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Arsenic in Philippine Groundwaters: Exploring Governance Limitations for Drinking Water Safety

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ABSTRACT

Arsenic in drinking water is an emerging environmental health threat in the Philippines. Local studies investigate the occurrence and health effects of the hazard, but governance dimensions remain understudied. This study explores why some consumers remain vulnerable to arsenic poisoning despite the existence of a water institution framework for groundwater management and drinking water safety. The framework for arsenic risk management for safe drinking water in the Philippines was mapped from "source-to-sip". Textual analysis of pertinent legal documents and official reports; and transcripts of a roundtable discussion and minutes of meetings with national agency representatives were undertaken with regard to the principles of integrated groundwater management and the human right to safe drinking water. Findings suggest that existing programs and policy instruments for groundwater quality monitoring provide insufficient information for early arsenic detection. Furthermore, while the country's legal framework supports functions for arsenic risk mitigation for formal water supplies, the current regulatory approach fails to protect self-provisioning households as they access water from informal systems uncovered by water quality surveillance. Enhancing groundwater quality monitoring in suspected arsenic hotspots to alert self-provisioning households will promote a self-protection policy so they can shift to safer sources of drinking water.

Keywords: *arsenic contamination, drinking water, safe water, groundwater, governance*

INTRODUCTION

Access to safe drinking water is a universal human right (*UN Committee on Economic, Social and Cultural Rights 2003*). From only 76% in 1990, safe drinking water access increased to 91% in 2015 as a result of global efforts (*World Health Organization [WHO] 2015*). Despite this development, an estimated 2 billion people are still vulnerable to consuming biologically and/or chemically contaminated drinking water (*Amrose et al. 2015*).

Arsenic, a hazardous and naturally occurring chemical in groundwater, is one of the many threats to drinking water safety (*WHO 2017*). Ingestion of even low levels of arsenic over a long period has been proven to adversely affect human health while symptoms may manifest only after 5 to 15 fifteen years of exposure (*Hassan 2018*). Furthermore, the definite effects of arsenic on the human body are difficult to predict as they may vary based on each person's nutritional status and genetic predisposition (*Vahter 2007*). Arsenic as a human carcinogen has been associated with skin, lung, liver, kidney, urinary bladder, and prostate cancer (*International Agency for Research on Cancer 2018*).

More than 140 million people from developed and developing countries alike are at-risk to groundwater arsenic poisoning; among these countries are the United States of America, Australia, New Zealand, India, Bangladesh and South Africa (*Ravenscroft et al. 2009*). In the Philippines, hazardous levels of groundwater arsenic gained attention after clusters of arsenic poisoning cases in Pampanga were detected in 2014 (*Kleinendorst et al. 2015; Sy et al. 2017*). Further groundwater quality testing from 2017 to 2019 confirmed groundwater arsenic contamination in more municipalities in Central Luzon (*Petrusevski et al. 2017; Solis et al. 2020*). Published medical research also reported cases of arsenic poisoning from contaminated drinking water among residents of Compostella Valley and Laguna (*Sy et al. 2017; Ang-Tangtatco et al. 2017; Camaclang et al. 2019*). In 2022, high levels of arsenic were detected in groundwaters of multiple towns in Batangas province (*Mallari 2022*). While groundwater resources account for only twenty-nine percent of the Philippines' water resource potential, they remain as the primary source of drinking water by almost half of the country's population (*Pulhin et al. 2018*).

The threat of arsenic in drinking water has been approached from various disciplinary orientations. Globally, literature on the subject is abundant, and many of these investigate technological and stakeholder studies at the end-user level (*Amrose et al. 2015*). The same can be observed in the Philippines where local studies in the medical, natural science, and engineering fields investigate the occurrence and health effects, of the arsenic hazard (*Solis et al. 2020; Camaclang et al. 2019; Ang-Tangtatco et al. 2017; Petrusevski et al. 2017*). Meanwhile, research on the policy and governance dimensions of arsenic in drinking water are few (*Shrivastava 2016*) despite the declarations that the water crisis is mainly one of governance (*Global Water Partnership 2000*). This gap merits consideration as institutions can significantly shape on the process and outcomes of arsenic risk reduction (*Khan and Yang 2014*).

Progressive realization of the human right to safe drinking water requires an enabling institutional context that accounts for human rights principles. Mainstreaming its principles into national legislation and institutional systems is a key step in operationalizing this global agenda at the country level (*Bos et al. 2016*). It is acknowledged in this study that such a policy environment is essential in mitigating arsenic in drinking water. Furthermore, tackling this "wicked problem" requires an integrative approach that accounts for the constellation of systems that give rise to governance outcomes. Integrated groundwater management which endorses a systems approach to account for social and ecosystems dimensions (*Jakeman et al. 2016*) is also recognized in this study.

This study sought to understand why some drinking water consumers in the Philippines remain vulnerable to arsenic poisoning despite the existence of institutional arrangements for ensuring drinking water safety. The exploratory study was facilitated by mapping the water institution framework for reducing arsenic risk in drinking water from "source to sip". The breadth of legislation encompassing water governance issues is large and manifold (*Bos et al. 2016*), therefore institutional mapping for a particular policy concern is an important starting point to elucidate gaps and needed reforms. Concurrently, the water institution framework was examined in light of integrated groundwater management and human rights agenda.

MATERIAL AND METHODS

The study was undertaken with a transformative worldview, a paradigm closely tied to the promotion of human rights (*Mertens 2009*). This paradigm is relevant where access to social justice is a concern. In the study of groundwater governance, *Neal Patrick et al.* (*2016*) puts forward the use of the human right-based lens as a means for surfacing embedded concepts relative to equitable utilization of water resources. Textual analysis served as the primary method in the conduct of this study. It is a process of "sense-making" to identify obscure paradigms and constraints embedded in a certain context (*Baldo-Cubelo 2021*). Textual analysis facilitated the institutional mapping process and the close examination of the resulting institutional framework in light of the human right-based and integrated groundwater management concepts.

