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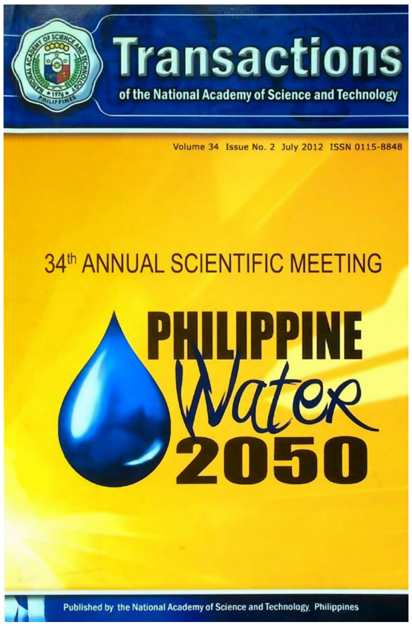

Purification and Quality of Drinking Water: Issues and Concerns

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Keywords
bottled water, drinking water, water purification. water quality

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PURIFICATION AND QUALITY OF DRINKING WATER: ISSUES AND CONCERNS

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Abstract

The Philippines is committed to achieve the United Nations Millennium Development Goal Number 7 to halve by 2015 the proportion of population without sustainable access to safe drinking water and safe sanitation. This paper analyzes and discusses the purification processes and quality of drinking water and their regulation in the country; it further discusses issues and concerns and makes recommendations. The Local Water Utilities Administration (LWUA) have more than 6,280 water service providers (WSPs) which provide potable water to the country's 92 million population. The purification processes employed by the WSPs, such as Manila Water Inc. (large scale) and Laguna Water District (medium scale), rely mainly on conventional water purification methods that include coagulation/flocculation, sedimentation, filtration and disinfection. The chemical disinfectant used is either chlorine (large scale) or chlorine dioxide (medium scale). Bottled water manufacturers use a combination of methods such as filtration, reverse osmosis, ozonation and others.

The standards for drinking water quality are defined in the Philippine National Standards for Drinking Water 2007 (DOH Administrative Order No. 2007-2012) and apply to "all waterworks officials, developers and operators of water supply systems both government and private entities, water refilling station operators, water vending machine operators, ice manufacturers, all establishments and institutions that supply or serve drinking water, drinking water laboratories, health and sanitation authorities, the general public and all others concerned". Bottled drinking water manufacturers must also comply with Good Manufacturing Practices based on DOH-BFAD Administrative Order No. 18-A series of 1993, since bottled water is considered a food product and is directly regulated by the DOH Food and Drug Administration.

It is recommended that existing policies on the quality of drinking water and monitoring procedures be reviewed and harmonized for all WSPs including water districts, bottled drinking water manufacturers, refilling stations and small bottlers. DOH should be empowered, in terms of budget, structure and equipment, to effectively monitor and enforce compliance with quality guidelines, including monitoring of refilling stations and all bottled water manufacturers. Policies for recognition (more accurate term than accreditation) of water testing laboratories by DOH should be updated and should include laboratory space requirement and qualifications of persons certifying reports of analyses and evaluating laboratories. In addition to providing safe drinking water to its increasing population, the Philippine government should strive to strengthen the regulation of water service providers to ensure that the standards for good quality drinking water are met and sustained.

Keywords: bottled water, drinking water, water purification, water quality

Introduction

The Philippines is a signatory of the United Nations Millennium Declaration of 2000 along with other 189 states and is committed to achieve the Millennium Development Goals (MDGs). The MDGs are defined, time-bound and quantifiable goals and targets to reduce poverty and ensure that globalization will benefit all the people around the world. MDG Number 7 targets to halve by 2015 the proportion of population without sustainable access to safe drinking water and safe sanitation.

