Microbial Risk Assessment: Application and Stages to Evaluate Water Quality

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Abstract This works presents the stages of microbial risk assessment and its application in the evaluation of drinking and recreational water quality and further the risk of diseases attributable to pathogens present in these waters. In Brazil, infectious diseases were responsible for 5.1% of deaths, the fifth place of mortality cause. Most affected people are children, elderly and immunocompromised population. According to Brazilian Health Ministry, from 1995 to 1999, environmentally-caused diseases occupied 3.4 million beds in hospitals. All of these reports showed a very public health concerning scenario.

This tool can provide bases to establish tolerable (acceptable) risk and thus defining the protection level to human health for each hazard, in this case, pathogens microorganisms. The stages are hazard identification, exposure assessment, dose-response relationship and risk characterization. The hazard identification is related to the presence of microorganism and toxins and their association with specific diseases. The exposure assessment includes the intensity, frequency and duration of human exposure to a specific agent. The aim of dose-response relationship is to acquire a mathematical relation between amount of microorganism (concentration) and adverse effect on human health. Risk characterization represents the integration of the previous stages. Risk assessment is a tool used for decisions making and providing information to take measures of control and interventions, as well as to evaluate the impacts of these actions. It provides support to a decision-making process based on scientific results in several areas of the knowledge. In Brazil, risk assessment is a recent area of research, but promising for the management of water's quality such as catchments points and recreational waters, in special in periurbans areas of metropolitan regions, which show precarious sanitary conditions.

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1 Introduction

In recent years it has been observed that an increasing number of waterborne outbreaks have occurred due to water resource contamination by sewage and solid waste that carry pathogenic microorganisms. These microorganisms do represent a public health concerning which of them can survive long enough to cause human health disturbs. Out of them, emerging and reemerging pathogens deserve special attention. According to World Health Organization, in developing countries it was estimated that 94% of the diarrhea burden of disease is attributable to environmental and associated with risk factors such as unsafe drinking-water and poor sanitation and hygiene, on average, children in developing countries lose eight-times more healthy life, per capita, than their peers in developed countries from environmentally-caused diseases. Infectious diseases which contributing to the environmental burden of disease among children from 0 to 14 years old are intestinal nematode infections (1.5%) and diarrhea disease (29%) (WHO 2006). Bartram (2006) reported that 1.8 million people, mostly children, die of diarrhea every year. In Brazil, infectious diseases were responsible for 5.1% of deaths, the fifth place of mortality cause. Most affected people are children, elderly and immunocompromised population. According to Brazilian Health Ministry (Brasil 2004), from 1995 to 1999, environmentally-caused diseases occupied 3.4 million beds in hospitals. All of these reports showed a very public health concerning scenario.

According to Hass et al. (1999), the preventing of infectious diseases transmission from human exposure to contaminated food, water, soil and air remains a major role of environmental and health professionals. In this way, microbial risk assessment is a very useful tool to evaluate drinking and recreational water quality, applying it and further to determine the risk of diseases attributable to pathogens present in waters sources. Besides, this tool can provide bases to establish tolerable risk and thus defining the protection level to human health for each hazard, in this case, pathogens microorganisms. Establishing tolerable risk is an important issue to be considered because of the risk perception occurs in different ways dependable on affected people, magnitude of the adverse effects, how people are habituated to face the adverse effects and amount of people affected (Peña et al. 2001), moreover this perception can be diverse by the general population, politics, researches and managers. Undoubtedly, microbial risk assessment allows an improvement in the capacity to evaluate and control the risks as well as in the making-decision process to minimize risks as choosing the best sanitary barriers option. Acquiring all this knowledge would be an advance to protect human health, mainly in developing countries where there are many areas with evident environmental vulnerability.

The goal of this work is present the stages of microbial risk assessment and its application in the evaluation of drinking and recreational waters quality.