Guided by the above-discussed analytical frameworks, Philippine laws, policies, and administration mechanisms related to drinking water quality governance were analyzed with respect to the unique challenges presented by the arsenic contamination problem. The documents studied are publicly available resources obtained from government agencies' official websites (**Table 1**).

Analytical Framework

Elazegui et al. (*2018*) refer to institutional mapping as a policy technique for determining institutional stakeholder roles for potential coalition- and strategy-building. In adopting this procedure, this study integrates the water institution framework of *Saleth and Dinar* (*2004*) and the "source to sip" model of safe water systems recommended by *Amrose et al.* (*2015*). The interdependence of groundwater resources to legal and institutional systems requires an integrative approach that utilizes various fields or knowledge sources (*Neal [Patrick] et al. 2016; Jakeman et al. 2016*). The macro scale water institution framework proposed by *Saleth and Dinar* (*2004*) has three major components: water law, water policy, and water administration. It enables examination of formal systems which are more amenable to reform and more legally binding to all water service providers in the country. The broad range of water issues that can be tackled by the water institution framework necessitated the supplementation of the "source to sip" model to focus the inquiry on drinking water safety. This model analyzes safe water delivery beyond a discrete scope of intervention (e.g. treatment, storage, or conveyance only) as commonly tackled in literature. The "source to sip" model considers that drinking water maybe achieved in any one point of these stages, but altogether it determines the system's effectiveness in providing potable drinking water (*Amrose et al. 2015*). This study is guided by the "source to sip" model by providing a framefor delineating the examination of water laws,

Table 1. Drinking water quality governance documents reviewed for water law and water policy analysis.

Document	Online Access Link
Water Laws	
Presidential Decree No. 1067: Water Code of the Philippines (1976)	https://www.officialgazette.gov.ph/1976/12/31/presidential-decree-no-1067-s-1976/
Republic Act No. 9275: Clean Water Act (2004)	https://www.officialgazette.gov.ph/2004/03/22/republic-act-no-9275/
Presidential Decree 856: Code on Sanitation of the Philippines (1976)	https://www.officialgazette.gov.ph/2004/03/22/republic-act-no-9275/
Implementing Rules and Regulations of Chapter II Water Supply of the Code on Sanitation of the Philippines (P.D. 856)	(P.D. 856) https://www.doh.gov.ph/sites/default/files/publications/Chapter_2_Water_Supply.pdf
Water Supply Supplemental Implementing Rules and Regulation (1999) of Sanitation Code	https://www.academia.edu/9363454/025Supplemental_IRR?auto=download
Republic Act No. 7394: Consumer Act of the Philippines (1992)	https://www.officialgazette.gov.ph/1992/04/13/republic-act-no-7394-s-1992/
Republic Act No. 7942: The Philippine Mining Act of 1995	http://www.mgb.gov.ph/images/stories/RA_7942.pdf
Water Policies	
Department of Environment and Natural Resources Administrative Order No. 2005-10: Implementing Rules and Regulation of the Philippine Clean Water Act of 2004 (Republic Act No. 9275)	http://pab.emb.gov.ph/wp-content/uploads/2017/07/DAO2005-10-Clean-Water-Act-IRR.pdf
Department of Environment and Natural Resources Administrative Order No. 2016-08: Water Quality Guidelines and General Effluent Standards of 2016	https://pab.emb.gov.ph/wp-content/uploads/2017/07/DAO-2016-08-WQG-and-GES.pdf
Department of Health Administrative Order No. 10: Philippine National Standards for Drinking Water (2017)	https://www.fda.gov.ph/wp-content/uploads/2021/08/Administrative-Order-No.-2017-0010.pdf
Department of Health Administrative Order No. 24: National Policy on Water Safety Plan (2014)	http://pawd.org.ph/wp-content/uploads/2014/09/Philippine-National-Policy-on-Water-Safety-Plan.pdf
Presidential Administrative Order No. 47: Creating an Inter-Agency Task Force on Arsenic Risk Reduction and Management (2015)	https://www.officialgazette.gov.ph/downloads/2015/08aug/20150826-AO-0047-BSA.pdf
Department of Health Administrative Order No. 18-A: Standards of Quality and Requirements for the Processing, Packaging and Labeling of Bottled Drinking Water (1993)	https://ww2.fda.gov.ph/index.php/issuances-2/food-laws-and-regulations-pertaining-to-all-regulated-food-products-and-supplements/food-administrative-order/15936-aono18as1993
DENR Administrative Order No. 34 (1990)	https://emb.gov.ph/wp-content/uploads/2016/04/DAO-1990-34.pdf
Other Documents	
Department of Environmental and Natural Resources - Environmental Management Bureau Water Quality Monitoring Manual, Volume I, Manual of Ambient Water Quality Monitoring	https://water.emb.gov.ph/wp-content/uploads/2017/09/Water-Quality-Monitoring-Manual-Vol.-1-ambient_14aug08.pdf
Development of Groundwater Management Plan for Highly Urbanized Water Constraint Areas	http://nwrb.gov.ph/images/Transparency/4a_nwrb_projects/NWRB_Major_Projects_2018.pdf
Groundwater Resource Mapping and Vulnerability Assessment Program	http://www.nwrb.gov.ph/images/Publications/Groundwater_Management_Plan_for_CDO.pdf
	http://www.mgb.gov.ph/2015-05-13-02-02-11/mgb-news/353-mgb-to-produce-1-250-000-scale-groundwater-availability-maps

policies, and administration structure for providing and accessing arsenic-safe drinking water in the Philippines (**Figure 1**).