In 2004, the World Health Organization released a cost benefit analysis study which showed that by increasing interventions, between US$18.1 billion and US$555.9 billion could be saved worldwide if drinking water and sanitation services are improved (Hutton and Haller, 2004). These interventions include: (1) improvements to meet the MDG No. 7 to halve by 2015 the proportion of people without access to safe drinking water; (2) halve the proportion of people without access to improved sanitation; (3) increase access to improved water and sanitation for all; (4) in addition to access to improved water supply and sanitation, provide disinfection at point-of-use; and (5) provide access to regulated piped water supply and improved sanitation. Such savings accrue from direct economic benefits of avoiding waterborne illnesses, from indirect benefits due to decrease in work day loss and longer life span, and even non-health benefits which include a reduction in the time spent in collecting water, increasing property prices around water sources and increased time for leisure and other activities.

According to the National Statistical Information Center, 84.1% of the country's population as of 2008 or about 77 million had attained sustainable access to safe drinking water and improved sanitation and the target is to reach 86.5% by 2015. This corresponds to providing access to 3 million more Filipinos to attain 86.5% and 12 million more Filipinos to attain 100%. This paper analyzes and discusses the (a) standards and regulation of drinking water, (b) purification processes and quality of drinking water in the country and (c) relevant issues and concerns. Recommendations are presented to address key concerns.

Standards and Regulation

1. The Philippine National Standards for Drinking Water

The Philippine National Standards for Drinking Water 2007 (DOH Administrative Order No. 2007-2012) defines the standards for drinking water quality and applies to "all waterworks officials, developers and operators of water supply systems both government and private entities, water refilling station operators, water vending machine operators, ice manufacturers, all establishments and institutions that supply or serve drinking water, drinking water laboratories, health and sanitation authorities, the general public and all other concerned" (PNSDW, 2007). These standards are based on guidelines and/or criteria recommended by the World Health Organization, the US Environmental Protection Agency, among others, with some modifications that consider national priorities and economic factors. Drinking water herein is defined as water obtained from an approved source that has undergone minimum treatment consisting of filtration and disinfection process. Bottled water is water in a sealed container or package and is sold for human consumption as drinking water.

In addition to the PNSDW standards, bottled drinking water has to follow the DOH-BFAD Administrative Order No. 18-A s. 1993, Standards of Quality and Requirements for the Processing, Packaging and Labeling of Bottled Drinking Water, as amended by AO No. 39 s. 1996 and AO No. 2007-0044.

Sources of water for households are categorized into three levels: Level I, or point source which may be a well or a developed spring with an outlet but without a distribution system, and serves only 15 to 25 households; Level

II, a communal faucet system of standpost, which consists of source, a reservoir, and piped distribution network which can serve an average of 100 households; and Level III, a waterworks system with individual house connections, which requires a minimum treatment of disinfection.

2. Water Quality Standards

Standards of water quality are classified into: (a) microbiological, (b) chemical and physical qualities, and (c) radiological quality.

(a) Microbiological Quality. All parameters of microbiological quality are priority drinking water quality parameters for monitoring (Table 1). While the parameters and values remain the same, the required sampling frequency differs among the levels. For example, required sampling for determining microbial quality for Level 1 is only once in three months, for Level 2, once in two months and for Level 3, one sample monthly.

(b) Physical and Chemical Quality. Physical quality of drinking water refers to its odor, taste, turbidity and color while the chemical quality considers inorganic constituents, organic constituents and other organic contaminants such as pesticide residues and other chemical waste residues.

Certain inorganic constituents may be present in drinking water as a result of leaching out of piping or plumbing materials such as lead, copper, asbestos, nickel and cadmium. Some of these chemicals are known or suspected carcinogens such as arsenic, lead, chromium and cadmium among others. Organic constituents in water could come from various sources such as the decomposition of organic debris, domestic, agricultural and industrial activities and contamination that occur during water treatment and distribution. These activities generate wastewater discharges, agricultural and urban runoff and leachates from contaminated soils that may include pesticides, solvents, metal degreasers and plasticizers and petroleum products. Other organic contaminants are also formed during water treatment processes such as coagulation, chlorination and ozonation.

