

World Vision WASH Procurement Guidelines

Procedures and Standards for Suppliers

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Title	WASH Procurement Guidelines, Procedures and Standards for Suppliers	
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Purpose	Define the core requirements related to the quality of all WASH goods and services provided by suppliers to World Vision. Should be reviewed and followed by all WASH suppliers to ensure materials meet standards and to ensure proper documentation.	
When Used	Programme implementation	
Primary User/s	Technical Programme Lead, Area Programme Manager, FO Operations Director, Supply Chain Management and Procurement Staff	
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1. INTRODUCTION

For decades, World Vision (WV) has worked towards providing clean and safe water, sanitation, and hygiene (WASH) services to local communities in more than 60 countries. As such, it is crucial to guarantee that the materials used in the projects comply with international and national standards for quality assurance.

This document will be used to define the quality assurance expected by World Vision WASH entities (“Buyer”) from World Vision suppliers (“Supplier”).

2. WORLD VISION PROCUREMENT

The Buyer will conduct the procurement of goods and services in an open and competitive environment to ensure that the quality of goods, products and services are in compliance with national and international standards and policies.

The origin (or source), the manufacturer certification, the stamping and labelling, and the written guarantee of quality are key elements that will be considered as evidence of quality while procuring goods, materials, chemicals, and additives.

3. SCOPE AND PURPOSE OF THIS DOCUMENT

The purpose of this document is to define the core requirements that relate to the quality of all goods and services provided by the seller to the buyer during the term of any agreement with World Vision.

This document should be reviewed and followed by all suppliers while providing goods, equipment, materials, and services to maintain safety for drinking water contact. This document should also be included in any further tendering process such as a RFP.

Specifically, the purpose of this document is to:

- i. Ensure that materials received by the buyer are in accordance with all applicable international and national standards, regulations, codes, and ordinances.
- ii. Ensure proper documentation of all supplied materials that shall be subject to audit.

4. RESPONSIBILITY OF THE SUPPLIER

4.1. Supplier Quality Assurance

The supplier is responsible for the quality assurance of all goods and services delivered and must meet a minimum set of criteria below to conduct business with World Vision:

- i. Be registered and certified by appropriate International, Regional or National Standards Authority to procure WASH system construction products and services. Or, in the case of supplier being an authorized dealer of the products they are supplying they must ensure it's from a registered and certified supplier as previously indicated.

- ii. Ensure that the quality and sustainability of construction materials (such as metals, polymers, brass, and alloy materials used to manufacture goods and products) delivered to the buyer meet the required standards.
- iii. Check all technical and quality specifications of the goods and services supplied to ensure they meet the standards.
- iv. Provide evidence of quality by providing documentation, analysis, or certifications showing the compliance of the suggested goods and services requested by the WASH project.
- v. Ensure that the quality of the product is known and controlled.

4.2. Supplier Quality Records

The Supplier is responsible for providing the following records for each product and service supplied:

- i. The manufacturer references
- ii. Certificates of analysis
- iii. Certificates of conformity with the specification
- iv. Results of the laboratory analysis test for Quality
- v. Specified composition on the label

4.3. Supplier Performance

- i. The Supplier must inform the buyer immediately if there is any possible risk involved in the safety, reliability, function, or deviation from the national or international compliance related to the product supplied to the buyer.
- ii. If a supplier's assistance is required to develop the technical specifications for the goods to be procured, the buyer will request this support and all materials gathered or prepared that way will be shared with all potential bidders.
- iii. Supplier will be responsible for any costs incurred to replace or remove and products supplied that do not adhere to the standards set forth in this document. Further the supplier could be assessed a penalty if this reflects the inability of WVI to meet goals that have been committed to its donors.

4.4. Supplier Documentation

The supplier must:

- i. Provide a certified copy of a certificate of business registration, certificate of incorporation, business license or similar document
- ii. Provide a certified copy of tax registration, tax clearance certificates or similar documents

- iii. Provide information on ownership structure (Name of directors of the company / Owner)
- iv. Provide last two years of audited financial statements or tax filing, or similar documents
- v. Provide at least three references from previous customers and attach brochures of products and services provided in the past years 3 years.
- vi. Be cleared of legal disputes that ended in Court in the past three years.

