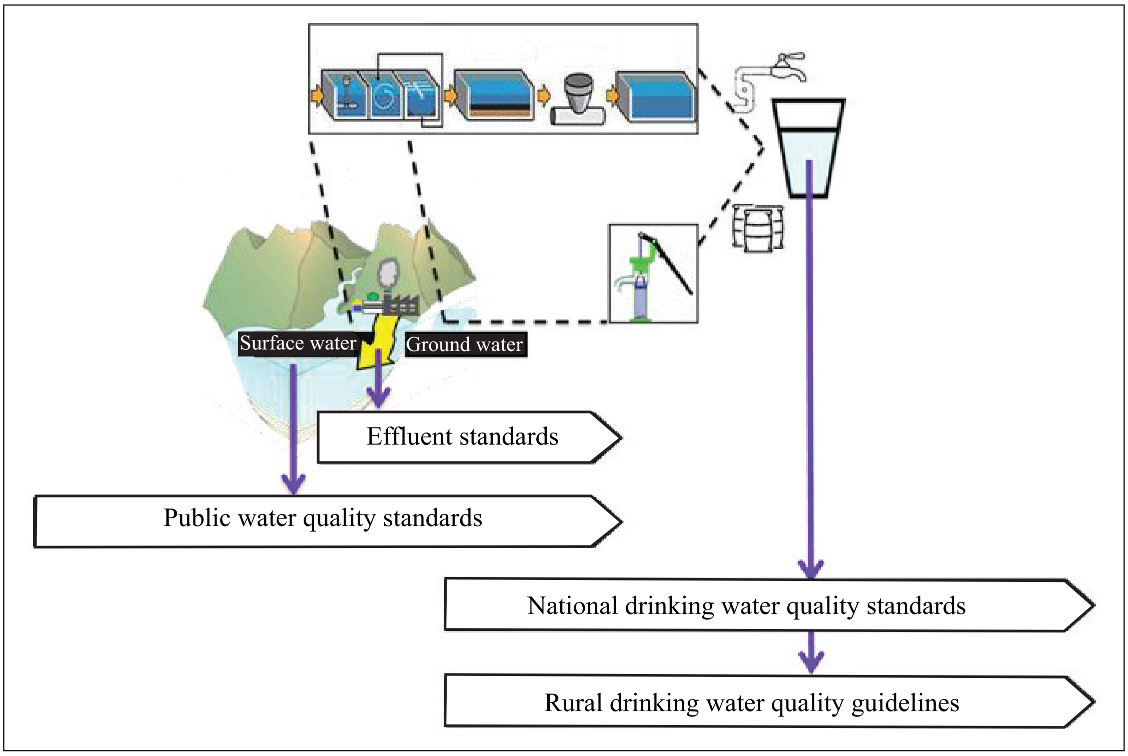
Cambodian Water Quality Standards: A Focus on Interconnection

Introduction

Clean water is essential to human life and environmental health. Recent water quality problems in Cambodia's surface water caused by algal blooms and pesticide pollution have highlighted the importance of regulatory controls. Drawing on a literature review of water quality parameters and national guidelines, the study suggests that an efficient strategy for reducing the harmful effects of water contamination is comprehensive water pollutant management based on interconnected water quality standards (W. Cunningham, M. Cunningham and Saigo 2003; UN-Water 2011; WHO 2011; 최지용 and 신은성 1997; 한대호 and 최지용 2009).

To protect human and ecological health and ensure safe drinking water, Cambodia has developed three water quality standards (see Figure 1). The quality of surface water such as in a river, wetland, lake or ocean is maintained in accordance with public water quality standards, and the concentration of wastewater pollutants discharged into public water areas or sewers is regulated under effluent standards. The Ministry of Environment (MOE) manages these two water quality standards under the Sub-Decree on Water Pollution Control, which has not been updated since its release in 1999. Drinking water quality must satisfy the requirements of national drinking water quality standards (NDWQSs) which are regulated by the Ministry of Industry and Handcrafts (see Figure 2).[1]