Table 1. Microbial quality standards for drinking water

Parameters	Value/Unit	Drinking Water	Bottled Water
		Point of Compliance	**Source of water**
Total coliform	< 1.1 MPN/ 100 mL	Service reservoirs Water treatment works Consumer's Taps Refilling Stations Water Haulers Water Vending Machines	MPN <2.2/100 mL Provided that no sample shall contain MPN of 9.2/100 mL
Fecal coliform	< 1.1 MPN/ 100 mL	Service reservoirs Water treatment works Consumer's Taps Refilling Stations Water Haulers Water Vending Machines Point Sources– Level I *	
Heterotropic plate count	< 500 CFU/mL	Service reservoirs Water treatment works Consumer's Taps nearest meter Refilling Stations Water Vending Machines	Not more than 300 CFU/mL

Source: PNSDW (2007); **Note:** MPN = most probable number

Table 2 shows the physical and chemical quality parameters of drinking water and bottled water and the priority parameters for monitoring are highlighted which include color, turbidity, chloride, iron, manganese, pH, sulfate and total dissolved solids.

The standard values of inorganic chemical constituents in both drinking water and bottled water are presented in Table 3.

Possible contaminants of ground and surface waters are industrial chemicals and pesticides, herbicides and fungicides from farms (Table 4). For the latter, there are no identified priority parameters for drinking water monitoring. However, the list of allowed and banned chemicals issued by the Fertilizer and Pesticide Authority is the basis for identifying which to include in the priority list.

Table 2. Physical and chemical quality standards of drinking water and bottled water

Constituent	Maximum level (mg/L) or characteristic				
	Drinking Water	Bottled Water			
		Purified/Distilled		Mineral	
		Guide level	Max. Level	Guide Level	Max. Level
Taste	No objectionable taste				
Odor	No objectionable odor				
Color	Apparent=10 color units True = 5 color units				
Turbidity	5 NTU	1 NTU			
Conductivity		<5 uS/cm			
Aluminum	0.20	0.05	0.2		
Chloride	250			25	250
Copper	1.0	0.1	1.0		
Hardness	200 as $CaCO_3$				
Hydrogen sulfide	0.05				
Iron	1.0	0.3	1.0		
Manganese	0.4	0.05	0.1		
pH	6.5-8.5/5-7	5-7	9	6.5-8.5	
Sodium	200			10	12
Sulfate	250				
Total Dissolved Solids	500/<10**	<10			
Zinc	5.0	0.5	5.0		
Fluoride		0.8 For fluoridated water	2.0		
Calcium				30	50
Magnesium				20	175
Potassium				25	200

Source: PNDWS (2007)

The World Health Organization has set radioactivity levels for gross alpha and gross beta activity as shown in the Table 5, in radioactivity units of Becquerel per liter (Bq/L). The guidelines are based on the fact that radioactivity in drinking water contributes only a minor part of the total radiation dose received from natural sources.

Table 3. Standard values for inorganic chemical constituents with health significance

Constituent	Maximum level (mg/L)	
	Drinking water	**Bottled water (For source water or finished product)**
Antimony	0.02	
Arsenic	0.05	0.05
Barium	0.7	
Boron	0.5	
Cadmium	0.003	0.01
Chromium (total)	0.05	0.05
Cyanide (total)	0.07	0.01
Fluoride	1.0	
Lead	0.01	0.05
Mercury (total)	0.001	0.001
Nickel	0.02	
Nitrite	3	0.1
Selenium	0.01	0.01

Screening of gross alpha and gross beta emitters is used to determine whether more complete analyses for specific radio nuclides are needed. The term screening value is used in the same manner as reference level as defined by the International Commission on Radiological Protection (ICRP). A reference level is not a dose limit requirement.

It is also important for water providers to provide evidence of controlling the generation of by-products of disinfection such as the use of pre-treatment to remove precursors, and use of treatment technology that removes disinfection by-products (Table 6). If two successive analyses for a water service provider show that suspected by-product do not occur, then such chemical disinfection by-products will be removed from the priority list for said WSP.