4.5. Supplier Ethics

The Supplier must:

- i. Sign Conflict of Interest disclosure showing any relationship with WV staff.
- ii. Sign statement that the bidder (or any of its directors or officers) would be open to background checks including watch dog screening (where applicable)
- iii. Sign Supplier Code of Conduct
- iv. Sign WV's Child Protection Policy
- v. Sign the Anti-Corruption Policy

4.6. Supplier Bid Responses

Submission of tender responses:

- i. It is the responsibility of the Supplier to ensure that their responses are submitted correctly in accordance with the conditions stated in the tender document.
- ii. During the tendering process, WVI will use its Procurement System (ProVision) to conduct any RFQ / RFP. All terms and conditions of the tendering process will be defined within the specific tender.
- iii. Supplier tender responses should be in a PDF format

4.7. Noncompliance

A noncompliance is any disturbance in the supply of quality goods provided by the supplier to the buyer. If there is a problem with the origin, quality, and conformity of the goods or services received, the Supplier will bear all risks of loss pertaining to the noncompliant product and reimburse all costs incurred by the buyer.

The Buyer retains the right to remedy or relieve the Supplier of its responsibilities for the noncompliant material.

5. STANDARDS AND SPECIFICATIONS

Suppliers ordering materials for World Vision should have understanding of Standards that apply to WASH products. These Standards cover the performance expectations of the products as well as, in the case of drinking-water contact, the chemicals that may be leached from the product into the water. Specifically, products must meet the relevant ASTM performance specifications and the product's wetted contact materials shall not leach/contribute chemicals that represent a health risk.

Most developed countries have national standards or codes that set out the minimum requirements for material specifications, design and use of specific water system products. Countries that are members of the International Organization for Standardization (ISO) adopt the ISO framework as a minimum standard set for products and materials. WHO Guidelines for Drinking-water Quality are used as reference in decisions concerning health-related matters. Several national and international standards and certifying organizations utilize and expand upon those basic principles by identifying specific products that comply. **As World Vision is a global organization with several national offices, the products procured by its Suppliers need to be in compliance with both the national and international Standards.**

Information on various national/international certification bodies are listed in APPENDIX 1 and APPENDIX 2. **WV Suppliers should refer to the Global Standard labels, logos and markings in the Appendices as they procure products for the organization.**

5.1.WASH Contaminants

5.1.1. Toxic metals

Trace metals usually occur in very low concentrations in nature. While humans need some of them at very small amounts for good health outcomes, high levels of these metals can be toxic. Most of these metals occur naturally in drinking water because of water-rock interactions. These interactions cause some of the toxic elements to be released to drinking water from corrosion of well materials, pipes, faucets, and other plumbing fixtures. Additional information on Toxic Metals can be found in APPENDIX 4.

5.2.Standards

5.2.1. Global Standards

Globally, various organizations have worked in partnership with other stakeholders to set guidelines and standards for products and services. Most widely known are the International Organization for Standardization (ISO) and National Sanitation Foundation (NSF).

There are two types of materials available for water pipework systems: metallic and non-metallic materials. Of these, the most used materials for drinking-water supply piping are stainless steel, copper, polybutylene, unplasticized polyvinylchloride (uPVC), chlorinated polyvinylchloride (CPVC) and polyethylene (PE). Materials that are mostly used for WV in water systems construction can be grouped as follows:

- I. Wells and associated plumbing products: (Hand pumps, pipes, riser pipes, connecting rods etc.). These come in metallic and non-metallic

- II. Plumbing materials used for surface-piped water systems – pipes and pumps for mechanized water systems, including water storage tanks. These come in metallic and non-metallic
- III. Drilling Fluids (both natural and artificial)
- IV. Gravel Pack for construction wells
- V. Cement

