

Third edition of the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture and Aquaculture

Guidance note for National Programme Managers

HEALTH-BASED TARGETS

THE PURPOSE OF HEALTH-BASED TARGETS

The establishment and enforcement of standards and best practices are fundamental components of the risk assessment and management framework used to optimize the safe use of wastewater in agriculture and aquaculture. Yet, setting health-based targets is only worth the effort and resources if done in a properly contextualized way. The local setting will determine which health issues are relevant, and which risk reduction measures are feasible. Thus, formulating health-based targets is an essential first step in the process of integrated risk assessment of wastewater use, and the incremental management of these risks.

Health-based targets are measurable health-related water quality or performance objectives. They are established based on exposure and risk assessments of water-associated health hazards. The third edition of the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture and Aquaculture (WHO, 2006) distinguishes four components that singularly or in combination make up health-based targets.

- Health outcome targets, expressed as loss of disability-adjusted life years (DALYs) or risk of infection averted, are set through a national policy decision based on a judgement of tolerable risk and are used to inform derivation of performance and water quality, and technology targets. They may also be determined by epidemiological studies or public health surveillance and expressed as reduction in detected disease incidence or prevalence or the absence of one or more specific diseases.
- Wastewater quality indicators, such as concentrations of viable intestinal nematode eggs and/or *E. coli*, on the level of contamination with potentially toxic chemicals.
- Performance targets, expressed as log-reductions of pathogens or percentage removal of chemicals, and based on Quantitative Microbial Risk Assessment or chemical guideline values. Performance targets can be achieved through a range of interventions, including environmental protection of water catchment areas, management and treatment of wastewater, wastewater application techniques, hygiene at market places and best practice in safe food preparation.
- Technology specifications: general descriptions of required equipment and procedures, usually underpinned by validated performance, with reference to applications in settings that will influence these specifications.

SETTING HEALTH-BASED TARGETS FOR SAFE WASTEWATER USE

Health-based targets are a common component of the widely accepted concept for water quality management, known as the Stockholm framework. The advantage of this harmonized approach to water quality management comes to expression through the combined experiences in drinking-water quality, safe use of wastewater and safe recreational waters - and it is expected that agricultural water quality will also become part of this in the near future.

While the procedures and underlying methods for these different categories of water uses largely overlap, the institutional and associated actors greatly vary from one type of use to the other.

Providing benchmarks for drinking-water quality is straightforward in that these are generally set by the water quality regulator (often Ministry of Health, or Environment/Water or equivalent) and are typically applied to water supply utilities in a standardized fashion. Wastewater use in agriculture and aquaculture, on the other hand, is, in many parts of the world, an informal sector. It is the aspect of informality, in particular, that makes setting health-based targets a greater challenge. Farmers using wastewater are at best loosely organized in associations (as, for example, in the Pikin area of Dakar, Senegal), their plots may shift frequently, often remaining outside of the jurisdiction of municipal authorities, along the chain of events a more heterogeneous group of regulators may be involved and a lot of decisions with a bearing on the safety of food preparation are made at the household level. And even where wastewater use is part of the formal agricultural production system, the links between agricultural and public health authorities tend to be less well developed than those between drinking-water regulators and public health authorities.

In this connection, setting health-based targets is usually a task of local government, involving public health authorities, water quality and food safety regulators and inspectors overseeing market-places, leaving influence over the most informal decision-making to advocacy and educators. This implies key roles for primary health care workers, agricultural extension workers and farmer field schools¹. The use of health-based targets in the safe use of wastewater in agriculture is applicable to countries at all levels of development. Health-based targets must be based on scientific evidence, measurable and realistic and relevant in the local context of economic, social, cultural and environmental conditions². They must take into account the public health status and trends, and both health hazards and opportunities, considering the contribution of wastewater use to the transmission of infectious diseases as well as their role in improving people's nutritional status as a result of the increased availability to a greater variety of food items. This is not a matter of trade-offs - health-based targets should combine maximum nutritional benefits with minimal infectious disease risks. Health-based targets should be embedded in public health policy and linked to the capacity of the local health services.