If water providers could provide evidence of control of generation of disinfection by-product such as pre-treatment to remove precursors, use of treatment technology that evidently removes disinfection by-product or two successive analysis showing that suspected by-product does not

Table 4. Standard values for possible contaminants of drinking water from industry and agricultural wastes

Constituent	Maximum Level (mg/L)		Maximum Level (mg/L)
	Drinking Water		Bottled Water
Industrial pollutants			
Benzene	0.01		0.005
Carbon tetrachloride	0.004		0.005
Trihalomethane			0.01
1,2-Dichlorobenzene	1.0		
1,4-Dichlorobenzene	0.30		
1,2-Dichloroethane	0.03		
1,1-Dichloroethene	0.03		
1,2-Dichloroethene	0.05		
Dichloromethane	0.02		
Di(2-ethyhexyl) phthalate	0.008		
Edetic Acid (ADTA)	0.60		
Pesticides and related substances	**Maximum level (μg/L)**	**Status in the Philippines**	
Aldrin and Dieldrin (combined)	0.03	Banned	Carbamates, organochlorine, organophophates, 0.1 ppb; Herbicides, fungicides, 0.5 ppb
Atrazine	2.0	Registered	
Carbofuran	7.0	Registered	
Chlordane	0.2	Banned	
DDT**	1.0	Banned	
1,2-Dibromo-3-chloropropane (DBCP)	1.0		
2,4-Dichlorophenoxyacetic acid (2,4-D)	30.0	Registered	
Endrin	0.6	Banned	
1,2-Dibromomethane (Ethylene dibromide)	0.4	Banned	
Heptachlor and Heptachlor epoxide (combined)	0.03	Banned	
Lindane	2.0	Restricted	
MCPA (4-(2-methyl-4-chlorophenoxy) acetic acid)	2.0	Registered	
Pendimethalin	2.0	Registered	
Pentachlorophenol (PCP)	9.0		0.5 ppb

occur then such chemical disinfection by-products will be removed from the priority list.

Table 5. Standard values for radiological activity

Radiological activity	Activity level (Bq/L)	
	Drinking water	Bottled water
Gross alpha activity	0.1 (excluding radon)	0.1
Gross beta activity	1.0	1.0
Radon	11 (MCL)	

Note: MCL = Maximum Contaminant Level

Source: WHO Guidelines for Drinking Water Quality 2004, Third Edition

Table 6. Standard values for chemicals used in treatment and disinfection and disinfection by-products

Constituent	Maximum level (mg/L)
a. Contaminants from treatment chemicals	
Acrylamide	0.0005
Epichlorohydrin	0.0004
b. Disinfection chemicals	
Residual chlorine	0.3-1.5
Iodine	Not recommended for long term disinfection
c. Disinfection byproducts	
Bromate	0.01
Chlorite	0.7
Chlorate	0.7
Chloral hydrate (trichloroacetaldehyde)	0.01
Dibromoacetonitrile	0.07
Dichloroacetic acid	0.05
Dichloroacetonitrile	0.02
Formaldehyde	0.20
Monochloroacetate	0.02
Trichloroacetate	0.20
2,4,6-trichlorophenol	0.20

(c) Frequency of Sampling

For drinking water service providers, the frequency of sampling for microbiological analysis depends on the type of source and mode and ranges from monthly to once every three months. Physical and chemical analysis is the same: once a year for Level I, II and III and emergency suppliers of drinking water; and twice a year for water refilling stations and water vending machines (Table 7).

Table 7. Frequency of sampling for microbiological analysis and physical and chemical analysis of drinking water

Source and Mode of Supply	Population Served	Minimum frequency of sampling	
		Microbiological analysis	**Physical and chemical analysis**
Level I	90-150	Once in 3 months	Once a year
Level II	600	Once in 2 months	
Level III	<5,000	1 sample monthly	
	5,000-100,000	1 sample per 5,000 population	
	>100,000	20 samples and additional sample per 10,000 population monthly	
Emergency suppliers of drinking water		Before delivery to users	
Water refilling stations (product water)		1 sample monthly	Twice a year
Water vending machines (product water)		1 sample monthly	

For radiological screening, initial analysis should be done for four consecutive quarters for one year. If the results from four consecutive quarterly samples are >50% of MCL, the frequency of analysis can be one sample for every three years. If the initial average is 50% of MCL, the frequency can be reduced to one sample every six years.