After the water institution framework was defined and described, textual analysis was expanded to include minutes of meetings and a focus group discussion transcript. Government agencies at the national, regional, and local levels with mandates on water and health were consulted in relation to the implementation of a drinking water arsenic remediation project from September 2018 to July 2019. The discussions provided information on the current paradigm of managing the risk of arsenic contamination of drinking water in the country. In Personal consultations were conducted with the Department of Environment and Natural Resources (DENR) Environmental Management Bureau (EMB), DENR National Water Resources Board (NWRB), Department of the Interior and Local Government (DILG) Water Supply and Sanitation Project Management Office (WSSPMO), Department of Health (DOH), Department of Science and Technology Industrial Technology Development Institute (DOST-ITDI), Local Water Utilities Administration (LWUA) and water districts in two localities with confirmed toxic levels of groundwater arsenic. Additionally, the DENR Mines and Geosciences Bureau (MGB), DILG Bureau of Local Government Supervision (BLGS), and Department of Public Works

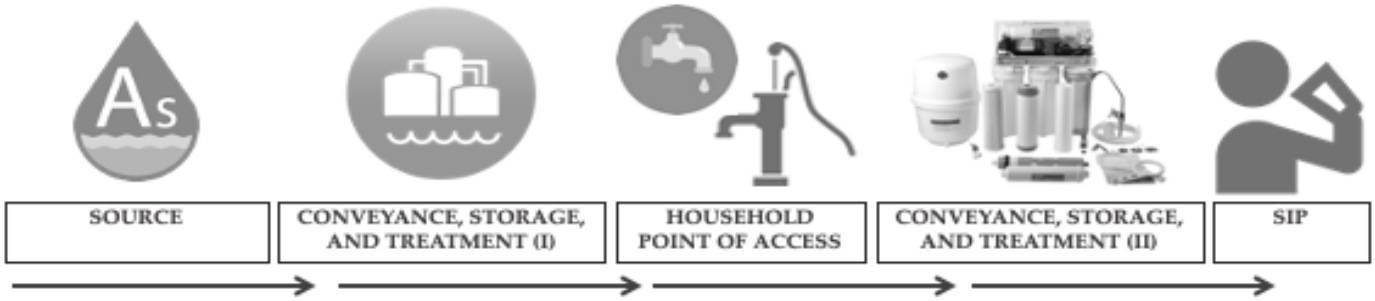

Figure 1. Stages of safe drinking water systems from "source to sip" (Adapted from *Amrose et al. 2015*).

and Highways (DPWH) were consulted via short message service and phone calls. A workshop and roundtable discussion was also held with representatives from DENR EMB, DENR MGB, DILG WSSPMO, DOST-ITDI, LWUA, Provincial Government of Pampanga Environment and Natural Resources Office (PENRO), University of the Philippines Los Baños (UPLB), and two water districts in attendance.

Textual analysis provided a means to account for the "presence of certain abstract concepts in human phenomena (*Baldo-Cubelo 2021*). In this study, "sense-making" to answer the research question was guided by the concepts of human rights and integrated groundwater management. Areas of concern were gleaned from the iterative review and analysis of the texts, and these were enriched and cross-examined with published and official grey literature.

RESULTS AND DISCUSSIONS

The water institution framework for managing arsenic risk in drinking water

The Philippines has multiple frameworks governing the water sector at various levels (*Hall et al. 2018*). Laws with provisions for arsenic risk management are the 1976 Water Code of the Philippines (Presidential Decree No. 1067), Philippine Clean Water Act (CWA) of 2004 (Republic Act No. 9275) and the 1976 Code on Sanitation of the Philippines (Presidential Decree 856) (**Table 2**). Broadly, the Water Code and the CWA provide the legal framework for water quality management, including the prevention and control of water resource pollution. The latter, on the other hand, focuses on human health protection by setting standards for developing and operating drinking water supply systems.

Provisions of the CWA of 2004 relevant to source water characterization to prevent extraction and consumption of unsafe drinking water are classification of groundwater sources according to most beneficial use (Section 19.i.), assessment of groundwater vulnerability (Section 19.d.), and designation and management of non-attainment areas (Section 6) consistent with water quality standards. The Code on Sanitation of 1976 prescribes measures for ensuring drinking water safety from the source, succeeding treatment (if any), and at the access point for private or public use. A Certificate of Potability of Drinking Water (CPDW) must be obtained from the local health officer.

The Consumer Act of the Philippines (Republic Act No. 7394) approved in 1992 has no direct provisions on arsenic regulations in drinking water, but is included in the discussion as the legal framework for consumer protection against health hazards. It regulates bottled drinking water processing, importation and distribution not covered by the Code on Sanitation for water supply systems.

Several policies and programs operationalize the laws introduced above. In accordance with source water protection, Administrative Order (AO) No. 2016-08 was issued by the Department of Environment and Natural Resources (DENR) pursuant to the *CWA* (*2004*). The AO sets the guidelines of ambient water quality monitoring for various purposes including water body classificationand designation of non-attainment areas (NAAs), and sets general effluent standards (GES). Groundwaters classified as sources of potable water must not have arsenic concentrations beyond 1.0×10^{-5} kg m^{-3} (aside from meeting other criteria). It must be noted, however, that arsenic as a secondary parameter is not required for all water quality monitoring activities. Groundwater vulnerability assessment is implemented through the Groundwater Resource Mapping and Assessment Program and Development of Groundwater Management Plan (GMP) for Highly Urbanized Water Constraint Areas.

