Where there is no training — pollution-risk assessment by field-staff

by Guy Howard and Alice Simonds

People are waking up to the fact that pollution, and the risk of pollution, must be assessed and monitored. Hard-pressed, untrained fieldworkers can contribute — with a little help.

IT IS BECOMING increasingly important that water-resource and water-supply agencies in developing countries carry out pollution risk assessment (PRA) and pollution-monitoring activities. It is rare, however, to find enough, adequately qualified, staff to do this. What commonly happens is that field-workers with other responsibilities are asked to perform monitoring functions in addition to their existing duties, for which they receive limited, if any, additional training.

Some field-staff already critically appraise the environment surrounding water supplies in order to assess the sanitary risk to the water supply from local activities. The protocols and forms designed to facilitate these are widely available in a number of texts, for example, WHO's *Guidelines for Drinking-Water Quality, Volume 3.*[1]

A new priority

Pollution risk assessment methodologies and forms designed with the field-worker in mind are not widely available, however, principally because this is a new priority in much of the South. Pollution risk assessment is further complicated by the wide-ranging nature of pollution, and the enormous array of potential pollutants. Unlike sanitary risks, it may not be easy to identify sources of other contamination; it is often difficult to detect chemical pollutants; and field-staff often find it hard to assess the likely risks.

In a recent training event for Zimbabwe's Department of Water Development, the authors worked with field-staff to produce a pollution risk assessment protocol which can be used to provide basic information about the risk to water supplies or sources from pollution. This protocol is not designed to provide a comprehensive risk assessment, but rather to provide a preliminary indication of whether any significant pollution risk exists.

The pollution risk to water sources from any human activity is a combination of both the pollutant 'load' (quantity and concentration of pollutant), and the water source's degree of vulnerability to the pollution.

Many different activities cause pollution; Table 1 summarizes some key activities which have the potential to pollute groundwater, and shows their influence on the suitability of a source to be used as a drinking-water supply. The actual pollutant load affecting a water source will be site-specific, and would need to be calculated for any water source at risk.

Water vulnerability is a measure of how accessible the water source is to polluting activities. In some cases, this is simple to assess: for example, if a chemical factory has a effluent-pipe discharging directly into a surface water source, it is obvious that the water source will be susceptible to any pollutants released. Estimating the vulnerability of a groundwater source may not be so easy.

The risk of groundwater contamination (aquifer vulnerability) depends on the porosity, permeability, and thickness of the overlying soil and rock (the hydraulic accessibility), and the quantity and concentration of the pollutant (pollution load). Where aquifers are deep and overlain with impermeable layers, the hydraulic accessibility of the aquifer is low and, therefore, the risk of even high pollution loads reaching the groundwater may be relatively low. Aquifers which are at shallow

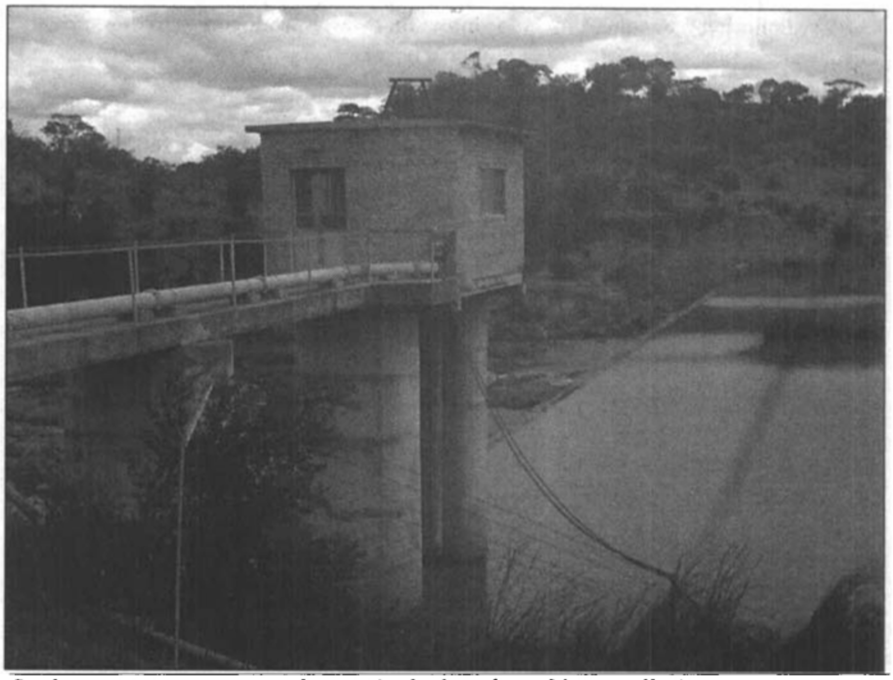
Table 1. Principal characteristics of pollution