In most settings, food produced with wastewater or the handling of wastewater to produce food will not be the only source of microbial or chemical hazards. Depending on the local sanitation and hygiene conditions, attribution of a fraction of the disease burden to wastewater use in a scenario of multiple exposure routes ranges from difficult to mission impossible. As a consequence, setting strict health-based targets as a starting point for safe use of wastewater is often neither helpful nor desirable. Strict targets will call for a disproportionate allocation of resources towards achieving results under conditions of relatively high uncertainty. This does not imply that health-based targets should remain completely flexible. As more evidence becomes available they should be tightened. This may be evidence that specifies with greater certainty the fraction of the disease burden attributable to wastewater use. Alternatively, it may be evidence of the overwhelming predominance of another transmission pathway that renders the impact of wastewater use insignificant.

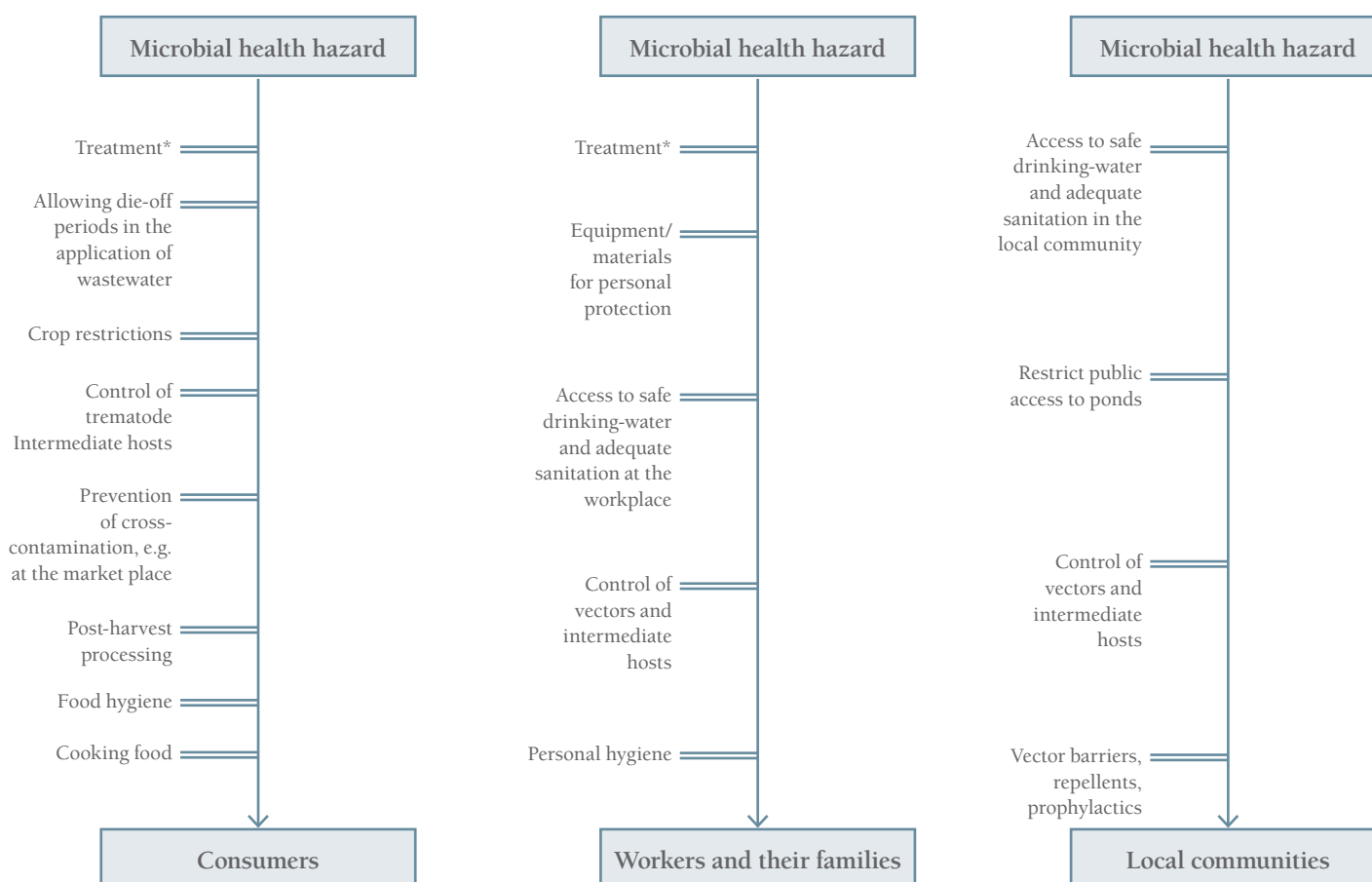
¹ Reference is made to the *Fact Sheet for Farmers and Agricultural Extension Workers* prepared by staff of the IWMI Africa in Accra, Ghana, and contained in the first Information Kit published in 2008 – available on the web www.who.int/water_sanitation_health/wastewater.