Figure 1: Existing water quality standards in Cambodia



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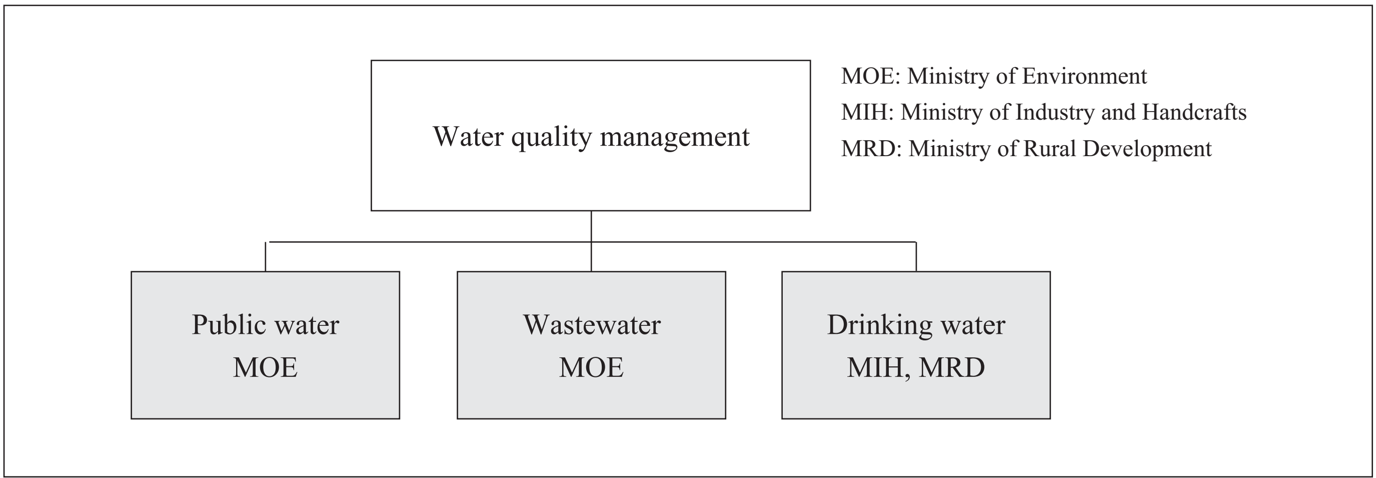
1 Interviews with representatives from the Royal University of Phnom Penh and the Ministry of Environment.

Figure 2: Ministries responsible for management of water quality standards



The NDWQSs were revised and national rural drinking water quality guidelines (NRDWQGs) separately established in 2015. This was achieved with support from the Water Quality Partnership, initiated by Australia's Department of Foreign Affairs and Trade (DFAT) and the World Health Organization (WHO) to assist countries in Southeast Asia and the Western Pacific in establishing and implementing water safety plans (WSPs). The main aim of a WSP is to identify and manage risk at each critical step of the water supply system from source to consumption. In Cambodia, the Ministry of Rural Development (MRD) is responsible for the management of rural water supply systems, and has incorporated the implementation of WSP into National Strategy for Rural Water Supply, Sanitation and Hygiene 2011-25 (Water Safety Portal 2016; WHO 2014; MRD 2011).

This study investigates Cambodian water quality standards by reviewing the recently revised and established NDWQSs and NRDWQGs to suggest improvements, especially for better interconnections between them.

Methodology

To identify the key characteristics and practicality of the new standards, the study compared current Cambodian drinking water quality standards with both former standards and the results of drinking water quality analyses conducted by several research groups. Major effluent and surface water contaminants and their measured values evaluated by previous studies were also compared with existing water quality parameters and standard values. In addition, the study looked at the relationships between some of the parameters of Cambodia's water quality standards for effluent, public water and drinking water to understand how the different standards are connected for better integrated management of water pollutants.

Terms related to water quality that apply to this study are defined in a short glossary at the end of the article.

Findings

Characteristics of current drinking water quality standards

The updated NDWQSs applied to water supplied from urban purification plants are considered more practical for implementation in Cambodia than the previous standards. Comparison of former and current NDWQSs in Table 1 identifies three key changes. First, the number of parameters is significantly reduced from 53 to 27. This means that levels of pesticides, benzene, trihalomethanes, selenium and nickel no longer have to be monitored in urban drinking water even though they are recommended parameters in the 2011 WHO guidelines. As a result, former organic parameters are mostly excluded. Second, the revised standard values are higher than the previous ones, meaning that drinking water quality standards are less stringent. And third, exceptions to parameters have been introduced; for example, groundwater is examined for hardness, iron and manganese only if it is used for drinking.

The results of drinking water quality analyses (Luu, Sthiannopkao and Kim 2009; Shanghai Laboratory 2013; Vanny, Jiwen and Seingheng 2015) indicate that water purification plants meet most of the new NDWQSs, though excessive concentrations of some parameters were measured in tap water. Notably, supply could be contaminated through corroded pipelines from purification plants to consumers, leading to the presence of colour, turbidity and total coliforms in drinking water. Pipe corrosion in water distribution systems can stimulate microbial growth and cause increased bacterial levels in tap water. To prevent microbial contamination, sufficient quantities of disinfectant in the form of free residual chlorine must be maintained throughout the pipeline system. But the minimum standard value of residual chlorine in drinking water was lowered from 0.2 mg/L to 0.1 mg/L when the NDWQSs were revised.