Activity	*Category*	*Main types of polllutant*	*Impact on suitability as source for drinking-water supplies*
Urbanization			
Unsewered discharge of sewage	P-D	pno	xxxx
Stream discharge of sewage	P-L	pno	xx
Sewage oxidation lagoons	P	opn	xx
Sewer leakage	P-L	opn	x
Landfill, solid-waste disposal	P	osnh	x
Well-head contamination	P	pn	xxx
Industrial development			
Process water/effluent lagoons	P	ohs	xx
Tank and pipeline leakage	P	oh	xx
Accidental spillages	P	oh	xxx
Stream discharge of effluent	P-L	ohs	x
Landfill residue & waste	P	ohs	xx
Well disposal of effluent	P	ohs	xx
Agricultural development			
Cultivation with:			
Agrochemicals	D	no	xxx
Irrigation	D	sno	xxx
Wastewater irrigation	D	nosp	xx
Livestock rearing/crop processing:			
Unlined effluent lagoons	P	pno	x
Stream discharge of effluent	P-L	onp	x
Mining development			
Mine-drainage discharge	P-L	sha	xx
Process water/sludge lagoons	P	hsa	xx
Solid mine tailings	P	hsa	xx

Category	**Types of pollutant**		
P Point	p Faecal pathogens	h Heavy metals	x to xxxx Increasing impact
D Diffuse	n Nutrients	s Salinity	
L Line	o Organic micropollutants	a Acidification	

depth, with a thin unsaturated zone overlying them, are much more vulnerable. The same pollutant load will pose a different risk, depending on the vulnerability of the source.

Most fieldworkers will not have access to the information necessary to allow an accurate assessment of aquifer vulnerability and, in any case, they are very unlikely to be trained to interpret this data. They can collect basic information, however, concerning the depth of boreholes, and the depth of outflow of a polluting activity. If this information indicates that the source is likely to be vulnerable, a detailed assessment should be made by either a hydrologist or a hydrogeologist.


A. Rickards

Surface water sources can be particularly vulnerable to pollution.

Preliminary integrated pollution-risk assessments

The primary aim of these assessments is to provide information which can provide guidance when a more specialized, comprehensive assessment is undertaken. For example, in an area with industrial discharges, a preliminary assessment would aim to identify the type of industry, and attempt to obtain some information about the chemicals used or produced, and the waste disposal/treatment facilities. At the same time, a sample should be taken and sent to a suitable laboratory for a full analysis of relevant parameters, and some basic parameters measured in the field.

The results of the on-site testing and the completed pollution risk assessment form can then be sent to the pollution-control agency. This information allows pollution-control staff to decide whether a follow-up visit and more detailed investigation into the site is warranted.

The information gathered during preliminary pollution-risk assessments requires some level of informed judgement as to what constitutes a significant pollution risk. It may be difficult for staff to be able to identify differences between low, medium, and high risks. In this situation, it is imperative that field staff are provided with some guidance notes by specialist pollution-control staff. The authors are currently working with Zimbabwe's Department of Water Development (DWD) to develop guidance notes to accompany pollution-risk assessment forms.

The DWD staff who recently attended a training course found many aspects of risk assessment easy, but had difficulty in assigning relative scores to different activities. For example, industrial pollution tended to be judged a greater risk than intensive agriculture, or the runoff from urban storm drains or leaking fuel-stores.

In many cases, this may be justified, as controls on industry are not always enforced strictly. It is apparent, however, that in Zimbabwe — in common with many other developing countries — industrial pollution is by no means always the greatest threat to water quality, and there are many other polluting activities which affect developing countries. These include nitrate build-up in groundwaters from agrochemical use.

Desk study

In order to make an accurate assessment of the risk for a water body, the assessor must have access to a reasonable amount of information concerning both the activities undertaken in the vicinity of that water body, and information concerning the water body itself. The most effective role a fieldworker can play is to provide information on the likely pollutant load, and to identify broadly the groups of pollutant which will be discharged. Field-staff should also be able to make visual assessments of surface waters.

The forms shown in Figures 1 and 2 summarize the information required before a preliminary pollution-risk assessment for a borehole supply can be undertaken. To collect this information, a structured approach is essential, to ensure that it is done with the greatest efficiency and accuracy.

