A pilot rural water surveillance project in Indonesia

by Barry Lloyd and Sri Suyati

Rural water supply in Indonesia is characterized by many hundreds of thousands of public and private unpiped facilities. This article describes cost-effective methods which have been developed for sanitary inspection of these facilities. The results of the pilot surveillance project in Java have been evaluated and are to be used as the basis for remedial action strategies which will be replicated in other provinces of Indonesia.

IN 1985 THE Directorate General for Communicable Disease Control and Environmental Health of the Ministry of Health was made responsible for ensuring that drinking-water supplies do not present a health risk. Water surveillance for rural supplies was initiated as a pilot project with support from UNEP and the World Health Organization in the province of Yogyakarta, central southern Java, in 1985. It is intended that surveillance should be phased in other provinces on an incremental basis over the next five to 10 years using the lessons learned and the strategies developed in Yogyakarta. Consequently the principal objectives of the project were the following:

- To develop, test and evaluate the methods described in WHO's *Guidelines for Drinking Water Quality, Vol.3, Water Quality Control for Small Communities.*[1]
- To develop a surveillance infrastructure at sub-provincial level to ensure that drinking-water supplies are kept under continuous public health assessment.
- To provide a scientific basis for strategies of remedial action which will protect the consumer from the risk of water-borne disease.

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Phase 1

One of the most important preparatory planning activities in surveillance is the development of comprehensive inventories of all water supply facilities in the area under consideration. This is necessary to define the water supply coverage and existing levels of service. The district selected for the project, Gunung Kidul, has a population of 702,000 of which 560,000 (about 80 per cent) live in the rural areas. The magnitude of the problem of providing any form of surveillance service became clear at the outset of the project when 21 sanitary technicians began to prepare inventories of the supplies for all the villages in the district. For the 144 villages and 1,421 hamlets over 21,000 public installations were recorded. It was clear that the total number of facilities, principally private, unprotected wells could easily amount to four times this number.

This brings us to the next planning step and raises the question of how to select installations for inspection and testing. It has therefore been recommended that the first priority must be given to public facilities serving the larger populations. The inventory of the different types of public water sources was as follows:

Piped supplies	13
Artesian wells	2
Rainwater tanks	11,027
Protected springs	45
Shallow wells with handpumps	459
Deep wells with handpumps	808
Dug wells	9,204
Surface water sources	91
Total number	21,649

After completing the inventory, 21 sanitary technicians and laboratory staff were trained, equipped and sent out to begin water testing and inspecting a selection of these facilities.

At the end of the first year of the project 2,546 samples had been collected and analysed for faecal coliform contamination but complementary sanitary inspection had not been done. The analytical results for the first year demonstrated that 86 per cent of facilities were faecally contaminated and classified as bad.

Phases 2 and 3

The results of bacteriological analysis were classified as good or bad, and sanitary inspection also classified the facilities as being in a good or bad state in a somewhat subjective manner. A bad bacteriological result was considered to be any sample from which at least one faecal coliform

Sanitary worker sampling and inspecting converted dug-well with insanitary cover and handpump.

was recovered from 100ml of sample and/or the total number of coliforms exceeded 10/100ml.

In the second year of the project, 500 facilities were sampled and tested and 77 per cent were classified as bad. In addition the sanitary inspection suggested that 72 per cent of these same facilities were bad.

In the third year, 1,012 facilities were surveyed of which 66 per cent had a bad bacteriological result and 67 per cent had a bad sanitary inspection result. Unfortunately faecal contamination did not correlate statistically with the bad result suggested by sanitary inspection.

The lack of association between observed sanitary risk and measured bacteriological risk was particularly worrying since so many of the facilities were grossly contaminated. It appeared that the majority of facilities were in need of improvement or rehabilitation but there was no rational basis on which to build an improvement strategy.

Retrospectively it is clear that there were three principal errors. First, to expect sanitary workers to come to an objective decision about the sanitary status of a facility without clear guidelines on what was good or bad. Second, that the sanitary inspection form was not designed to permit a quantitative assessment of the status of the facilities, and it was not possible for the supervisors to evaluate the most important points of risk of contamination. Third, that there was no distinction between high, intermediate, low or no faecal pollution, and so the majority of sources were simply graded as bacteriologically bad.

New procedures for Phase 4

It is extremely discouraging for sanitary workers to find that the great majority of systems, which they may have helped to construct, are functioning as badly as suggested by the surveys in Phases 1 to 3. It was proposed therefore that a more elaborate grading of the level of faecal contamination be developed, as well as a quantitative evaluation of the number of points of risk of pollution of the supply as judged by sanitary inspection. However it should be emphasized that the purpose of these revised classifications are not primarily to give comfort to depressed sanitary workers, but rather to assess more accurately the health risk attributable to each drinking-water installation in order to plan remedial action.