For bottled water manufacturing, frequency of sampling for microbiological analysis is every 2–3 hr on-site and once every two months for off-site.

(d) Agencies in Charge of Regulation

According to PD 198 (1973) which created LWUA, one of the functions of the LWUA is to "monitor and evaluate local water standards." Thus, the LWUA regulates the quality of water produced only by water districts. As of 2005, there were 6,280 WSPs serving 88 million people. The LWUA undertakes its regulatory functions through the following: (a) issuance of memorandum circulars to all water districts; (b) submission of monthly reports from water districts; (c) sanctions for non compliance; and (d) water district performance evaluation through fixed indicators.

However, bottled drinking water manufacturers must satisfy additional requirements in order to comply with Good Manufacturing Practices since bottled water is considered a food product and is directly regulated by the DOH Food and Drug Administration. As of April 2012, there are 22 and 93 licensed bottled drinking water manufacturers in the National Capital Region and outside, respectively, for a total of 115. Water refilling stations do not need to obtain a license to operate from FDA, however, these stations are not allowed to pack their drinking water in retail sizes (e.g., 250 mL to 2 L). The water refilling stations are under the monitoring of the local government. The PNSDW guidelines also apply to concessionaires in Metro Manila and refilling stations. However, the number of parameters and frequency of monitoring are not the same and is lenient for refilling stations. Unfortunately, there is no regulation for vending machines and emergency suppliers.

Purification Processes for Drinking Water

The following are some standard processes followed by many agencies and companies in purifying drinking water (Kawamura, 2000; Crittenden *et al.*, 2005; Edzwald, 2011; Recios, 2012).

1. Clarification

Clarification is a multi-step process for removing suspended matter. It involves addition of chemical coagulants or pH-adjustment chemicals that form flocs; these settle by gravity in settling tanks or are removed by filtration. This process removes particles larger than *25* microns; however, it is not 100% efficient as the water may still contain some suspended materials.

2. Chemical Methods

pH adjustment. This is done in order to prevent acid corrosion of metal pipes and containers. The recommended pH of water is in the range 8.3 - 9.0.

Sequestering (chelating) agents. Chelating agents, such as EDTA (Ethylenediamine tetraacetic acid), their sodium salts and DTPA (Diethylenetriaminepentaacetic acid), are used to reduce water hardness by removing Ca, Mg, Fe, Mn and Al ions as complexes (chelates) in order to prevent precipitation of these ions.

Oxidizing agents. These neutralize reducing agents and are biocidal. An example is potassium permanganate which can oxidize most organic compounds, as well as convert ferrous to ferric ions that form salts which can be further removed by precipitation and filtration.

Reducing agents. These are added to neutralize oxidizing agents such as chlorine or ozone. In membrane and ion-exchange systems, reducing agents neutralize oxidizing agents which may degrade some membranes and resins. Some examples of reducing agents are sodium metabisulfite, sulfides, and nitrites.

3. Ion Exchangers

Water softening. This involves removal from water of scale-forming calcium, magnesium and ferrous, ions. However, this method is not used for producing highly purified water because ions remain in the water after the ion exchange process. Examples of water softeners are commercial ion exchangers with Dowex and Amberlite brands.

Demineralization/deionization. Ion-exchange deionizers use synthetic resins similar to those used in water softeners. A two-stage process is employed in order to remove essentially all ions remaining in water using a cation exchanger followed by an anion exchanger. Examples of these resins contain the carboxymethyl (CM) group as cation exchanger and the diethylaminoethyl (DEAE) group as anion exchanger.