The first step is to make a desk study of the water source and its surroundings so that the assessor has as much information as possible about the source, in particular the potential vulnerability and the likely sources of pollution in the area, prior to making the field assessment. This should include checks on: available water-quality data; water-intake construction details; local industries' discharge consents or limits, and their records of compliance; the location of pollution sources relative to the water source; and whether there are point or diffuse sources of pollution.

Field assessment

Once this information has been collected and summarized in the form of a brief description highlighting key points about the source, such as water-table depth, screen length, aquifer type (if known), and the location of the polluting activities identified, a field assessment can be made.

The first stage of the field assessment is a visit to the water source; assessors should make sure there are no problems in the immediate area which may contribute to pollution of the water. For borehole supplies, this will mean checking well-head construction, and assessing whether surface water can enter the borehole easily. For surface-water sources, this will mean checking whether any activities undertaken at the source, such as pumping, or waste discharged from the water-treatment plant, can pollute the source.

Once the results have been recorded, assessors should visit all the potential sources of pollution in the area. At industrial sites, this will include a visit to the plant to meet key staff, to assess what treatment facilities exist, and to establish what pollution-prevention systems are in place. Discharge points should be visited, basic on-site tests carried out if possible and, preferably, a

Pollution-assessment form for individual waste-producing activities

Local water source reference:....... Source type gw/sw
Pollution Control Officer........... Province.........
1.Site...
2.Activity: Agricultural/Industrial/Urban/Mining/Livestock/Fish farm/Other

3.**Waste-producing activities within site**	**Type of potential contamination source** **Point**	**Diffuse**
1.		
2.		
3.		
4.		
5.		

4.Is there on-site disposal? Y/N
Is there leakage from lagoon/waste-heap? Y/N

5.Is there effluent discharge to a river? Y/N
how far away is that discharge point? ......km
does the effluent pipe leak? Y/N

6.Waste composition/agricultural application

metals	Y/N	Type:..
solvents, detergents	Y/N	Type:..
waste oils/fuels	Y/N	Type:..
inorganic complex	Y/N	Type:..
pesticide/herbicide	Y/N	Type:..
chemical fertilizer	Y/N	Type:..
animal/human waste	Y/N	Type:..

7.Does the site have discharge limits/consent? Y/N
8.What is the record of compliance in the last five years?
low(0-20%) medium(21-60%) high(>60%)

9.Estimated risk of groundwater pollution LOW/MEDIUM/HIGH
If discharge point is within 30km upstream of a surface water abstraction point, what is the estimated risk of contamination to the surface water supply? LOW/MEDIUM/HIGH

Detailed information:
1. No.of years of site activity ......years
2. No.of effluent-discharge points ......
3a.No.of hectares of on-site disposal ......hectares
3b.No.of hectares under cultivation ......hectares
4a.Volume of waste produced annually ......m^3
4b.Volume of chemical fertilizer/pesticide applied annually ......m^3
5. Does site undertake quality control activities?
eg:regular in-house monitoring and surveillance Y/N
6. Do emergency procedures exist?
eg: in case of accidental spillage Y/N
7. Which are the appropriate quality standards for this type of activity?
8. What pollution control measures have been taken?
eg: relocation of underground storage tanks above ground, with appropriate containment walls/bunds.

Figure 1. Pollution-assessment form.

sample taken for analysis. Assessors should always carry a copy of the relevant effluent standards, to make comparisons with any on-site tests, and to ensure that polluters are aware of current standards.

In agricultural areas, assessors should note the main farming activities — arable or pastoral — and they should visit farms close to the water source. Farmers should be questioned about the agrochemicals they use, how much they use, and how often, and when they apply them.

Where livestock are reared, details should be sought as to how wastes and carcasses are disposed of. Fuel-stores should also be checked to see if they meet minimum safety standards, and waste-fuel disposal methods should be ascertained. In urban areas, the assessors need to carry out investigations into storm drainage and solid-waste disposal facilities; and they must ensure that places such as fuel stations have protected fuel storage, and that they have acceptable procedures for disposing of waste oils and fuel.

Once the polluting activities in the area have been investigated, they can be related back to the water source. The information derived from the assessment of pollution risk from individual activities — and summarized on the pollution-assessment form (Figure 1) is transferred over to the risk-assessment form (Figure 2). It is combined with the desk study findings to provide a preliminary overview of the pollution risk to the water source.