In rural areas, NRDWQGs are applied to several drinking water supplies (e.g. piped water, collected rainwater, dug or tube-well water). Of the 27 NDWQSs, only 14 are included in the new national rural guidelines. Among them, arsenic and fluoride testing is recommended only for drinking water sourced from groundwater. Guidelines for turbidity, residual chlorine and total hardness in rural drinking water are designated differently from the standard concentrations applied to urban drinking water. Based on the analytical results of tube-well water quality (Buschmann et al. 2007; Luu, Sthiannopkao and Kim 2009; Phan et al. 2010), four water contaminants – iron, manganese, total hardness and turbidity – detected in some wells exceed guideline

Table 1: Former and current drinking water quality standards and guidelines (mg/L)

		2004 DWQSs	**2015 NDWQSs**		**2015 NRDWQGs**	
Total		53	27	9	14	3
No.	Parameter	Standard value	Standard value	Exception	Guideline value	Exception
1	Aluminium	0.2	0.2	alum used	-	
2	Arsenic	0.05	0.05	groundwater	0.05	groundwater source
3	Copper	1	2	copper pipes used for household plumbing	-	
4	Fluoride	1.5	1.5	groundwater	1.5	groundwater source
5	Hardness	300	300	groundwater	500	
6	Iron	0.3	0.3	groundwater	0.3	
7	Manganese	0.1	0.1	groundwater	0.1	
8	Residual chlorine	0.2-0.5	0.1-1.0	chlorine used for disinfectant	0.2-0.5	chlorine used as residual disinfectant
9	Sodium	200	250	coastal areas	-	
10	Ammonia	1.5	1.5		-	
11	Barium	0.7	0.7		-	
12	Cadmium	0.003	0.003		-	
13	Chloride	250	250		-	
14	Chromium	0.05	0.05		-	
15	Colour	5 TCU	5 TCU		-	
16	Lead	0.01	0.05		-	
17	Mercury	0.001	0.006		-	
18	Nitrate as N0^{3-}	50	50		50	
19	Nitrite as N0^{2-}	3	3		3	
20	Odour	acceptable	acceptable		acceptable	
21	pH	6.5 - 8.5	6.5 - 8.5		6.5 - 8.5	
22	Sulphate	250	500		-	
23	Taste	acceptable	acceptable		acceptable	
24	Thermotolerant coliforms or E. coli	0 per 100ml	0 cfu or MPN /100ml		0 cfu or MPN /100ml	
25	Total dissolved solids (or conductivity)	800 (~ 1600 uS/cm)	800 (1600 uS/cm)		800 (1600 uS/cm)	
26	Turbidity	5 NTU	5 NTU		10 NTU	
27	Zinc	3	3		-	

Sources: MIME 2004; MIH 2015; MRD 2015

values. Moreover, aluminium, sulphate, barium and lead, which are not included in rural drinking water quality guidelines, are present at the levels of NDWQSs in certain wells.

Connections between water quality standards

The quality standards prescribed for effluent, public water and drinking water have no organic and only six inorganic parameters in common (Table 2). In other words, current water quality standards cannot ensure the monitoring of water pollutants in a consecutive water system from source to consumption. This is mainly because the updated drinking water quality standards exclude most organic parameters due to the high cost and technical complexity of analysis tests for identifying organic compounds. Apart from these six parameters, none of the other standard values for public water and drinking water overlap, whereas effluent and drinking water quality standards share an additional nine parameters (Table 3).

Effluent standards, unlike those for drinking water and public water, do not include microbial parameters such as for total coliforms and E coli. Yet E coli have been detected even in treated effluent found in natural wetlands, especially in the rainy season (Visoth et al. 2010; Sovann et al. 2015). For chromium, the concentration of 0.05mg/L applies equally to quality standards for public water, drinking water and effluent. This is a stringent requirement for the discharge of wastewater from any pollution source into protected public water areas. Chromium, aside, target concentrations of pollutants in effluent are 2 to 100 times higher than in public water and drinking water (see Table 2). As a reference, Korean and Japanese effluent standard values are generally 10 times higher than those for public water quality because wastewater is diluted as it is released into water bodies (환경부 2005; Takatoshi Wako 2012).

The interrelationships between certain effluent and drinking water quality standard parameters are found to be non-logical. Specifically, quality standards for mercury, copper, nitrate and zinc concentrations in effluent are more stringent than those in drinking water, as indicated in Table 3.