Directly supporting the state's mandate in ensuring drinking water safety are the Philippine National Standards of Drinking Water (DOH AO No. 2017-0010), National Policy on Water Safety Plan (WSP) for All

Table 2. Water laws relevant to the management of arsenic contamination of groundwater in the Philippines and corresponding safe water system stage based on "source-to-sip" model.

Water Law	Pertinent Provisions	System Stage
Presidential Decree No. 1067: Water Code of the Philippines (1976)	Protection of Water Supply Sources – No person shall discharge into any source of water supply any domestic sewage, industrial waste, or pollutant not meeting the effluent standards set by the Department of Environment and Natural Resources (DENR)	Source
Republic Act No. 9275: Clean Water Act (2004)	Classification of groundwater sources according to most beneficial use Assessment of groundwater vulnerability Management of non-attainment areas (NAAs) – The DENR shall designate water bodies, or portion thereof, where specific pollutants from either natural or man-made source have already exceeded water quality guidelines (WQG) as non-attainment areas for the exceeded pollutants… Identification of existing sources. The Environmental Management Bureau [EMB] of the DENR shall identify as part of the plan to upgrade water quality, existing sources of water pollutants in designated non-attainment areas, including pollutants that are naturally occurring in the area	Source
Presidential Decree 856: Code on Sanitation of the Philippines (1976)	Sanitary requirements for the development of drinking water supply systems - Drinking water site clearance based on sanitary survey Water quality monitoring of source water in conformance with the Philippine National Standards for Drinking Water (PNSDW)	Source
	Classification of raw-water quality with respect to its treatment requirements Review and certification of water treatment products by the Department of Health	Treatment (I)
	Sanitary requirement for the development of drinking water supply systems - Certificate of Potability issued vis-a-vis the requirements of the PNSDW	Point of access
Republic Act No. 7394: Consumer Act of the Philippines (1992)	Protects the interests of the consumer, promotes general welfare and establishes standards of conduct for business and industry; Promulgation and adoption of consumer product standards	Point of access

Drinking-Water Service Providers (DOH AO No. 2014-0027), and Presidential AO No. 47 Creating an Inter-Agency Task Force (IATF) on Arsenic Risk Reduction and Management (**Table 3**).

The standards and procedures on drinking water quality to be complied with as stipulated in the *Code on Sanitation* (*1976*) are presented by the *PNSDW* (*2017*). The *PNSDW* (*2017*) categorizes arsenic, among others, as a legally enforceable mandatory drinking water quality parameter. The *PNSDW* (*2017*) prescribes a Maximum Allowable Level (MAL) of arsenic at 1.0 x 10^{-5} kg m^{-3} in accordance with the Global Drinking Water Quality Guidelines published by the *WHO* (*2017*). The sampling and testing of water quality from the source and the treatment plant outlet (if applicable) signify protection measures at these stages of the safe drinking water system. The PNSDW is likewise deemed as relevant to the 'sip' stage in light of provisions on creating public awareness on the importance of water quality standards, impact of contamination on health, and measures on how to keep drinking water safe at all times.

A management tool for ensuring drinking water safety using risk assessment approaches was adopted through the National Policy on Water Safety Plan (WSP) for All Drinking-Water Service Providers. This preemptive approach can be a promising strategy for preventing arsenic ingestion that may cause acute and chronic illnesses among consumers.

In 2014, the much-publicized discovery of arsenic poisoning from ingestion of contaminated groundwaters in Lubao, Pampanga served as a "focusing event" (*Atkinson 2019*) that nudged a policy response very specific to the arsenic hazard. AO No. 47 Creating an IATF on Arsenic Risk Reduction and Management was signed in 2015 by the then President of the Philippines, Benigno S. Aquino III. The IATF on Arsenic Risk Reduction and Management was led by the Department of Public Works and Highways (DPWH) with its then Secretary appointed as the administration's water czar (*Executive Order No. 806, series of 2009*). Among the IATF's functions were to conduct risk mapping, assessment and planning; formulate an action plan; and engage technical assistance of local and foreign institutions (Section 2, AO No. 47). The authors attempted to trace updates from the IATF during the consultative meetings with its member agencies, however, as of September 2018, the group appears to be no longer active. Most of the key

Table 3. Water policies relevant to the management of arsenic contamination of groundwater in the Philippines and corresponding safe water system stage based on "source-to-sip" model.

Water Policy/Program	Pertinent Provisions/Description	System Stage
Department of Environment and Natural Resources Administrative Order No. 2016-08: Water Quality Guidelines and General Effluent Standards of 2016	Guidelines for Groundwater Quality (Section 6.2). Groundwater shall be maintained at a quality consistent with its intended beneficial usage Source of potable water and other domestic use adopt class A WQG (except biochemical oxygen demand and dissolved oxygen)	Source
Groundwater Resource Mapping and Vulnerability Assessment Program	Aims to determine the availability and quality of groundwater in the various rock units of geologic formations and assess groundwater vulnerability of aquifers in the country	Source
Development of Groundwater Management Plan for Highly Urbanized Water Constraint Areas	To effectively and equitably manage the groundwater resources of the study area through the development of systematic and science-based management strategies that does not only consider the current situation, but also the future impact of climate change, to ensure long-term sustainability of this resource	Source
Department of Health Administrative Order No. 10: Philippine National Standards for Drinking Water (2017)	Prescribes the standards and procedures on drinking-water quality to protect public/consumers' health	Source; Point of access; Sip
Department of Health Administrative Order No. 24: National Policy on Water Safety Plan (2014)	Declares the development and implementation of Water Safety Plan by all drinking-water providers as a national policy for drinking-water quality management	All
Presidential Administrative Order No. 47: Creating an Inter-Agency Task Force on Arsenic Risk Reduction and Management (2015)	Creates an inter-agency task force to ensure full coordination and implementation of all government agencies in order to bring to fore measures to address arsenic exposure both at the national and local levels	All
Department of Health Administrative Order No. 18-A: Standards of Quality and Requirements for the Processing, Packaging and Labeling of Bottled Drinking Water (1993)	License to operate (Section IV) based on good manufacturing practice (GMP) (Section V) Licensing of Bottled Water Processors and/or Importers/ Distributors (Section IV)	Source Conveyance, storage and treatment (I); Conveyance and storage beyond access point (II); Consumption