4. Cross-flow Filtration

This involves feed flow under pressure, across a membrane (such as cellulose acetate or polysulfone) with part of the feed permeating through the membrane and the balance of the feed sweeping tangentially along the membrane to exit the system without being filtered. The filtered stream is called "permeate" and the second stream is called "concentrate" or "retentate". Because the feed and concentrate flow parallel to the membrane instead of perpendicular to it, the process is described as cross-flow or tangential-flow.

Reverse osmosis (RO). RO was the first cross-flow membrane process to be widely commercialized. It removes virtually all organic compounds and 90 to 99% of all ions in water. It completely rejects viruses, bacteria and pyrogens. High pressure (13.8 -68.9 bar) is required. It is much more energy efficient compared to heat-driven purification (distillation) and more efficient than the strong chemicals required for ion exchange. No energy-intensive phase change is required.

Nanofiltration (NF). This process removes organic compounds with MW of 300 -1000 Da and selected salts (usually divalent) but allows higher water throughputs at lower operational pressure compared to RO.

Electrodialysis (ED). This removes ions from impure water using membranes which are semi-permeable to ions based on their electrical charges. Two flat sheet membranes, one permeable to cations and the other to anions, are stacked alternately with flow channels between them. Electrodes are placed on each side of the alternating stack of membranes in order to force ions through the membranes. This leaves low ionic concentrations in the water of the alternate channels. Recent developments have improved the efficiency of ED by reversing the polarity of the electrodes periodically. This is called electrodialysis reversal and has reduced the scaling and fouling problems common to ED.

Applications of nanotechnology provide promising improvements in decentralized water purification systems which emulate biological capabilities. Better control of nanoscale fabrication could lead to substantial gains in efficiency and useful lifetime, not only in membrane technologies such as RO and ED, but also in adsorption processes, e.g. ion exchange, as well as in advanced oxidative technologies (such as photo-oxidation) for disinfection (Gillett, 2012).

5. Distillation

Distillation involves collection of steam condensate/distillate after the water is vaporized and the water vapor is cooled. Most contaminants do not vaporize and, therefore, do not pass into the condensate. It allows removal of both organic and inorganic contaminants, as well as biological impurities and pyrogens. All impurities are removed down to the range of 10 parts per trillion producing extremely pure water. Careful temperature monitoring is required in order to ensure purity and avoid contamination of the purified water. Organic substances with boiling points near that of water are difficult to remove and are carried over into the vapor. In these cases a double distillation system is usually required.

6. Disinfection

Disinfection is one of the most important steps in producing safe drinking water. Chlorine gas is the chemical disinfectant often used; it is added to water to kill bacteria after clarification and/or softening. In order to maintain the "kill potential", an excess of chlorine is fed into the supply to maintain a residual concentration. The chlorine level must be constantly monitored in order to avoid accumulation of chloramines or chlorinated hydrocarbons which pose health risks to humans.

Large-Scale and Medium-Scale Municipal Drinking Water Systems

1. Large-Scale Municipal Drinking Water (MDW) System

The Manila Waterworks and Sewerage System (MWSS) supplies drinking water to Metro Manila through the participation of Manila Water (East Zone) and Maynilad (West Zone). The water treatment plants of both Manila Water and Maynilad use the conventional treatment system with 1600 million and 900 liters per day (MLD) capacities, respectively. A flow diagram for Manila Water's Balara water treatment plants is presented in Figure 1. Maynilad's Putatan treatment plant has a 100 MLD capacity is a large-scale microfiltration and RO system; Manila Water's large scale RO plant with 50 MLD capacity is still in the pipeline. MDW systems are required to have residual disinfectant in the distribution system (piping and tanks) in order to prevent bacterial contamination. Neither ozone nor ultraviolet light can provide this residual disinfectant property. Different disinfectants have advantages and disadvantages, as well as varying degrees of cost effectiveness. The use of chlorine is favorable in many cases.