If it can be shown that there is likely to be a large pollutant load, and that there are concerns about the vulnerability of the water source to pollution, then specialist staff can undertake a more detailed pollution assessment. This will include full chemical, biological, and microbiological analyses, and full investigations into the hydrology and hydrogeology of the area to assess water-body vulnerability, and to predict pollutant movement.

Application

Essentially, there are two situations where field-staff should be expected to carry out a preliminary pollution-risk assessment. The first is when a new water source is to be developed for drinking-water supply, whether a groundwater or a surface water source. The second is where a new waste-producing activity is initiated in an area where there is a water source supplying a domestic water supply.

Commissioning a new borehole

It is no longer appropriate to assume that groundwater from a newly drilled borehole will be of drinking-water quality without further treatment. An assessment of the potential for groundwater pollution is, therefore, integral to the siting of new boreholes. This should include as a minimum the procedure described above, but in a large drilling programme in which many boreholes are to be sunk, a more detailed assessment should be made.

The pollution-risk assessment should be complemented by a full analysis of water quality to cover all likely chemical and microbiological constituents. Where possible, some basic parameters should be analysed on-site during a preliminary risk assessment, to highlight any immediate problems.

Surface-water sources are often vulnerable to pollution, as many industries

Training field-staff in pollution risk assessment and on-site testing.

discharge directly into rivers and streams. This has significant implications for countries like Zimbabwe, where surface-water sources are used in a great many water supplies of all sizes.

New surface-water sources

When a new surface-water source is being developed, it is important that a very thorough risk assessment and water-quality analysis is undertaken. A preliminary risk assessment is still appropriate, however, as this will help to focus a more detailed assessment on identified likely problem areas. When surface-water sources are being developed, the range of the assessment may be much larger than for a groundwater source, because of the rapidity of surface-water flow. An assessment of likely pollutant sources, therefore, may stretch for many kilometres upstream of a surface water intake.

When an activity is established in an area where there are drinking-water sources, a pollution risk assessment will be required. Ideally, a full, independent environmental impact assessment (EIA) will be undertaken, and the results of this made available to the pollution-control and water-supply agencies. Very often, however, this is not the case, and the pollution-control body only finds out about a new activity after a pollution event.

Where an EIA has not been undertaken, field-based staff can carry out a preliminary pollution-risk assessment to evaluate the risk to local water sources. Indeed, in some circumstances, a number of assessments may be made over a period of a few months or years, as a means of monitoring the risk to water resources.

This process should be supported with regular sampling from effluent discharges and water sources in the vicinity — both those in unaffected areas (baseline stations) and those in affected areas (impact stations).

Future developments

By using a structured PIPRA, field staff can make initial investigations of likely pollution inflow into water bodies. The forms shown here can be reproduced to make a reasonable assessment of pollutant load. Combined with the information gathered on the water source, this should enable fieldworkers to make a reasonable risk assessment for water pollution.

The forms are still in their infancy, however, and require further refinement. The approach to pollution monitoring requires further development in many countries over the next few years, as it becomes an increasing priority. Waste-producing activities are likely to increase, as will demands on water resources.

It will be many years before there are groups of well-trained, specialist pollution-control field-staff in developing countries like Zimbabwe and, until then, existing fieldworkers from water-supply and water-resource agencies will take on the extra work. These staff can provide the information only if they are given sufficient support and training.

References

1. *Guidelines for Drinking-Water Quality, Volume 3: Drinking-Water Quality Control in Small-Community Supplies*, WHO, Geneva, 1986.

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Risk-assessment form for a borehole supply

1. Water supply reference no. ....
2. Total number of waste-producing activities within a 10km radius......
3. Breakdown of local activities:

	Number of *point sources*	**Number of *diffuse sources***
Industrial	......	......
Agricultural	......	......
Mining	......	......
Urban	......	......
Other	......	......

4. Estimate of containment load from individual waste-producing activities
   (see Pollution-Assessment Form)
   Total no. of High Risk estimates......
   Total no. of Medium Risk estimates......
   Total no. of Low Risk estimates......

   Overall containment load estimate HIGH/MEDIUM/LOW
5. Aquifer vulnerability, estimated from
   depth of water-table
   degree of rock fissuring
   degree of confinement
   lithology of unsaturated zone
   soil zone (clay rich — sand rich) HIGH/MEDIUM/LOW
6. Risk of groundwater pollution is proportional to the aquifer vulnerability and the containment load, therefore, risk of groundwater pollution is: HIGH/MEDIUM/LOW

Figure 2. Risk-assessment form.