agency representatives had limited knowledge about the IATF nor the outputs, e.g., risk maps, produced by thegroup. The IATF could have catalyzed the mitigation of groundwater arsenic contamination, but the policy that created it is highly subject to political shifts after a new administration- with its own priorities- has taken over. *Hall et al.* (*2018*) also notes how the ambiguous role of the water czar constrained the initiation of reforms in the country's overall water governance landscape in which the issue of arsenic in drinking water is embedded. At present, groundwater arsenic contamination concerns are being tackled by the DOH under the water and sanitation group of the Inter-Agency Task Force on Environmental Health.

The DOH AO No. 18-A: Standards of Quality and Requirements for the Processing, Packaging and Labeling of Bottled Drinking Water (1993), issued pursuant to the *Consumer Act of the Philippines* (*1992*) may be considered as a counterpart of the PNSDW. The former regulates bottled drinking water products sold as goods in the market while the latter applies to water supply systems for water service delivery. Not updated since 1993, the MAL of arsenic specified by DOH AO 18-A is 5.0×10^{-5} kg m^{-3}, exceeding the 1.0×10^{-5} kg m^{-3} set by the PNSDW.

Operationalizing the above-discussed water-related laws and policies involves an array of institutional actors given the many decision makers at the national level (*Elazegui 2004*). A preventive management approach critical for arsenic risk reduction- as illness symptoms emerge only after significant exposure- necessitates multi-agency action accounting for drinking water safety from the source to the consumer. The *WHO* (*2017*) identifies

authorities in public health, local environmental health, water resource management, drinking water supply, and certification as among the most vital actors in this process.

The National Water Resources Board (NWRB), Environment Management Bureau (EMB), and Mines and Geosciences Bureau (MGB) of the DENR are in charge of the various interrelated functions for groundwater resource management (**Table 4**).

The EMB monitors ambient water quality and effluent discharge. However, regular monitoring of the EMB covers surface waters only and groundwater quality monitoring is conducted on a per-project basis. Moreover, monitoring of effluent discharge accounts for arsenic from anthropogenic sources, whereas elevated arsenic concentrations in groundwater have been attributed to naturally occurring geological processes that spike arsenic levels of groundwater (*WHO 2017*).

The MGB is in charge of implementing the Groundwater Resource Mapping and Vulnerability Assessment Program which investigates groundwater availability given local geological settings and factors affecting water quality. However, the six parameters (dissolved oxygen, conductivity, temperature, pH, oxidation-reduction potential, and depth) included in the assessment exclude arsenic.

In the institutional arrangement for groundwater resource management for drinking water source protection, the designation of non-attainment areas and classification of groundwaters is according to most beneficial use, which are yet to be done, are associated with both NWRB and EMB (**Figure 2**).

As in most countries, the health authority of the Philippines is the primary agency responsible for drinking water quality regulation. Overall, it sets the standards for both drinking water service providers and the bottled water industry (**Figure 3**). Surveillance of health status and trends is also performed by the agency as it did in the investigation of arsenic poisoning in Central Luzon together with the local government. In terms of wider policy development, the DOH leads the Inter-Agency Committee on Environmental Health, which develops evidence-based policies among its other functions. At present, the issue of arsenic poisoning from drinking

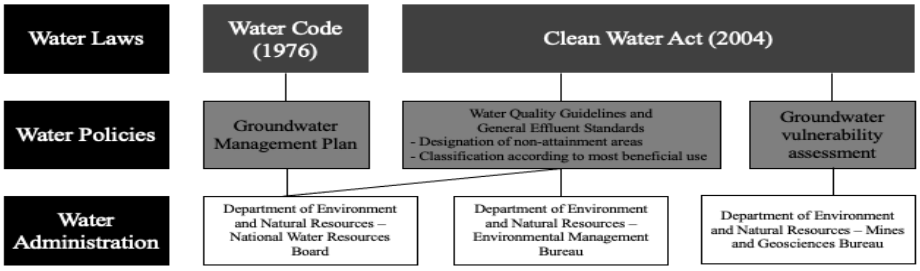

Figure 2. Water institution of groundwater management for drinking water source protection based on water laws, water policies, and water administration in the Philippines.

Table 4. Philippine government agency mandates on groundwater resource management based on national laws and policies.