² Reference is made to the Guidance note for national programme managers and engineers: *Applying the Guidelines along the Sanitation Ladder* prepared by P. Drechsel and B. Keraita of IWMI, contained in the second edition of the Information Kit.



Broad public health policy provides the enabling environment for meeting health-based targets through the safe use of wastewater in agriculture. Meeting the targets can, therefore, not be considered in isolation from other efforts to improve sanitation, waste disposal, personal hygiene and people's nutritional status. Improved capacity of primary prevention by public health services, reduced pathogens loads and reduced levels of contamination of wastewater will all contribute to safe wastewater. In this context, it is crucial to ensure that health-based targets maintain their focus on vulnerable groups, i.e. farmers and their families, marketers and consumers. Examples of hazard barriers for the vulnerable groups, incrementally leading to risk reduction, are presented in Figure 1.

FIGURE 1: Examples of hazard barriers for wastewater use in agriculture, incrementally building up towards achieving health-based targets.



*Treatment intended in this context as a way to reduce community pathogen load.

TOLERABLE BURDEN OF DISEASE

The disability-adjusted life year (DALY) is a measure of community health combining the loss of healthy life years due to premature death and/or due to disability caused by disease or injury. This loss is expressed as the burden of disease, and makes it possible to attach a relative weight to different conditions of ill-health, as well as to measure the effectiveness of different intervention options. DALYs are an important tool for measuring health outcomes. They account not only for acute health effects, but also for delayed or chronic effects. The burden of disease concept places risk assessment and management in a clear health economics framework. When risk is described in terms of DALYs lost, different health outcomes can be compared and risk management decisions can be made in a way that is informed about the ratio between required resource allocation and expected effectiveness.

The WHO Guidelines for drinking-water quality (third edition, 2003) propose a tolerable burden of waterborne disease from consuming drinking-water of $\leq 10^{-6}$ DALY per person per year. This upper limit DALY is approximately equal to one excess case of cancer per 100 000 people consuming drinking-water containing a carcinogen at its guideline value concentration.³

The rationale for setting this global guideline value for both drinking-water and food crops irrigated with wastewater goes back to the premise that those who drink the water or eat the food expect it to be perfectly safe. Yet, exactly those conditions that challenge authorities to effectively achieve this health-based target are also the conditions under which many other risk factors contribute to high overall exposure risks and serve as important confounding factors. Meeting the global $\leq 10^{-6}$ DALY loss per person per year target is usually not feasible under these conditions, and authorities should set realistic health-based targets with the intention to move towards the global target. In other words, responsible national authorities set health-based targets that reflect a tolerable burden of disease, i.e. an upper limit of the burden of health effects associated with waterborne disease.

There are multiple benefits to setting health-based targets as the outcome of negotiations with environmental, social, cultural, economic and political dimensions. These benefits are associated with the different stages of the development and use of targets as presented in Table 1.

Developing, implementing and evaluating health-based targets for agricultural wastewater use must take the informal nature of the production system into account by including the following components:

- Development and testing of locally relevant education and training materials on health-based targets, from local authorities, leaders of communities and farmers' associations and managers of local NGOs.
- Production of information materials for consumers, in collaboration with food safety authorities and consumers associations on locally relevant good practice for safe food handling and preparation.
- Involvement of farmers in the development of health-based targets and the associated health risk management measures.
- Introducing the subject of health-based targets in environment and health curricula of secondary schools.

