination. However, the presence of any latrine at all represents a sanitary risk to water well irrespective of the soil condition or state of the latrine. Similarly, possible variation in particularly proximity of latrine to wells is catered for within the 1 – 5 scoring range. It should be noted that sanitary survey exercises provide a longer term perspective on the risks of contamination (Schmoll et al., 2006), helps to identify sources of sanitary risks, which in turn provides basis for safety interventions. The exercise also provides a useful tool for communities, water suppliers and surveillance institutions (Schmoll et al., 2006). Sanitary inspection tools therefore needs to be kept as simple as possible.

Conclusions

The sanitary condition of most of the self supply wells in Abeokuta, Nigeria is poor. Safety intervention towards sanitary improvement and systems upgrade is recommended. The research moderated sanitary inspection forms and suggests forms suited to the needs of self supply wells in the study area. The sanitary survey exercise revealed the existence of a possible relationship between sanitary inspection scores and microbial contaminations of water sources. With further research, the relationship may prove a useful tool in drinking water quality modeling. Constant review of standard format of assessment is imperative. The need to keep the standard format simple is however advised.

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Keywords

Sanitary survey, sanitary inspection tools, self supply systems, hand dug wells

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Contact details

Grace Oluwasanya
University of Agriculture, Abeokuta, Nigeria.
Tel: +234 (0) 703 9594417
Email: grace.olutopsy@googlemail.com

Jennifer Smith
Cranfield University,
UK.
Tel: +44 (0) 1234 750111 ext. 5576
Email: j.a.smith@cranfield.ac.uk

Richard Carter
Water Aid,
UK.
Tel: +44 (0) 2077 934500
Email: richard@richard-carter.org

Annex 1: Questions included in the initial sanitary survey exercise, SI form 1

1. Is there a latrine within 10 m of the well?
2. Is the nearest latrine on higher ground than the well?
3. Is there burial point(s) within 10 m of the well?
4. Is the nearest burial point on higher ground than the well?
5. Is there any solid waste dump within 10 m of the well?
6. Is there any ponding of stagnant water within 2 m of the well?
7. Is the well drainage channel faulty e.g. broken, allowing ponding or needs cleaning?
8. Is the fence missing or faulty, which would allow animals in?
9. Is there animal breeding and animal waste within 10 m of well?
10. Is the well head protected with cemented apron and floor?
11. Is the cement less than 1 m. in radius around the top of the well?
12. Are there any cracks in the cement floor around the well?
13. Is a bucket also in use and left in a place where it could be contaminated?
14. Is the surface pump loose at the point of attachment to well, which could permit water to enter through to the well?
15. Is there a well cover?
16. Is there a well wall lining (cement or ring)?
17. Are the walls of the well inadequately sealed at any point for 3 m below ground level?

Annex 2: Sanitary Inspection Form for Self Supply Wells (SI 2)

Type of Facility: **Self Supply Well (protected/unprotected)**

1. General information

- LGA: ………………………………………….
- Location: …………………………….……..
- Cluster group number: ………..………………
- Date of visit: …………………..……………… Weather at time of visit: ……………………………………………………….
- Water sample taken? ………………………..… Sample No.: ……………………. Faecal Coliform/100ml: ..……………….

2. Specific Diagnostic Information for Assessment

SN	Questions	Risk scores				
		1	2	3	4	5
1	Is there a latrine within 10 m of the well?	x				
2	Is there burial point(s) within 10 m of the well?		x			
3	Is there any solid waste dump within 10 m of the well?					x

4	Is there well head protection?		x			
5	Is there animal breeding and animal waste within 10 m of the well?		x			
6	Is a bucket also in use and left in a place where it could be contaminated?	x				
7	Is there a well cover?	x				
8	Is there a well wall lining (cement or ring)?	x				
	Total per unit scores	4	3	0	0	1
	SI score = Sum of total per unit scores: ………15/40					

Contamination risk scores: 8 - 16 = Very high; 17 -24 = High; 25 - 32 = Intermediate; 33 - 40 = Low; Scale of scoring: 1 = poor; 5 = good; NB: Included in this form is an example of sanitary survey scoring and estimation of total scores for a self supply well, x indicate scores; Estimation of total score and risk level: 4*1+3*2+0*3+0*4+1*5 = 15

Remedial action: …….…

Adapted from Godfrey & Howard (2005) and Lloyd & Helmer (1990)

3. Risk scoring criteria per question:

Q1 & 2:

1. Latrine/soak away distance of < 5 m and on higher ground than well
2. Latrine/soak away distance of < 10 m and on equivalent ground level with well
3. Latrine/soak away distance of < 10 m and on lower ground level than well
4. Latrine/soak away distance of 10 m and on equivalent ground level with well
5. Latrine/soak away distance of > 10 m and on lower ground level than well/No burial site

Q3:

1. High heap solid waste distance of < 5 m
2. High heap solid waste distance of < 10 m
3. Moderate solid waste heap distance of 10 m
4. Low heap solid waste distance of > 10 m
5. No solid waste

Q4:

1. No cement apron, floor and drainage around well head with ponding
2. Well head with apron, but no cement flooring and drainage with ponding
3. Well head with apron, crack in cement flooring and poor drainage
4. Well head apron, crack in cement flooring with good drainage
5. Adequate well head apron with cement flooring and good drainage

Q5:

1. No fence, gate and well head protection with very likely animal invasion
2. No fence, incomplete well head protection with likely animal invasion
3. No fence and gate, moderate well head protection with less likely animal invasion
4. Low fence and gate, good well head protection, not likely animal invasion
5. Adequate well fencing and gate, well head protection and not likely animal invasion

Q6:

1. Users use bucket and rope kept on the floor around well
2. Users come with bucket and rope
3. Users use owners' bucket and rope kept on well
4. Users' use owners' bucket and rope kept indoor
5. Use of bucket and rope kept permanently within the well

Q7:

1. Open well
2. Well cover with large openings and without lock and key
3. Well cover with little openings and with lock and key
4. Airtight well cover without lock and key
5. Airtight well cover with lock and key

Q8:

1. No wall lining
2. Well lining made with blocks and within < 3 m of depth
3. Well lining with rings or cement and within 3 m of depth
4. Well lining with rings from apron to > 3 m of depth
5. Well lining with rings from apron to bottom