2 Microbial Risk Assessment Application

Risk assessment process consists of estimating the probability that an event can occur and the probable magnitude of its adverse effects (Gerba 2000). In relation to microbial risk assessment, it can be said that it is a process which evaluate the probability of an adverse effect on human health after exposure to pathogenic microorganisms or contact with a source (water, soil, air, food) with pathogens presence as well as their toxins. The advantages of using this kind of analysis is estimate the results of exposure to infectious microorganisms as well as express it quantitatively in terms of probability of infection, morbidity (disease) and/or death. With these results is possible to do prevision about the expected number of infectious diseases, diseases and fatalities due of a determined exposure. In addition, microbial risk assessment can provide bases to establish tolerable risk and thus defining the protection level to human health for each relevant pathogen.

United States Environment Protection Agency (US EPA), due to occurrence of waterborne infectious agents in surface waters catchments points such as *Giardia* cysts and enteric viruses developed the Surface Treatment Rule (STR). The STR, based on microbial risk assessment, required that all drinking water plants be capable of removing 99.0% of *Giardia* cysts and 99.9% of enteric viruses, to get to the infection tolerable risk because of these etiologic agents was not superior to 1 per 10,000 exposed persons annually (10^{-4} per year) (Gerba 2000). The same approach can be transferred to other sort of waters as recreational or else wastewater with potential reuse.

World Health Organization (WHO) in the latest publication of Guidelines for drinking water quality and Guidelines for recreational waters environments – Coastal and Freshwaters, consider microbial risk assessment as a way to estimate risks to human health related to microbiological quality of drinking and recreational waters as well as permit to translate risk of developing a specific illness to disease burden per case expressed in DALY (Disability-adjusted life-year) (WHO 2004). It is interesting for the reason that it allows to compare severity among diseases and microbial agents.

3 Microbial Risk Approach

Microbial risk assessment is characterized by a framework which consists of problem formulation and hazard identification, exposure assessment, dose-response assessment and risk characterization. Each component aims to characterize the entire scenario and its impact of human health as shown in Fig. 1.

Accordingly Soller problem formulation involves all stakeholders and its point is to identify the purpose of the risk assessment, critical issues and the treatment of the obtained results to protect public health (Soller 2006).

Identifying hazard is a step that consist of acquiring information from clinical studies and epidemiological and surveillance studies. All aspects to lead to potential hazards reach drinking and recreational waters and furthermore human being affecting their health condition should be considered. This information