Agency	Mandate	Enabling law/policy
DENR-NWRB	Responsible for all the water resources in the Philippines; coordinates and regulates all water-related activities in the country that has impact on the physical environment and the economy Classification of groundwater sources. The [Environmental Management] Bureau shall coordinate with the NWRB and other relevant agencies in the classification of groundwater sources	Presidential Decree No. 1067: Water Code of the Philippines (1976) DENR Administrative Order No. 10 (2005): Implementing Rules and Regulations of the Clean Water Act of 2004 (Republic Act No. 9275) Republic Act No. 9275: Philippine Clean Water Act (2004)
DENR-EMB	Standards for ambient water quality and general effluents; Classification of water bodies suitable for drinking (Class AA) Monitoring through groundwater sampling and analysis	DENR Administrative Order No. 34 (1990) Republic Act No. 9275: Philippine Clean Water Act (2004)
DENR-MGB	Mandates MGB to undertake land and marine geoscientific surveys including groundwater resource exploration and vulnerability assessment (Geosciences Division)	The Philippine Mining Act of 1995 (RA No. 7942)

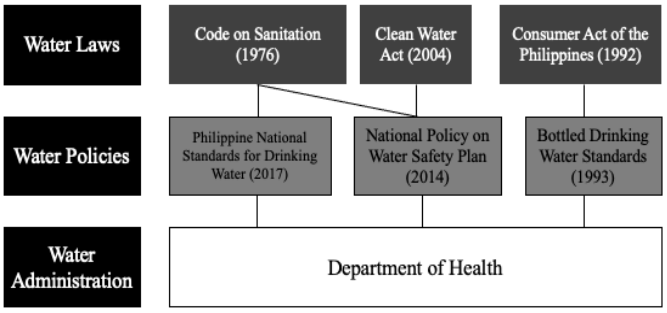

Figure 3. Department of Health mandates on drinking water safety as the national public health authority based on water laws, water policies, and water administration.

water is handled by the Committee's sectoral task force on water and sanitation.

The surveillance agencies that ensure compliance to drinking water safety policies are as numerous as the modes of drinking water provision and access. These are the Metropolitan Waterworks and Sewerage System (MWSS), Local Water Utilities Administration (LWUA), Philippine Economic Zone Authority (PEZA), Tourism Infrastructure and Enterprise Zone Authority (TIEZA), Bases Conversion and Development Authority (BCDA), Local Government Unit (LGU), and the Food and Drug Administration (FDA) (**Table 5**).

The institutional arrangements for implementing the policies set forth by the DOH to ensure the safety of drinking water shows the multiplicity of deputized government agencies mandated to regulate formal drinking water providers operating at different scales and with various management models (**Figure 4**). A number of drinking water provision modes are under the supervision of LGUs. Meanwhile, bottled drinking water is covered under a different policy framework solely regulated by the FDA.

Limitations of the current water institution framework

This section draws attention to aspects of the water institution framework that constrain effective mitigation of arsenic in drinking water. It offers insights with regard to the study's main research question, "Why do some

Table 5. Mandates of Philippine government agencies on drinking water quality surveillance based on national laws and policies.

Agency	Mandate	Enabling Law/Policy
MWSS	The proper operation and maintenance of waterworks system to insure an uninterrupted and adequate supply and distribution of potable water for domestic and other purposes and the proper operation and maintenance of sewerage systems are essential public services because they are vital to public health and safety. It is therefore declared a policy of the state that the establishment, operation and maintenance of such systems must be supervised and controlled by the state (Section 1)	Republic Act 6234: An Act Creating the Metropolitan Waterworks and Sewerage System and Dissolving the National Waterworks and Sewerage Authority; and for Other Purposes (1971)
LWUA	Promotes/finances/regulates the construction and operation of local water utilities outside Metro Manila; Exercises regulatory powers over local water districts and Rural Waterworks and Sanitation Associations (RWSA)	Presidential Decree No. 198 (1973): Provincial Water Utilities Act, as amended and Executive Order No. 124 (1987)
LGUs	Section 17: Provision of infrastructure facilities intended primarily to service the needs of the residents of the municipality… including, but not limited to… artesian wells, spring development, rainwater collectors and water supply systems; maintenance of water supply systems; non-communicable disease control services Section 16: Promotion health and safety for general welfare	Republic Act No. 7160: Local Government Code (1991)
	Section 20. Role of Local Government Units – Local government units shall share the responsibility in the management and improvement of water quality within their territorial jurisdictions… Each LGU shall, through its Environment and Natural Resources Office (ENRO)… have the following powers and functions: Monitoring of water quality; Coordination with other government agencies and civil society and the concerned sectors in the implementation measures to prevent and control water pollution.	Republic Act No. 9275: Philippine Clean Water Act (2004)
FDA	Ensure the safety, efficacy or quality of health products which includes bottled drinking water	Republic Act 9711: Food and Drug Administration Act (2009)
PEZA, TIEZA, BCDA	The DOH shall designate, deputize, coordinate or call other agencies that can assist in the implementation of the national policy on WSP	DOH Administrative Order No. 2017-006: Guidelines for the Review and Approval of the Water Safety Plans of Drinking-Water Service Providers