2. Medium-Scale MDW System

An example of a medium-scale MDW system is the Laguna Water District system which is shown in Figure 2. A catalytic filtration process is used which is a low-cost and highly efficient method for removing iron and manganese from water. This process can remove trace organic contaminants from water treatment systems more effectively than conventional treatment systems.

3. Production of Bottled Drinking Water

Bottled water is usually produced at the water source and sealed in containers, usually plastic, such as polyethylene terephthalate (PET). Three primary processes are commonly used to produce purified water, namely deionization, distillation and reverse osmosis (RO). Many bottlers choose RO over the others because of the many advantages, including reduced cost, high energy efficiency and increased performance. RO removes from water all organic compounds and practically all ions, as well as viruses, bacteria and fever producing substances. The following are some types of bottled water:

(a) **Distilled water**: this is produced by conventional distillation resulting in highly purified water.
(b) **Spring water**: this comes from an underground source that flows naturally to the earth's surface.
(c) **Mineral water**: typically from a spring, this contains dissolved solids like calcium, magnesium, sodium, potassium, silica and bicarbonates.
(d) **Purified drinking water**: this type of water has been processed to remove chlorine and a majority of dissolved solids, such as magnesium.

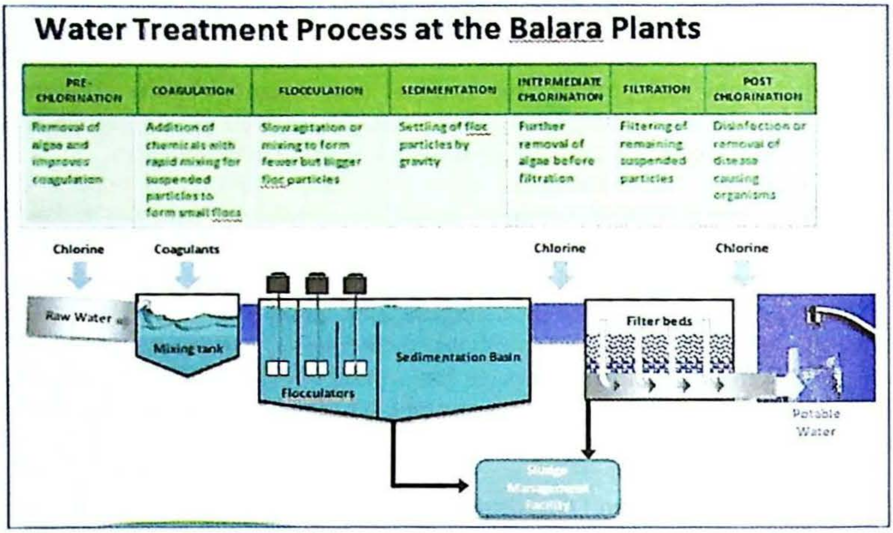

Figure 1. Process flow diagram for a large-scale MDW system (Manila Water). (From Manila Waters)

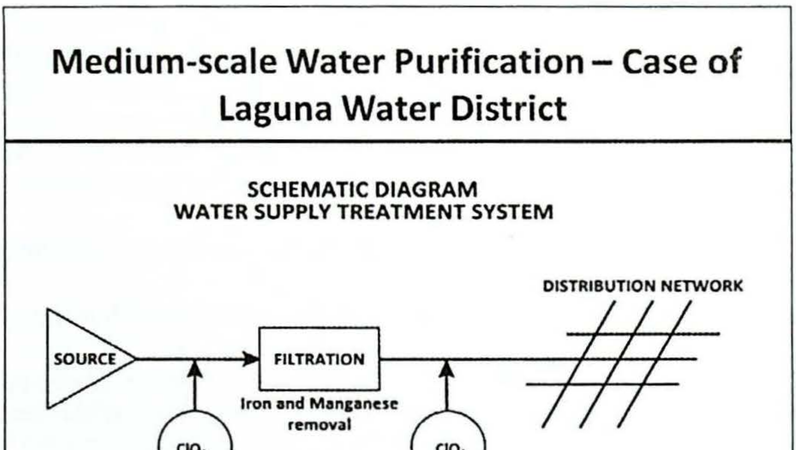

Figure 2. Process flow diagram for a medium-scale MDW system (Laguna Water District; Tabanao, 2012).

