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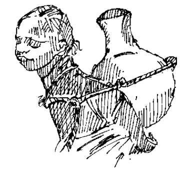
INTEGRATED DEVELOPMENT FOR WATER SUPPLY AND SANITATION



Developing realistic drinking-water quality standards

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THE CONTROL OF drinking water quality has been a major public health goal in many countries since the last century when John Snow identified water as being the transmission medium for the cholera outbreaks in London. Since then, the development of drinking water standards and their monitoring and enforcement (to ensure water is both safe and wholesome to consume) has been a central component of environmental health protection in industrialised countries. In addition, control of drinking water plays as an important role in ensuring that drinking water supplied satisfies the demands and needs of the population.

In developing countries, there has been much argument over the relative importance to health of water quality and other aspects of improvements in water, sanitation and good personal hygiene. It is not the purpose of this paper to review the arguments regarding health, however it is based on the assumption that good quality water is an essential component in epidemic control and provides substantial benefits to health and well being.

In developing countries the enforcement of standards has tended to be a lower priority than in industrialised countries. Governments, traditionally directly involved in the provision of services, perceived trying to redress the lack of access to water and sanitation in many communities as a higher priority than the enforcement of standards. However, the changing emphasis on Government roles in the water sector - away from service provision to one of facilitation and regulation - and the increased involvement of the private sector has made establishment and enforcement of drinking water standards more important. The use of standards is seen as a mechanism by which Governments can represent and protect the public interest, particularly with regard to health, and can monitor the performance of the service providers.

The basis of most water quality standards is the WHO Guidelines for Drinking Water Quality (WHO 1993). These Guidelines, covering 128 chemicals plus microbial and physical parameters, represent the state of the art understanding of the health risks posed by contaminants of water. It should be noted that the Guidelines only provide information of substances known to either have adverse effects on health or cause consumers to reject water because of taste, appearance, and colour or odour problems.

Whilst the Guidelines are an invaluable tool in the establishment of standards, they should not be applied wholesale as national standards. They are a blueprint of best available knowledge on health impacts of different substances. Indeed, WHO state that *'guidelines values are not mandatory limits. Such limits should be set by national authorities, using a risk-benefit approach and taking into consideration local environmental, social, economic and cultural conditions'* (WHO, 1993, p2). This clearly indicates that, to make standards appropriate, factors such as life expectancy, social acceptability, costs of treatment and numbers of people likely to be affected need to be considered as well as the risk posed by certain concentrations of substances or presence of microbes in water.

This actual process of incorporation of such concerns in setting standards based on protection of public health is not always well understood. Standards Boards and politicians often feel that they should apply stringent standards in order to protect public health. However, some substances may not actually be present in the waters of a particular country or analytical capacity to monitor the substance may be lacking. More fundamentally, given the costs of removing certain contaminants, application of inappropriate standards may in fact lead to greater health problems as rising costs reduce accessibility.

In general, standards will be inappropriate unless a parameter:

- can be shown to be of concern to health or acceptability;
- is present or can be expected to be present in the short-term in water;
- can be analysed for; and
- can be removed.

Furthermore, clearly different organisms and substances may have different priorities: thus microbiological quality has a greater priority than say nitrate as the impacts may be felt by many people and health problems may be fatal.

Developing standards in Ghana

The Water sector in Ghana is undergoing a profound change. The Government with the support of external support agencies is embarking on a programme of Private Sector Participation in the delivery of water services in urban areas. The programme – the Water Sector Improvement Programme (WSIP) is designed to ensure that better quality, more efficient and economically sustainable water supplies can be assured for the urban populations. The Government of Ghana is looking to sign lease contracts with two water supply operators in the year 2000 to take over the running of urban water supply for an initial 10-year period.

As part of the lead-in to this hand-over, the Government of Ghana clearly identified the need to set appropriate levels of performance expected by the PSP operators and to provide protection for the population utilising PSP provided services through regulation of water quality. The purpose of the work carried out by the WEDC/RCPEH team was, using the conceptual outline for standard formulation, to review the viability of the draft standards prepared by the Ghana Standards Board (which were largely based on the WHO Guidelines) and to recommend modifications and a framework for regulating standards under the new PSP operator regime.