None of the rural supplies in the pilot project area is chlorinated and it is inevitable that the majority will contain large numbers of total coliform bacteria which may have limited faecal significance. It was decided to base the classification scheme primarily on 44°C thermotolerant faecal coliform bacteria.

Sanitary inspection report forms

A sanitary survey form was designed for each of the main types of facility listed in the inventory. The objective was to establish a reporting system which could be rapidly but accurately completed at the site at the same time that the bacteriological sampling is carried out. The report form is intended to serve several purposes:

- To identify all the potential sources of contamination to the supply.
- To quantify the level of risk attributable to each facility.
- To provide a graphical means of explaining the risks of each facility to the users (hygiene education).
- To provide clear guidance to the user, and a record for the health centre supervisor, as to the remedial action which is required.

To meet these needs, double-page report forms (Figure 1) were designed to improve upon the models provided in the 1976 WHO publication.[2]

The sanitary workers should first inspect the facility and complete the check-list on the report form with the assistance of the owner or community representatives; this can take half an hour. The number of risk points can be immediately totalled to give a sanitary inspection risk score in the range 0 (no risk) to 10 (very high risk).

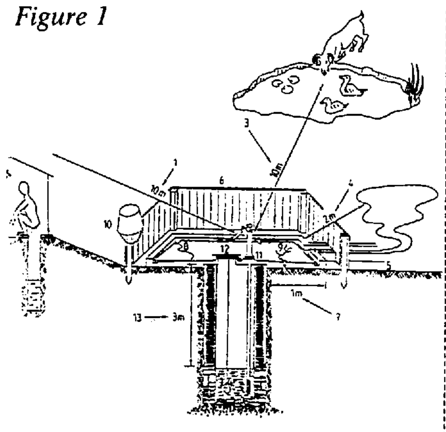
The sanitary worker should then circle each of the points of risk on the diagram, preferably in red ink. The diagram should be separated from the report form and given to the owner or community representative together with instructions and an explanation of what needs to be done to improve the facility. The recipient should sign the report form which the sanitary worker retains for the health centre records.

The sanitary worker should take a water sample in a sterile sample bottle for bacteriological analysis. This may be analysed there or sent to the district hospital laboratory in a cold box for analysis the same day. It is most cost-effective for the sanitary worker to make at least a half-day per week available for the surveillance activity so that at least four inspections and samples can be done in that time.

Phase 4

The procedures described were applied in the pilot project area for the first time from June to September 1988. Right now, 328 facilities have been bacteriologically analysed and, of these, 244 inspected. Using faecal coliform counts, systems may be classified as A=0/100ml, B=1-10/100ml, C=11-

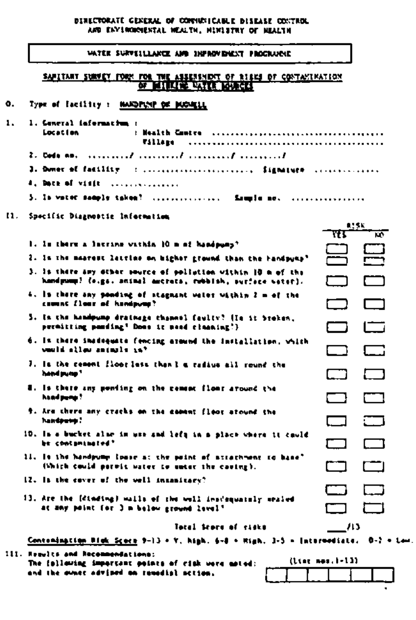
Figure 1



Circle all sanitary risks in red ink.

Advise 14 pot chlorination where risk score is greater than 3/13

Separate sheet along dotted line & give the diagram to the owner of the facility



DIRECTORATE GENERAL OF COMMUNICABLE DISEASE CONTROL AND ENVIRONMENTAL HEALTH, MINISTRY OF HEALTH

WATER SURVEILLANCE AND IMPROVEMENT PROGRAMME

SANITARY SURVEY FORM FOR THE ASSESSMENT OF RISKS OF CONTAMINATION OF DRINKING WATER SOURCES

0. Type of facility : HANDPUMP OR DUGWELL

I. 1. General information :
Location : Health Centre ....
Village ....
2. Code no. ..../........./........./........./
3. Owner of facility : ...., Signature ....
4. Date of visit ....
5. Is water sample taken? .... Sample no. ....