International bodies that are accredited to offer certification to wetted contact material safety Standards include, American Society Of Sanitary Engineering (ASSE International), NSF International, CSA Group, International Code Council (ICC), Underwriters Laboratory (UL), Water Quality Association (WQA), International Association of Plumbing and Mechanical Officials (IAPMO) and ALS Trusdail. For performance of water system products, ASTM International (formerly known as American Society for Testing and Materials) have Standards that cover these areas. Other bodies have been accredited which is determined by product type. The International Plumbing Code (IPC)), IAPMO – UPC and National Plumbing Code of Canada (NRC Codes of Canada) have developed plumbing codes.

The products and construction materials that meet the requirements of the international and national certification bodies are awarded certification marks and seals of approval. Various certification bodies have various designated marks. Suppliers should **refer to the Global Standard labels, logos and markings in APPENDIX 1 and APPENDIX 2 when ordering products for WV.**

The standards applied to the construction materials for water projects include but are not limited to:

Pipes

- NSF/ANSI 61 - Pipes and fittings, valves and coatings water meters, faucets and filters. Includes stainless steel pipes for India Mark II pump riser and connecting rods.
- NSF/ANSI 14 - Large diameter pipes, fittings, drain, vent pipes, liners, waste, plastic piping system components and related materials
- Unplasticized Poly (Vinyl Chloride) (PVC-U) - This applies to pipes used to complete wells and plastic pipes uses to pipe water and Afridev pumps.
 - ISO 1452-1:2009 - Plastics Piping Systems for Water Supply And For Buried And Above-Ground Drainage And Sewerage Under Pressure - Unplasticized Poly (Vinyl Chloride) (PVC-U) - Part 1: General
 - ISO 1452-2:2009 - Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly (vinyl chloride) (PVC-U) — Part 2: Pipes
 - ISO 1452-3:2009 - Plastics Piping Systems for Water Supply And For Buried And Above-Ground Drainage And Sewerage Under Pressure - Unplasticized Poly (Vinyl Chloride) (PVC-U) - Part 3: Fittings
 - ISO 1452-4:2009 - Plastics Piping Systems for Water Supply And For Buried And Above-Ground Drainage And Sewerage Under Pressure - Unplasticized Poly (Vinyl Chloride) (PVC-U) - Part 4: Valves

- PE Pipes
 - ISO 4427-1:2019 - Plastics piping systems for water supply and for drainage and sewerage under pressure — Polyethylene (PE) — Part 1: General
 - ISO 11298-2:2018 - Plastics piping systems for renovation of underground water supply networks — Part 2: Lining with continuous pipes
 - ISO 4427-3:2019 - Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part 3: Fittings
 - ISO 4427-5:2019 - Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part 5: Fitness for purpose of the system

Treatment Systems, Water Purifiers, Filters, Water softeners

- NSF/ANSI – 55 – Ultraviolet Microbiological Water Treatment Systems
- NSF/ANSI – 58 – Reverse Osmosis Drinking Water Treatment Systems
- NSF/ANSI – 62 – Drinking Water Distillation Systems
- NSF – P231 – Microbiological Water Purifiers
- NSF/ANSI 42&53 – Point of use filters, refrigerator filters, filter pitchers
- NSF/ANSI 14 – Water softeners
- NSF/ANSI 60 – Treatment tanks, filters, pumps, generators

Drilling muds (e.g. bentonite) and additives; lubricants, cement; gravel pack for well

- NSF/ANSI 60-2016 – Drinking Water Treatment Chemicals, rehabilitation and disinfection, Coagulants and corrosion scale control
- ISO 10426-1:2009 - Petroleum and natural gas industries — Cements and materials for well cementing- Part 1: Specification

Hand and Submersible pumps

- NSF/ANSI 61 - Drilled well Casings and submersible pumps,
- ISO 5199:2002- Technical specifications for centrifugal pumps — Class II (Reaffirmed in 2018)
- IAPMO TS 15-2006- Hand actuated water pumps [IAPMO- International Association of Plumbing and Mechanical Officials]