Issues and Concerns

1. Regulation

(a) The guidelines (parameters and frequency of sampling) prescribed by the Philippine National Standards for Drinking Water (PNSDW) for municipal drinking water and refilling stations are different. PNSDW guidelines are also applied for bottled water but the values for some parameters and the frequency of monitoring are different from those prescribed for municipal providers and refilling stations.

(b) Municipal drinking water providers outside Metro Manila show poor compliance with PNSDW guidelines. This could be partly explained by the limited number of certified testing laboratories, as well as lax enforcement of the guidelines. Furthermore, procedures and penalties for non-compliance are not standardized.

2. Testing Capability

Results are questionable on the monitoring of water drinking quality. For example, sampling methodology and sample integrity are not updated and need reassessment. Furthermore, laboratory test methods and capabilities of certified laboratories for physico-chemical and microbiological analyses should be evaluated.

3. Bottled water

(a) Current policies for recognition (more accurate term than accreditation) of water testing laboratories by DOH are outdated including laboratory space requirement and qualifications of persons certifying reports of analyses and evaluating laboratories. The National Reference Laboratory (East Avenue Medical Center) currently performs only microbiological analysis and does not conduct proficiency testing for physico-chemical parameters.

(b) Bottled water refilling stations are not adequately monitored by DOH. For example, sampling is done by refilling station owners and there is no assurance of sample integrity. Refilling stations bottle their water; this is non-compliance with DOH rules.

(c) Labeling of bottled water containers, such as oxygenated, ionized, iodine-fortified, etc. presently lacks monitoring and regulation.

(d) There is a problem of chemical leachates (such as phthalate) with PET bottles; analytical methods should be developed for detection of these contaminants, which commonly pose health risks to humans.

4. Water purification process

Chlorine is the commonly used chemical disinfectant for MDW, being effective and economical. For example, it is used by Manila Water and Maynilad in their water treatment plants. However, some DWPs, such as Laguna Water District, use chlorine dioxide as disinfectant. The PNSDW requires residual chlorine at the farthest end of the distribution; chlorine dioxide dissipates more easily. Chlorine is also preferred because of the easy monitoring of residual chlorine in the distribution system. Chlorine dioxide needs to be generated on site; generator efficiency and optimization difficulty can cause excess chlorine to be fed at the application point, which can potentially form halogen-substituted DBPs. Chlorine dioxide does not form THMs, does not chlorinate organics and does not react with water to form free chlorine. However, it can lead to production of chlorite and/or chlorate which are harmful to humans. It is soluble in water, is less corrosive than chlorine and effective across a broad pH range. It decomposes in sunlight and can lead to production of noxious odors.

Recommendations

(a) It is recommended that existing policies on the quality of drinking water and monitoring procedures be reviewed and harmonized for all water service providers (WSPs) including water districts, bottled drinking water manufacturers, refilling stations and small bottlers. DOH should be empowered, in terms of budget, structure and equipment, to effectively monitor and enforce compliance with quality guidelines, including strict monitoring of refilling stations which do "bottling" of water, and all bottled water manufacturers.

(b) Policies for recognition (more accurate term than accreditation) of water testing laboratories by DOH should be updated, including laboratory space requirement and qualifications of persons certifying reports of analyses and evaluating laboratories. The National Reference Laboratory (East Avenue Medical Center, Quezon City) should provide proficiency testing for physico-chemical parameters. Proficiency tests are presently done only for microbiological analysis.

(c) It is recommended that DOH formulate policies for the proper labeling of bottled water containers as oxygenated, ionized, iodine-fortified, etc.
(d) In view of unresolved issues regarding use of either chlorine or chlorine dioxide as chemical disinfectant, further evaluation should be done as basis for future recommendation.

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