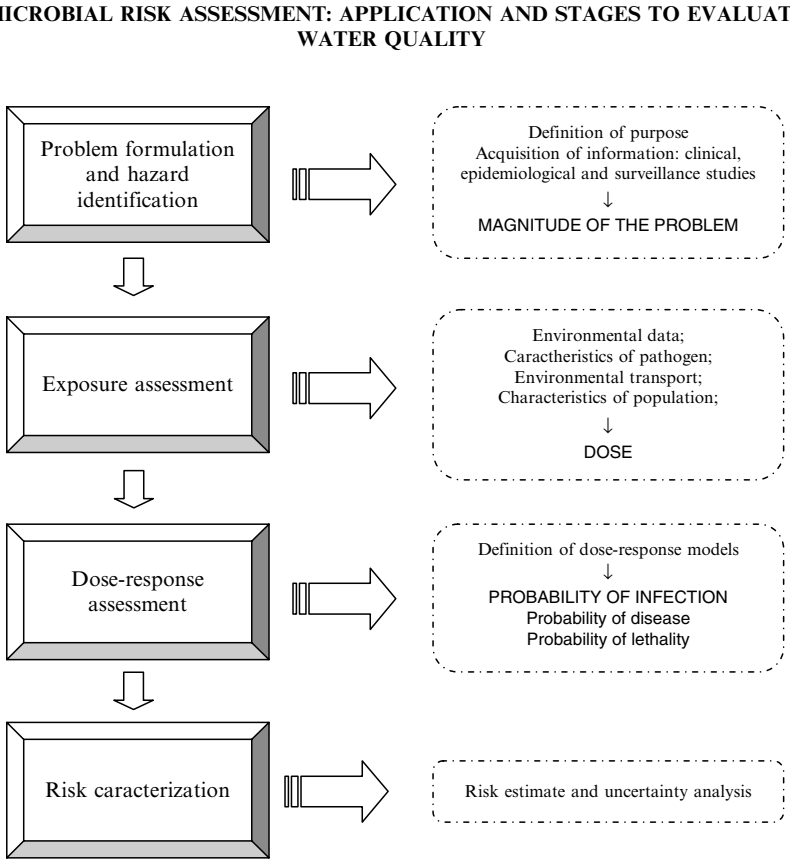

Fig. 1 Microbial risk assessment approach

gives the magnitude of the problem and how it impacts affected population health. It is not easy to do because a part of affected population does not look for medical attention for several reasons (mild symptoms or difficulty medical accesses, for instance), asymptomatic persons occurrence, unsatisfactory register data as source of infection and infectious agent, inappropriate pathogen method detection, medical attendance quality discrepancies among different areas around the country and some times microorganism infectivity and lethality are not clear.

The exposure assessment refers to the measure process or intensity, frequency and duration of human exposure to a specific infectious agent. It is used to estimate the microorganism concentration which is corresponding to a single exposure or a total of organisms in a set of exposures (Haas et al. 1999; Gerba 2000). The exposure can happen via inhalation, ingestion of water or food or dermal. In this step is important to consider the population affected, real or

potential, and the contamination sources as well as transport mechanisms and biotransformation and moreover all pathogenic microorganism pathways until reach its host including ingress via. In this case, the amount of drinking water is daily ingested or volumes ingested of water during recreation in swimming pools or beaches for that reason regional ingestion water data is important to conduct the exposure assessment.

Dose-response assessment is a result from experimental studies to develop a relationship between the level of microbial exposure and the likelihood of occurrence of an adverse consequence (Haas et al. 1999). These data are currently available for waterborne pathogen from studies using healthy adults volunteers (Gale 2001) to identify the infectivity to specific pathogens, on the other hand there are not studies with more susceptible population such as children, elderly, immunocompromised. The consequences from an infection process are highlighted: (a) asymptomatic illness, (b) acute symptomatic illness – mild to moderate symptoms, days loss from work and heath care cost and (c) chronic infections as, for example, hemolytic uremic syndrome or stomach ulcers. Dose-response models should approach the probability of infection as well mortality probability. Even though, in some cases data about pathogens infectivity are not available so mathematical models are useful to estimate dose-response relationship such as Poisson distribution and Exponential distribution as shown in Table 1.

Risk characterization integrates all information acquired in previously steps – problem formulation and hazard identification, exposure assessment and dose-response relationship –to calculate the probability of infection of the exposure by drinking and or recreational waters contaminated with pathogens. Besides that, this stage consists of uncertainty evaluation and risk communication.

In addition, the quantitative risk estimate is useful to obtain a burden disease expressed by DALYs (Disability-adjusted life-year). In countries such as Brazil, with so difference in socio-economical and sanitary conditions among its regions the DALYs calculating is interesting to give the adequate significance for each burden disease in specific areas avoiding distortions. It has a special meaning to risk management phase when financial support should be addressed and public policies elaborated to improve waters sanitary quality.

Table 1 Dose-response parameters for pathogen ingestion mathematical models studies (adapted from Gerba (2000))

Microorganisms	Best mathematical model
Echovirus 12	Beta-Poisson
Rotavirus	Beta-Poisson
Poliovirus 1	Exponential/Beta-Poisson
Poliovirus 3	Beta-Poisson
Cryptosporidium	Exponential
Giardia lamblia	Exponential
Salmonella	Exponential
Escherichia coli	Beta-Poisson

4 Final Considerations

In Brazil, microbial risk assessment is a recent area of research, but promising for the management of water's quality such as catchments points and recreational waters, in special in periurbans areas of metropolitan regions, which show precarious sanitary conditions that lead a high waterborne diseases incidence. In Brazil and others developing countries microbial risk assessment is useful to allow to maker decision to define more realistic goals to these poor areas considering not only minimizing risk but to evaluate benefit-cost of intervention actions.

On the other hand, developing countries present limiting structure to implement microbial risk assessment such as lack of truthful data and specific data for each studied area. It should be highlighted in view of applying imported information or models from others countries can increase the uncertainties and impair the use of this tool.

To sum up, it should be emphasized how important is the criteria flexibility in decisions demand institutions with political powerful and technically well prepared. In developing countries these aspects do not happen very often.

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