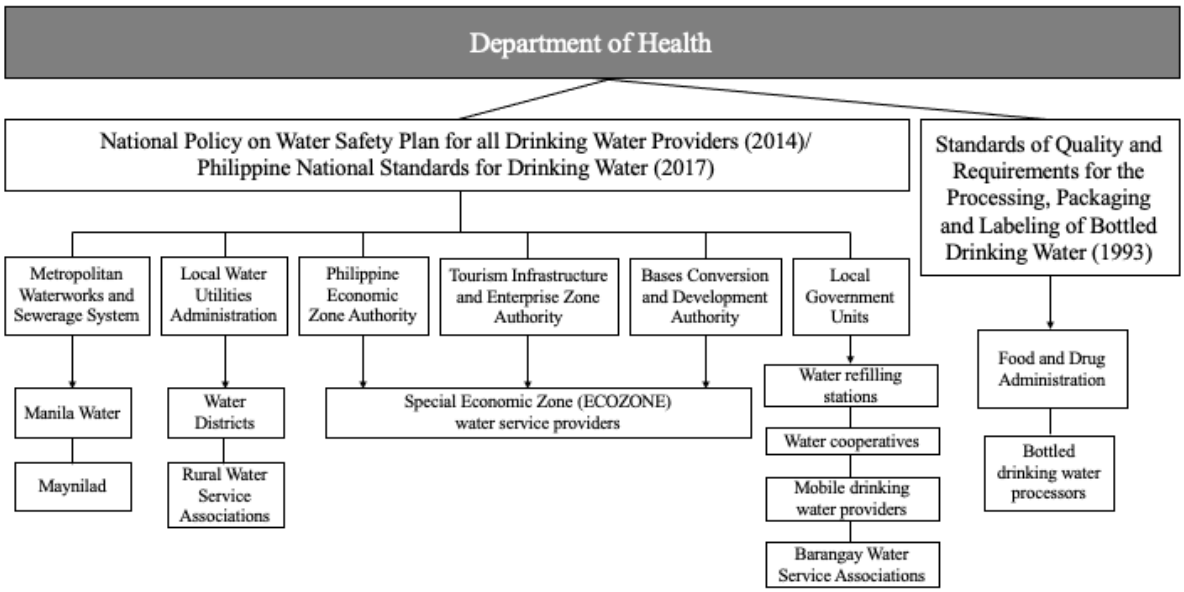

Figure 4. Drinking water quality and water safety administration structure in the Philippines.

drinking water consumers in the Philippines remain vulnerable to arsenic poisoning despite the existence of institutional arrangements for ensuring drinking water safety?" The first portion discusses limitations of the current groundwater governance paradigm within the described water institution framework. It describes limitations of groundwater resource management that can be enhanced to aid the safe delivery access to drinking water amid arsenic risks. The latter section focuses on the principles of equitable access to safe drinking water within the human rights agenda. It elucidates how the limitations of the water institution framework leads to inequitable outcomes for some drinking water consumers.

Water source protection is the first barrier against ingestion of contaminated drinking water. This preventive approach is crucial for chronic hazards such as arsenic in drinking water. Integrated groundwater management for arsenic involves understanding its spatio-temporal occurrence (*Warner et al. 2016*) to inform decision-making at the national and local levels. The Philippines' legal framework for water resource management provides for groundwater quality monitoring. However, existing programs and policy instruments are unable to provide information that will facilitate early detection of arsenic in groundwater sources. At present, classification of groundwater sources according to most beneficial use remains to be done, and if at all, excludes arsenic in its primary parameters. Designation and management of NAAs for groundwaters are limited at best, where more attention is granted to surface water sources. Pollution prevention relies primarily on GES that account for point-sources and anthropogenic pollution sources only, which does not apply to naturally occurring arsenic. The groundwater quality assessment programs likewise lack data on arsenic levels and have so far been implemented in a limited number of municipalities in the country. Although it would have been ideal to have readily available groundwater arsenic data, the realities of prohibitively expensive arsenic testing given finite financial resources is a legitimate hindrance.

Representatives of monitoring agencies present during the RTD confirm that groundwater quality data are collected by multiple agencies to varying extents and for different purposes. Groundwater resource characterization and assessments provide limited information on arsenic levels as the EMB conducts limited and only project-based, if any, groundwater quality monitoring activities; the NWRB rarely collects groundwater arsenic levels due to financial and logistical constraints; and the MGB likewise conducts limited arsenic testing due to high costs of arsenic analysis. Related studies similarly conclude that insufficient human and financial resources of these institutions hamper their ability to perform their mandates in general (*Rola et al. 2015*). Furthermore, despite all being under the DENR, ambiguity in roles and responsibilities as observed in some cases of waterborne outbreaks could cause disintegrated approaches that would need to be clarified (*Gunnarsdottir et al. 2014*).

Like the water institutions of the country, sources of arsenic contamination data are multiple and fragmented (*Rola et al. 2015*). To date, collected information remains insufficient to map arsenic hotspots and implement science-based action plans to mitigate groundwater arsenic contamination (*Solis et al. 2020; Kleinendorst et al. 2015*).

As important as the management approach for science-based reduction of arsenic risk in drinking water is the incorporation of human rights principles in the same water institution. Certain groups are more likely to be vulnerable to arsenic in drinking water as influenced by a host of social, economic, or demographic factors. Equity in access to safe water accounts for the differential needs (United Nations Children's Fund [UNICEF] and *WHO 2019*) of vulnerable populations.

The human right to safe drinking water assigned the state as the primary duty bearer to fulfill three types of obligations: to respect, protect, and fulfill these rights (*Bos et al. 2016*). In the context of protecting consumers against arsenic poisoning from drinking contaminated water, the state's duty to fulfill is of utmost importance. This means that states must create conditions that will enable the fulfillment of rights. It is gleaned from the analysis that the water institution framework described above does not provide an enabling environment for self-provisioning households.

Ensuring drinking water safety through standards enforcement is more suitable and favorable for formal water supplies. Based on a comparative assessment of nine developing countries, operational and surveillance water quality monitoring are more well-defined for formal, urban water supply systems (*Rahman et al. 2011*). As in the case of LWUA and water districts, compliance is more closely monitored and sanctioned accordingly. Policy implementation is reinforced by additional guidelines and Memorandum Circulars issued to water districts. This consistent surveillance monitoring of water quality by an independent agency not only facilitates a timely detection of water contamination, but also ensures that water service providers take measures to address health risks.

Meanwhile, informal access through self-provisioning is still practiced in the country as an alternative to or in conjunction with formal sources of water supply (e.g., combination of water district and handpump). The Philippines Environment Monitor reports that 60% of groundwater extractions were obtained without water-right permits (*Ancheta et al. 2003*). It is estimated that 20 to 21% of the country's population has no access to formal water supply services (*Abansi et al. 2018; World Bank 2005*).