Of critical importance was to review current performance in terms of drinking water quality; assess major problems and priorities for improvement in order to determine treatment requirements and protection norms; to assess whether the current infrastructure was adequate to meet proposed standards; and to identify implications of any upgrading required. The team looking at the standards had to work closely with other consultants involved in other aspects of the WSIP. These were teams carrying out a fixed asset survey; a review of willingness and ability to pay for water services; and marketing of PSP operation in urban water supply to the general public. Close liaison was also maintained with the Water Sector Restructuring Secretariat (WSRS), the body providing the overall co-ordination and supervision of the WSIP process. The findings of the review are contribute to development of the bidding documents and ultimately the contract being prepared by the Transaction Advisors.

When reviewing or establishing standards, it is preferable that long-term water quality information is available on all parameters concerned. However, in reality in many developing countries such data may not be available, may have significant breaks in analytical records and/or are only available for certain systems or types of system. In such circumstances, therefore, to assess the appropriateness of different standards requires both reviews of historical data and limited site assessments. Whilst the latter may provide more detail on water quality performance, the review of historical data should not be ignored, whatever its weaknesses, as this provides a longer-term perspective.

Data on the quality and pollution risk of source waters is also important as problems here may require either significant investment to meet standards or revision of standards to more achievable levels. The linkage of drinking-water quality standards to environmental legislation must therefore be emphasised. Furthermore, it is important to review the infrastructure of water supply production and distribution systems to assess the potential capacity to meet standards and to identify and prioritise investment.

In Ghana, the consultants addressed these issues through the following ways:

- Review of water quality in distribution systems focusing primarily on factors influencing microbiological quality plus some key chemical contaminants.
- Review of the quality of source waters that supply headworks and treatment works to assess treatment requirements to produce water of an adequate quality.
- Engineering assessments of the production works to evaluate the ability of the works to meet proposed standards and to identify the upgrading that may be required.

In addition local consultants were engaged to provide an overview of key issues including the current health burden associated with poor water supplies; major environmental problems in surface and groundwater catchments; opinions of stakeholders.

Collecting the data

The collection of water quality data for source water, treated and distributed water was carried out using two techniques: a review of the historical records of the existing GWSC labs; and on-site assessment of representative systems (approximately 25 per cent of all systems to be included in the PSP programme). Sites were chosen to reflect the range of importance of different methods of water sources and production: conventional treatment (using both river and impoundment intakes); groundwater systems; and, package plants.

In the WSIP review, the length of record was reviewed, to provide an indication of long-term capacity and priority accorded to water quality (and thus any capital expenditure or training needs). A more detailed review of the results collected in the last two years was carried out to provide a more reliable evaluation of current water quality delivered by the operator and to provide a reliable time horizon, given the likely changes in water sector funding over a longer time period.

The assessments provided a systematic review of water quality in the systems selected and, for distributed water, allowed a stratified random sampling approach to be adopted. This sampling regime provides adequate coverage of all the different parts of the system as well being able to pick up localised problems. Each assessment team was composed of two water quality technicians from the GWSC laboratories (Accra or Kumasi) and one member of the consultants team to supervise and support the technicians. A one-week refresher-training course was given to the technicians in the use of the equipment, quality control procedures and undertaking sanitary inspection.

Sampling programmes were developed based on number of sources, service reservoirs, supply mains type and pressure differences in supply mains. Where systems used multiple sources and/or had several service reservoirs the distribution system was zoned. The zoning protocol defined parts of the system with connections directly onto pumping mains and lines served by different service reservoirs as different zones. In addition to water quality analysis of the key parameters shown in Tables 1 and 2, sanitary inspections were carried out for each sampling area.

Sanitary inspections are a vital component of water quality assessment (WHO 1997; AWWA 1997). They fulfil two key functions.