II. Specific Diagnostic Information

	RISK YES	RISK NO
1. Is there a latrine within 10 m of handpump?	☐	☐
2. Is the nearest latrine on higher ground than the handpump?	☐	☐
3. Is there any other source of pollution within 10 m of the handpump? (e.g., animal excreta, rubbish, surface water).	☐	☐
4. Is there any ponding of stagnant water within 2 m of the cement floor of handpump?	☐	☐
5. Is the handpump drainage channel faulty? (Is it broken, permitting ponding? Does it need cleaning?)	☐	☐
6. Is there inadequate fencing around the installation, which would allow animals in?	☐	☐
7. Is the cement floor less than 1 m radius all round the handpump?	☐	☐
8. Is there any ponding on the cement floor around the handpump?	☐	☐
9. Are there any cracks on the cement floor around the handpump?	☐	☐
10. Is a bucket also in use and left in a place where it could be contaminated?	☐	☐
11. Is the handpump loose at the point of attachment to base? (Which could permit water to enter the casing).	☐	☐
12. Is the cover of the well insanitary?	☐	☐
13. Are the (lining) walls of the well inadequately sealed at any point for 3 m below ground level?	☐	☐

Total Score of risks ____/13

Contamination Risk Score 9-13 = V. high, 6-8 = High, 3-5 = Intermediate, 0-2 = Low.

III. Results and Recommendations:
The following important points of risk were noted: (List nos.1-13) ☐☐☐☐☐☐
and the owner advised on remedial action.

100/100ml, D=101-1,000/100ml and E=>1,000/100ml. Tubewell water is least contaminated, with 86 per cent of shallow wells and 84 per cent of deep wells falling into categories A and B. At the other end of the scale, 9 per cent of these deep wells and 7 per cent of shallow wells fall in the very high risk grades (D and E). This contrasts with 22 per cent open dug wells and 20 per cent of converted dug wells in the very high risk grades, while only 4 per cent of rainwater tanks were found to be contaminated at these levels.

It was considered essential to combine the faecal grading with the sanitary inspection risk score in monthly reports to the district office. Figures 2 to 4 show how the faecal coliform grades A to E and the sanitary inspection risk scores are associated for each type of facility in reports for this final phase of the pilot project. These figures provide a strategy for remedial action by order of priority by classifying each facility into one of four levels of action:

- Very high risk and hence urgent remedial action.
- Intermediate to high risk requiring action as soon as resources permit.
- Low risk.
- No risk; no action.

These figures can be used, at a glance, by the district surveillance co-ordinator not only to decide priorities for remedial action, but also for supervision purposes and for urgent re-sampling where gross faecal contamination does not correlate with a high-risk sanitary inspection score as indicated in the urgent re-sample category (see circled area in Figure 4).

Figures 2 to 4 also demonstrate at a glance how the different facilities cluster characteristically. The deep tubewells are typically well protected from sanitary risks and thus low sanitary risk scores correlate well with a high proportion of A or B category bacteriological results. This is characterized by clustering of results in the bottom left-hand corner of the graph (Figure 4). By contrast the converted dug wells (Figure 3) produce a dense cluster in the intermediate- to high-risk zone and a broad band correlation from top right to centre, but almost no facilities with no risk in the bottom left of the graph.

All the matched bacteriological and sanitary inspection data have been summarized in Table 1. The

Figure 2. Combined risk analysis of sanitary inspection and faecal coliform contamination of single point drinking-water facility.

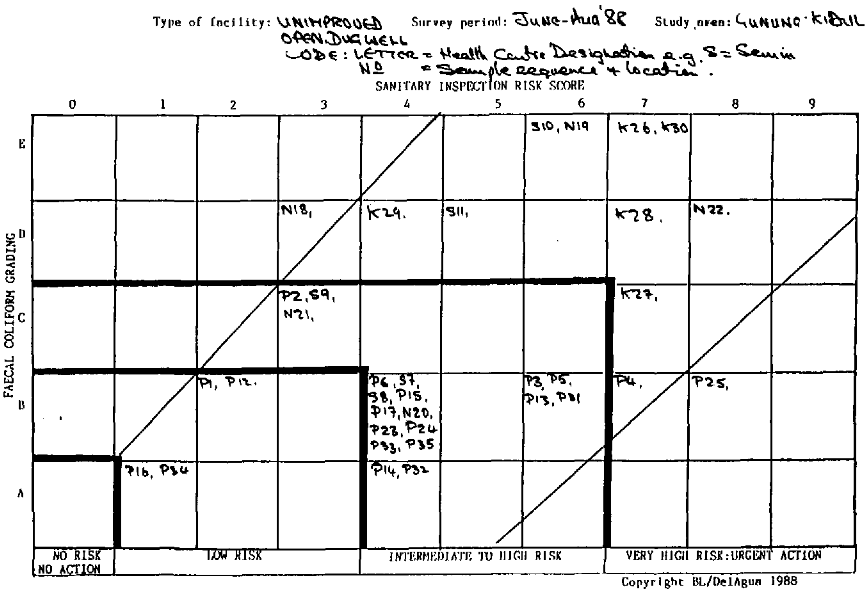


Figure 3. Combined risk analysis of sanitary inspection and faecal coliform contamination of single point drinking-water facility.