³ Reference is made to *The discussion paper: Options for Updating the 2006 WHO Guidelines, More appropriate tolerable additional burden of disease and other issues*, prepared by D.D. Mara (University of Leeds, UK), A. Hamilton, A. Sleight and N Karavarsamis (University of Melbourne, Australia) for a discussion on the universal suitability of the global guideline values.



TABLE 1. Benefits of health-based targets for the safe use of wastewater in agriculture and aquaculture.

Target development stage	Benefits
Formulation	<p>Provides insight into the health status of vulnerable groups. Reveals knowledge gaps, identifies research questions.</p> <p>Supports evidence-based priority setting.</p> <p>Allows harmonization of public health and agriculture policies.</p> <p>Points to both health risks and health opportunities in a context of agricultural production.</p> <p>Encourages involvement and participation of vulnerable groups.</p>
Implementation	<p>Provides a basis for targeted action by national or local authorities, farmers' associations and NGOs.</p> <p>Fosters stakeholder commitment.</p> <p>Links responsibility to accountability.</p> <p>Provides criteria for the rational allocation of resources.</p> <p>Adds a public health dimension to otherwise strictly economic decisions on crop selection and agricultural practice.</p>
Evaluation	<p>Provides an opportunity to take action to correct deficiencies and deviations. Identifies data discrepancies, contradictions and needs.</p> <p>Reveals weaknesses in the approach to risk assessment and management.</p> <p>Provides the basis for incremental improvements in method and procedure. Points to opportunities for improved intersectoral arrangements.</p>



TYPES OF HEALTH-BASED TARGETS

Health outcome targets

For public health authorities, health outcomes of managing risks associated with wastewater use in agriculture are the bottom line. They point towards contributions towards the health sector's overarching goal (attainment of the highest possible level of health by the population under its jurisdiction) and towards reducing the burden of demand on health systems and services. Yet, as already pointed out, in settings with complex exposure scenarios, attribution of health outcomes is a challenge.

Under exceptional circumstances, the attribution may become tangible. The 2010 events following the earthquake in Chile are a case in point. The earthquake destroyed Chile's only chlorine production facility. The acute shortage of chlorine led to a serious outbreak of diarrhoeal disease (30 000 cases reported) in the arid North of the country, 2000 kilometres from the epicentre, where agricultural production essentially depends on the use of wastewater. Exclusive reliance on disinfecting wastewater and crops using chlorine clearly provided a risk management measure that could meet the health-based target under "normal" circumstances, but the approach lacked the robustness of the multi-barrier management system that would have the elasticity to withstand the loss of this important control measure while maintaining overall capacity to meet the target.

The Guidelines propose five essential steps towards meeting health outcome targets:

- setting a tolerable risk of infection, based on a tolerable disease risk;
- carrying out a quantitative microbial risk assessment;
- establishing the required pathogen reduction measures;
- designing the combination of risk reduction measures to achieve the required pathogen reduction level
- define the indicator values for verification monitoring.

Microbial reduction targets

With two major groups at risk of concern (i.e. farm workers and consumers) and a large range of contextual determinants of hazards and risks at play, establishing microbial reduction targets is a process whose level of complexity depends on the number of determinants at play in a local setting. The considerations for establishing the level of reduction are discussed in the document *Updating the 2006 Guidelines*, contained in this information kit, as there has been new thinking on this recently. The analysis of the risk factors along the events chain, the exposures they entail and the incremental risk management measures they allow for require a checklist approach, linked to a flowchart of logical decision-making in a systems framework.

The first choice is between restricted and unrestricted irrigation. In settings where restricted irrigation with wastewater is legally enforced, the risk group of concern is narrowed down to farm workers and their children. In this context, the level of mechanization in agriculture will be another critical determinant, as exposure levels will drop along with a reduction in labour-intensive agriculture. Access to and use of basic sanitation is another determining factor, as is the level of treatment of human waste and wastewater. Setting microbial reduction targets in such a system, thought not necessarily simple, is straightforward.



For unrestricted irrigation with wastewater the scope increases, as more risk groups than the farm workers and their children are involved, the number of exposure points multiplies and the options for risk management measures (and the interactions between them) increase in number. In generic terms, determinants of infection exposure and disease transmission include:

- the pathogen load of the populations generating the wastewater;
- position of different relevant population groups on the sanitation ladder;
- level of treatment of wastewater, if at all;
- nature of agricultural production system: labour intensive on highly mechanized as the two extremes;
- irrigation technology and practice;
- crop selection and composition;
- physical lay-out (fields vs community centres) and fencing;
- harvesting and post-harvest practice;
- produce handling and management during marketing;
- food preparation practices in restaurants, catering services, fast-food outlets and household.