Table 2: Interrelationships between water quality standards (mg/L)

Water quality standards		Effluent	Public water	Drinking water
Overlapped parameters /total parameters		6/52	6/30	6/27
		23/52	23/30	
		15/52		15/27
			6/30	6/27
No.	Parameter	Standard value	Standard value	Standard value
1	Chromium (Cr^{6+})	0.05	0.05	0.05
2	Mercury (Hg)	0.002	0.0005	0.006
3	Arsenic (As)	0.1	0.01	0.05
4	Cadmium (Cd)	0.1	0.001	0.003
5	Lead (Pb)	0.1	0.01	0.05
6	pH	6 – 9	6.5 – 8.5	6.5 – 8.5

Table 3: Common quality standards for effluent and drinking water (mg/L)

Water quality standards		Effluent	Drinking water
Overlapped parameters/total parameters		15/52	15/27
No.	Parameter	Standard value	Standard value
1	Chromium (Cr^{6+})	0.05	0.05
2	Mercury (Hg)	0.002	0.006
3	Arsenic (As)	0.1	0.05
4	Cadmium (Cd)	0.1	0.003
5	Lead (Pb)	0.1	0.05
6	pH	6 – 9	6.5 – 8.5
7	Copper (Cu)	0.2	2
8	Nitrate (NO_3)	10	50
9	Zinc (Zn)	1	3
10	Ammonia (NH_3)	5	1.5
11	Chloride (ion)	500	250
12	Chlorine (free)	1	0.1 – 1
13	Iron (Fe)	1	0.3
14	Manganese (Mn)	1	0.1
15	Total dissolved solids	1000	800

Recommendations

In sum, the updated drinking water quality standards and newly established guidelines exclude most organic parameters such as trihalomethanes and pesticides because of the practical difficulties and limitations of chemical analysis. However, the quality standards for public water and effluent have not been updated since 1999, meaning that many organic parameters are still in place. Even so, among 25 parameters of public water quality standards for human health, only chromium is being monitored.

A practical approach to correct identified shortcomings would be to investigate prevailing contamination of ground and surface water and update water quality standards periodically, taking into account the feasibility of measuring and monitoring water pollution. Coordinated inter-ministerial efforts to increase interconnections between water quality standards should focus on the revised national drinking water quality standards to develop a more comprehensive approach to water pollution control. Based on the key findings, the study offers a few suggestions for improving water quality standards.

- ***National drinking water quality standards:***
  - Consider re-adding total coliforms as a parameter to monitor pathogens risk caused by intrusion or regrowth of bacteria in pipelines. Pathogenic microorganisms present in surrounding soil or water can enter through breaks and leaks in distribution pipelines; therefore, careful management of aging pipes is also needed at the same time.
  - Apply higher minimum value of residual chlorine in areas with high potential for bacterial contamination. WHO recommends that residual free chlorine should be at least 0.2 mg/L at point of delivery which is twice that set for urban drinking water in the revised NDWQSs.
- ***National rural drinking water quality guidelines:***
  - Establish individual water quality standards for different water sources (e.g. rainwater, well water, piped water) in rural areas, and consider setting standards for aluminium, sulphate, barium and lead in tube-well water.
- ***Public water quality standards:***
  - *Standards for bio-diversity:* Specify a range of standard values depending on regional water quality or water use.
  - *Standards for human health:* Stipulate a limit of detection (i.e. the lowest concentration likely to be reliably measured and at which detection is feasible) for parameters with standard values of zero or that are far too small for analysis.
- ***Effluent standards:***
  - Consider adding total phosphorous and biological parameters (e.g. total coliforms).

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Glossary of terms related to water quality

The following definitions apply to this article and are reproduced in good faith from *Drinking Water Quality Standards* (MIME 2004, 4-6).

cfu: a colony-forming unit is a measure of viable bacteria.

coliforms, total: both fecal and non-fecal bacteria from humans, animals, and decayed organic matter that are able to ferment lactose at either 35 or 37^{0}C within 24-48 hours.

disinfection by-products: these are formed by the reaction of excess disinfectant chlorine with organic substances found in water, especially surface water.

groundwater: any water found beneath the surface of the ground in rock crevices and in the pores of geologic materials.

inorganic parameters: non-carbon based chemicals such as arsenic, cadmium and iron.

monitoring: routine collection of water samples for analysis to determine water quality, usually done by water supplier.

NTU: nephelometric turbidity unit – a measure of the turbidity (cloudiness) of water as measured by a nephelometer.

organic parameters: carbon-based chemicals such as pesticides.

residual chlorine: excess chlorine in treated water, usually between 0.2 to 0.5 mg/L, which indicates sufficiency of chlorination and an assurance of protection from pathogens.

surface water: freshwater on the Earth's surface, such as stream, river, lake, pond or reservoir.

TCU: true colour unit – a measure of colour of filtered water sample that could come from iron or dissolved organic substances.

trihalomethanes: the main disinfection by-products produced in highest concentrations. Chemical compounds formed by reaction of excessive chlorine in water with naturally occurring organic substances.

turbidity: characteristics of cloudiness of water. The amount of solid particles that are suspended in water that can cause scattering of light. Low turbidity is essential for effective disinfection.

uS/cm: microsiemens per centimetre is a unit of measurement for the electrical conductivity of water.

water quality standard: a level for a water constituent which does not result in significant health risk and which ensures acceptability of the water to consumers.

Continued from page 5 **Status and Power...**

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