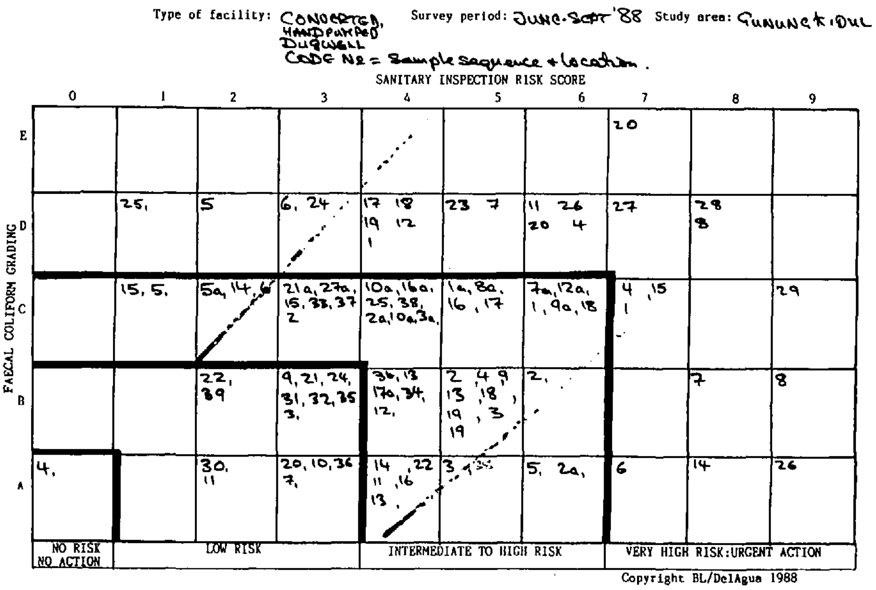


Figure 4. Combined risk analysis of sanitary inspection and faecal coliform contamination of single point drinking-water facility.

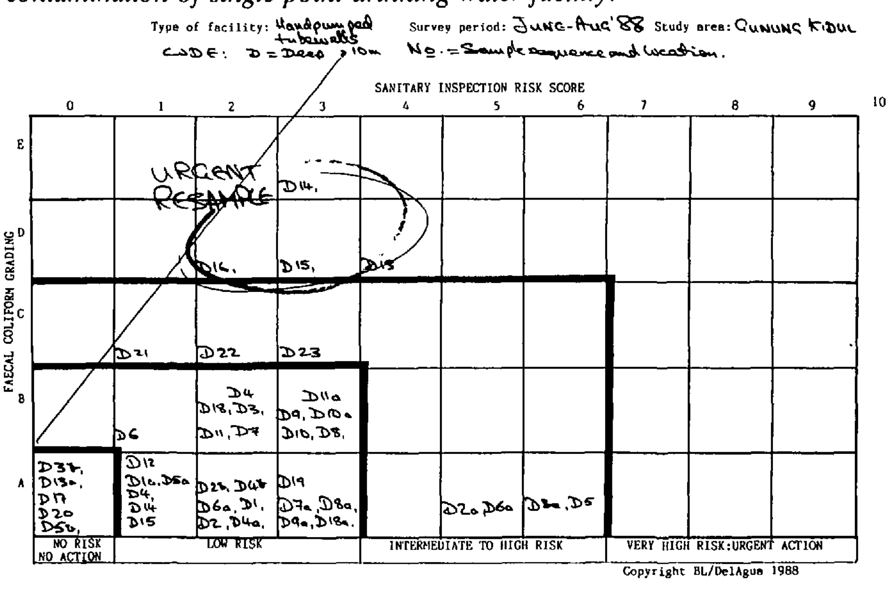


Table 1. Phase 4 summary of combined risks for sanitary inspection and bacteriological analysis of drinking-water facilities in the pilot project area in Java