Depending on the local feasibility of risk management options to deal with the specific determinants under each of the above generic items, contextual microbial reduction targets can be established⁴.

Performance targets

A third option is the establishment and monitoring of performance targets which can be derived from the agreed tolerable disease burden or from quantitative microbial risk assessment, provided sufficient data are available, resources are adequate for monitoring and the risk reduction potential of individual measures has been reliably estimated.

Three types of monitoring of performance targets are proposed in the Guidelines:

- Validation - the initial testing to prove that a system as a whole and its individual components are capable of meeting the performance targets and, thus, the health-based targets. Validation is done before the operations contained in a risk management plan start. It is used to test or prove design criteria. It should also be done when equipment is upgraded or when new equipment and/or processes are added under the risk management plan. The first step in validation sets the testing requirements, based on available data. In the second step, individual components and the overall system are tested under laboratory or pilot conditions in a range of realistic scenarios. Once the system has been validated and becomes operational other forms of monitoring for performance target achievement take over. If validation shows the system is not capable of meeting the performance targets, then (1) one or more of its components will need to be upgraded, and the system re-validated, or (2) if upgrading is technically or economically not feasible, the performance targets and, as a consequence, the health-based targets will need to be adapted until such time as the upgrades are feasible.
- Operational monitoring - the routine monitoring of parameters that can be measured rapidly to inform management decisions to prevent hazardous conditions from arising. It is a planned, systematic set of actions to make observations of measures included in the risk management plan and of their expected impacts. Proper operation of each measure and combinations of measures needs to be defined by limits for normative values. An example is the establishment of limits for turbidity where this is associated with the likely presence of pathogens. There are also on/off parameters such as the presence or absence of aquatic weeds in a wastewater-fed irrigation scheme in areas where schistosomiasis is endemic. Such weeds provide a major habitat of the snail intermediate hosts of this parasitic disease.

⁴ Reference is made to Guidance note for national programme managers and engineers *A Numerical Guide to Volume 2 of the Guidelines and Practical Advice on how to Transpose them into National Standards*, prepared by D.D. Mara (University of Leeds, UK), for detailed guidance on calculations. This Guidance note is contained in the first Information Kit published in 2008 - available on the web www.who.int/water_sanitation_health/wastewater.

- In brief, operational monitoring should consider parameters that indicate the potential for increased risk of hazard break-through. Mostly, it is based on simple and rapid observations at adequate frequencies, providing statistically meaningful information about the status of the locally most-important hazards. Like the risk management plan itself, operational monitoring must be technically and economically feasible in order to meet its objective of adequately monitoring control measures allowing for the timely signalling and communicating potential risks, to minimize adverse public health impacts.
- Verification monitoring - a periodic exercise to demonstrate that the system is working as intended. Verification complements operational monitoring by determining if the performance of the system of risk management measures for wastewater-based agricultural production complies with the stated objectives required to meet the health-based targets. Verification monitoring may lead to the conclusion that the system needs modification and/or upgrading and revalidation. The best-known example of verification monitoring is the testing of wastewater quality after it has passed through a treatment regime.

IN CONCLUSION

The concept of health-based targets is at the core of methods and procedures proposed in the third edition of the Guidelines for the safe use of wastewater, excreta and greywater in agriculture and aquaculture. Proper assessment of the local conditions in a setting where wastewater is used or is planned to be used in agriculture allows the health-based targets to be defined in a realistic way. The aim is to set targets that are achievable, with the intention to raise them, in an incremental way, to the optimal level that suits local conditions, while bearing in mind international standards for crops destined for export. Measuring the impact of risk management measures in relation to health-based targets becomes increasingly complex as the indicator is further removed from the measure in the overall chain of events. Therefore, measuring health outcome targets is a challenge because of the many confounding factors. Measuring for microbial reduction targets is often more feasible. Proper monitoring of performance targets is an essential element of any integrated risk management approach.

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