Household-based water self-supply is essentially self-regulated as informal water access is beyond the state's reach (*Rola et al. 2016*). This is consistent with the rules on groundwater extraction that exempts households from obtaining a water permit. Article 6 of the Water Code (1976) states that "the owner of the land where water is found may use the water for purely domestic purposes without securing a permit." This permit-exemption status, which is a common challenge even in Australia, the European Union and United States (*Nelson and Quevaviller 2016*), give way for such water supply systems to evade regulatory controls, i.e., the PNSDW and WSP. It follows that permits certifying potability of drinking water as required by the Code on Sanitation (1976) are not obtained by these domestic water operators. While the PNSDW applies to all drinking water service providers, the limits of state power entail the lack of administrative arrangements and capacity to implement the policy in informal drinking water access.

Informal access lacks a management structure that formal systems have (*Rahman et al. 2011*) and water access is also free of charge (*Rola et al. 2018*). As common in Level I water supply system, untreated water is consumed immediately or conveyed to homes and stored for later consumption. If treated at the household, the common method used is boiling, which does not eliminate nor reduce concentrations of arsenic in the drinking water.

The WSP approach which could serve as the preventive management framework sorely needed in arsenic risk mitigation has so far been feasible for Level III water supply systems only. *Sales et al.* (*2014)* reports that the implementation of WSPs among drinking water providers in the country is still low. Constraints cited by the respondents of their study include lack of personnel and limited capacity to treat and test drinking water quality, inability to maintain equipment and facilities, and transportation constraints especially for far-off areas. For Level I and Level II water systems, *Sales et al.* (*2014*) identified limited understanding of water safety planning concepts and standards, lack of training, and low financial means as additional barriers to WSP implementation. While capacity is still being developed on the preparation of WSPs, preventive management of arsenic in drinking water through this policy instrument is also in progress.

While water policies for arsenic risk reduction are legitimate in terms of its strong legal basis, it is feeble in rural areas where its presence is limited (*Rola et al. 2016*). It is not uncommon for informal operators in rural areas with no interface with water regulators to be uninformed of national standards and legislations (*Bos et al. 2016; Rola et al. 2016*). This lack of information is aggravated by the "invisible" characteristics of arsenic in drinking water, so consumers now all the more rely to the

state for access to such information.

In cases where informal operators are informed about the standards, their capacity to comply is also arguable. Rationally, informal operators would test their drinking water for arsenic in consideration of health risks. However, water quality testing for arsenic is known to be expensive at about PhP 2,000 ($ 40 USD) per sample. This may not be affordable for low-income households who opt to source drinking water from informal supply systems. Penalizing self-provisioning households for non-compliance would be unreasonable if their capacity to comply is lacking to begin with. This lack of awareness on prescribed standards compounded by limited capacity to comply and inadequate surveillance monitoring by regulating agencies render arsenic-safety policies ineffective in contexts of informal water access.

Addressing the current limitations of groundwater management can also cover the water quality surveillance issues associated with informal water supplies. As the Philippine government and scientists now gain consciousness of this impending health crisis, more resources can justifiably be allocated for investigation in areas where toxic arsenic in groundwaters is suspected. Self-provisioning households will be the primary beneficiaries of enhanced groundwater quality monitoring that accounts for arsenic concentration. Collection and provision of such information will promote a self-protection policy so households can shift to alternative sources of drinking water.

Realities of governance limitations on the ground

Guagua, Pampanga is one of the localities with toxic levels of groundwater arsenic. A year-long monitoring and analysis of arsenic from various drinking water sources confirmed arsenic concentrations as high as 95.0×10^{-5} kg m^{-3} (*Solis et al. 2020*). The same authors conducted statistical analyses that found significant differences in arsenic levels between the wet and dry seasons. The data suggests that recorded arsenic levels are higher during the dry season.

There are various modes of drinking water provision and access in the municipality. Based on the survey conducted by the Philippine Electrochemical Arsenic Remediation Project (PHIL-ECAR-I), residents obtain their drinking water from water refilling stations (63%), tube wells (17%), and household taps connected to the local Water District (13%). With a population of 128,893 (as of 2020), it can be estimated that at least 18,904 residents access drinking water from informal sources.

Unlike water refilling stations and the Water District, informally operated tube wells are practically not covered by periodic water quality surveillance. Furthermore, these systems are not equipped with treatment facilities that are common in formal water supply systems.

Arsenic is tasteless, colorless, and odorless; and adverse health effects do not immediately manifest. Therefore, consumers obtaining drinking water from informal sources have to rely on groundwater quality monitoring activities to be informed of their vulnerability to arsenic poisoning.

CONCLUSIONS AND RECOMMENDATIONS

The country's current legislation for managing arsenic in drinking water covers systems from "source to sip". However, operationalization of groundwater quality monitoring through existing programs and policies provides insufficient information for early arsenic detection. Integrated groundwater management may not be as crucial for such systems typically equipped with treatment facilities and where operational and surveillance product water quality monitoring are strictly implemented. The rules-based paradigm is conducive for formal water supplies covered by regulatory standards within well-defined institutional arrangements and administration mechanisms. However, it fails to protect self-provisioning households as they access water from informal systems uncovered by water quality surveillance. Enhancing groundwater quality monitoring in suspected arsenic hotspots to alert self-provisioning households will promote a self-protection policy so they can shift to those are tested and/or treated in compliance with safe drinking water standards in the country.

The limitations of the water institution framework discussed in this study are by no means exhaustive. Further analysis can reveal more areas for improvement to address the emerging arsenic crisis. Nonetheless, the propositions in this paper suggest hypotheses that can guide succeeding empirical studies to understand how the arsenic problem can be addressed from a governance perspective.

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