Type of facility	*No risk Number*	*(%)*	*Low risk Number*	*(%)*	*Intermediate to high risk Number*	*(%)*	*Very high risk Number*	*(%)*
Unimproved open dug well	2	(6)	2	(6)	15	(43)	16	(45)
Converted dug well + handpump	1	(1)	15	(16)	50	(53)	28	(30)
Shallow tubewell + handpump	0	(0)	2	(5)	30	(80)	6	(15)
Deep tubewell + handpump	5	(11)	28	(62)	8	(18)	4	(9)
Rainwater tanks	0	(0)	4	(12)	16	(50)	12	(38)
					Most urgent action			

*Total facilities under study = 244.

most obvious conclusion from this is that the facility presenting the highest risks are the 88 per cent of unimproved, open dug wells made up of the 43 per cent intermediate- to high-risk and 45 per cent very high-risk categories. What is worrying is that the expense of conversion of dug wells by fitting a handpump and a 'sanitary' cover does not make a more substantial reduction in risk; 83 per cent are still in the two high-risk categories.

A significant improvement in risk reduction is achieved by shallow tubewells, only 15 per cent of which are in the very high-risk category; however the highest proportion (80 per cent) are classed in the intermediate- to high-risk category. When we examined bacteriological quality alone it was seen that 72 per cent were in grade A (WHO guideline value) and a further 14 per cent were in grade B, making a total of 86 per cent low risk with respect to faecal contamination. The clustering of points, however, that can be observed in the cases of the shallow tubewells indicates a poor correlation between level of faecal contamination and sanitary risks. Thus the largest cluster of grade A facilities would be found in association with a high sanitary risk score of 6 (square A6). This may be due to one or more of the following reasons:

- The facilities are deteriorating structurally with age, but have not yet reached the point where they allow contamination to enter the tubewell.
- Several risk points in the sanitary inspection report form are being unnecessarily emphasized by the sanitary worker.
- The sanitary reporting procedure is perhaps over-rigorous.

Whichever reasons explain these apparent anomalies, they should be verified by the district co-ordinator re-checking the facilities in question. Whatever the outcome the results emphasize the considerable bacteriological source protection afforded by the drilled tubewell.

In contrast to the shallow tubewells, the combined risk analysis in Table 1 and clustering shown in Figure 4, for deep tubewells, are much closer to the situation which would be predicted from first principles. Only 9 per cent are very high risk, and 18 per cent in the intermediate- to high-risk group, thus leaving 73 per cent in the low-risk group. This correlates well with the 16 per cent (in grades C, D and E) high-risk and 84 per cent no-risk and low-risk bacteriological grades (59 per cent A, 25 per cent B), and lends further strong support to the case for installing tubewells. The four points which are grossly contaminated but have relatively low sanitary risk scores (D13, D14, D15, D16) may represent remote contamination of the aquifer rather than defects at the tubewell; hence the need for re-sampling.

Inspection vs analysis

It is important to emphasize the complementary nature of sanitary inspection and analysis. There are many occasions when the source of contamination is not visible to sanitary inspectors. In the case of groundwater contamination, for example, a tubewell with handpump may be in good repair, but the aquifer itself may be contaminated. Contamination of the aquifer can only be detected by bacteriological or chemical analysis. On the other hand a single water sample may be unrepresentative, and changing environmental conditions, particularly heavy rainfall or drought, may quickly alter the level of contamination of a poorly protected source. Thus the sanitary inspection should at the very least reveal the most obvious points of risk of contamination. It would be most unsatisfactory if sanitary inspection routinely underestimated bacteriological contamination. Happily the data show that this is rarely the case, and that generally the sanitary inspection reveals more of the chronic risks of contamination than can be revealed by a single and costly bacteriological examination. We would hasten to add that this is not an argument for dispensing with bacteriological testing but rather for an economical and intelligent approach to bacteriological testing where money is limited.

The sanitary inspection procedures and bacteriological grading proposed in this article are not considered by the authors to be the definitive listings of points of risk nor an ideal model for improvement strategies. They are presented to the readership, and especially to rural water supply project staff, as a working hypothesis for field evaluation in other project areas. We are aware of inadequacies in the system proposed. In particular we would welcome comment on the equal weighting of different inspection points and suggestions for additional factors to include. We have intentionally excluded problems of operation and maintenance of handpumps for example, although we are well aware of the risk to health imposed by breakdowns. We would also welcome discussion from readers about the importance of the radius of the concrete plinth protecting dug wells and tubewells, and the safe distance of the nearest latrine from the well point.

References

1. *Guidelines for Drinking Water Quality, Volume 3, Drinking Water Quality Control in Small Community Supplies*, WHO, Geneva, 1985.
2. *Surveillance of Drinking Water*, WHO, Geneva, 1976.