Table 1. Core parameters: to be carried out at all 20-selected sites

Raw and treated water	*Distributed water*
pH	pH
temperature	temperature
conductivity	conductivity
turbidity	turbidity
colour	colour
total coliforms	total coliforms
faecal coliforms	faecal coliforms
residual chlorine after chlorination	residual chlorine
nitrate	nitrate: in 30-50 per cent of samples
ammonia-N	ammonia-N in 30-50 per cent samples
iron	if iron is a problem in the source or the system has galvanised pipes

Table 2. Additional/Site - or sample specific parameters

Parameter	*Method*	*Raw and treated water*	Distributed water
nitrate	photometer	all sites	in 30-50 per cent of distribution system samples
ammonia-nitrogen	photmeter	all sites	in 30-50 per cent of distribution system samples
iron	photometer	all sites	if iron is a problem or the system has galvanised pipes
manganese	photometer	where iron is present	as iron
copper	photometer	where iron is present	not in distribution
fluoride	photometer	emphasis is for groundwater	not in distribution
phosphate	photometer	if conductivity > 1000	not in distribution
sulphate	photometer	if conductivity > 1000	not in distribution
chloride	table count	if conductivity > 1000	not in distribution
aluminium	photometer	only where alum is used in treatment	not in distribution
permanganate value	palintest	only surface water	not in distribution

- They allow analysts to identify the cause and source of any pollution or water quality failure found.
- They provide a framework to assess the on-going vulnerability of the supply to contamination and the major operational or infrastructural problems that may make future contamination likely.

The latter function is vital both for establishing standards and for making recommendations for investments and improvement required. Indeed, in many ways this should be key function of sanitary inspections as the weaknesses of sole reliance on water quality data, in particular microbiological data, are profound.

In addition to the review of water quality in distribution, historical reviews, environmental appraisals and assessments of raw and treated water quality were undertaken. This was carried out to asses whether source water quality was consistent with treatment processes currently used and to identify source management issues that may lead to contamination in the longer-term. These assessments indicated that, whilst source waters are generally of good chemical quality, with the exception of some groundwaters, there were significant concerns over the management of catchments. This supported adoption of standards and increased application of existing environmental legislation.

Outcomes

The principal output was a recommendation on drinking water quality standards covering the supplies to be leased to the PSP operators. In addition, comments were made regarding the investment required and the relative priority for investment. The sanitary inspection and environmental risk appraisal indicated that for the critical parameters, minor improvements in operation should be adequate to ensure compliance. For a few parameters (e.g. iron) upgrading of treatment may be required at some sites. Chlorine residuals were more problematic and improvement will require booster chlorination in the long-term with increased dosing in the short-term. Chemical contamination of source waters represented problems in certain areas and thus exemptions and options for improvement were provided.

A summary table detailed the parameters for which standards that should be set; the value of each standard; the relative priority of achieving each standard; and the application of relaxations (exemptions and interim standards) that could be applied to different parameters. In some classes of parameter, no standard was recommended because there was a lack of information available regarding the likely presence in source waters and a lack of analytical capacity to analyse for the parameter. In other cases, interim standards were suggested with a time frame established for meeting the interim standard and review process of upgrading the standard.

As standards are only meaningful when compliance is enforced, a review of the options for the regulation of water quality was also provided. The advantages and disadvantages of both independent analysis and audit approaches were reviewed and a suggested model for Ghana presented. In addition, the tools available for mitigating standards (exemptions, relaxation and interim standards) were discussed and the process for establishing these outlined. As not all supplies will meet standards for all parameters, it is important that regulatory bodies have access to other mechanisms for promoting water quality improvements.

Conclusion

If national drinking-water quality standards are to be meaningful they must take into account national conditions. The WHO Guidelines, whilst providing a state of the art review of the risk to health of different substances and organisms in water, cannot be universally applied. When establishing standards, a process of historical review, assessment of water quality (both source and distributed), capacity to meet standards and identifying priorities should be followed.

Finally, it should be stressed that the establishment of drinking water quality standards is not a one-off exercise. Standard setting should be dynamic and changes in standards are to be expected, as more information becomes available about health risks and water supply service and infrastructure develop. The processes discussed above in relation to the conceptual model of standard setting and practical experience in Ghana provides a framework that can be followed to ensure standards are relevant and enforceable.

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References

AWWA, 1997, 'Standard Methods for the examination of water and wastewater', Publisher: APHA-AWWA-WPCF.

WHO, 1993; 1997, 'Guidelines for drinking water quality' Publisher: WHO, Geneva, Switzerland.

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