Water overhead tanks/water storage tanks

- NSF/ANSI 61 - Water storage/overhead tanks, and coatings,
- AWWA D100 / AWWA D102 / AWWA D103 - Steel Water Storage Tanks Package [AWWA: American Water Works Association]
- AWWA D102-2017- Coating Steel Water-Storage Tanks
- ISO 1496-3:2019- Series 1 freight containers — Specification and testing — Part 3: Tank containers for liquids, gases and pressurized dry bulk
- AS/NZS 4766-2006- Polyethylene storage tanks for water and chemicals
- BS 8007: 1087 – Code of practice for design of concrete structures for retaining aqueous Liquids.

- Eurocode 2 – Design of concrete structures – Part 3- Liquid retaining structures vii. BS 8010 – Code for pipelines.

5.2.2. Examples of Country National Standards Authorities

The following list provides some examples of national authorities responsible for maintaining quality standards. Most of the national standard authorities tend to adapt standards from international regulatory bodies like ISO and NSF International. WV Suppliers should refer to these standards when they are procuring WASH products.

1) West Africa

- **Ghana**

The Ghana Standards Authority (GSA) provides standardization, quality assurance and promote standards in public and industrial welfare, health and safety. Some of the standards published by GSA is listed in APPENDIX 3.

Contact:

Phone: +233 302 50065

Email: gsadir@gsa.gov.gh

Website: <https://www.gsa.gov.gh/>

- **Mali**

The Agence Malienne de Normalisation et de Promotion de la Qualité (AMANORM) is responsible for coordinating and carrying out studies and research related to promotion of quality, certification and accreditation of standards.

Contact:

Phone: +223 20 21 06 37 / +223 20 21 06 45

E-mail: amanormmali@yahoo.fr

2) East Africa

- **Kenya**

The Kenya Bureau of Standards (KEBS) develops standards for products, measurements, materials and processes, certifies industrial products and promotes quality assurance. KEBS has marks depicting various standards. Locally produced goods are required to be certified through KEBS.

Contact:

Phone: +254 20 6948000

E-mail: info@kebs.org

Website: <https://www.kebs.org/>

- **Ethiopia**

Ethiopia Standards Agency (ESA) is the national standards body of Ethiopia. It is a non- profit government body under the Ministry of Science and Technology of Ethiopia. ESA is responsible for the development and sales of Ethiopian standards, training and technical support on implementation of standards. ESA also provides news on technical committees and technical training/support on standardization.

Contact:

Phone: +251 11 6 46 01 11

E-mail: info@ethiostandards.org

Website: <http://www.ethiostandards.org/>

3) Southern Africa

- **Zambia**

Zambia Bureau of Standards (ZABS) develops standards, conducts testing, provides quality control and assurance, training and consultancy in standardization, quality management and quality assurance.

Contact:

Phone: +260 21 1 23 13 85

E-mail: mbmweemba@yahoo.com

Website: <http://www.zabs.org.zm/>

4) Asia

- **India**

Bureau of Indian Standards (BIS) is responsible for standardization and quality control.

The IS documents tend to adapt standards from international regulatory bodies like ISO and NSF International.

Contact:

Phone: +911123230131, +911123233375

Email: info@bis.gov.in

Website: <https://bis.gov.in/>

5) Latin America and Caribbean

- **Honduras**

Honduran Standards Organization (OHN) is responsible for implementing the preparation, approval, publication and dissemination of standards to facilitate trade and technical regulations. OHN also facilitates conformity assessment, industrial development, and provides the basis for improving the quality of goods, processes, and services.

Contact:

Phone: +504 22139052

E-mail: sgomez@hondurascalidad.org

Website: <http://hondurascalidad.org/>

6. CONCLUSIONS

The longevity, sustainability, and safety of the water facilities installed through the WASH projects depends largely on the quality of the construction materials used. As such, World Vision will only accept materials according to the quality requirements stated by various international and national standard authorities.

APPENDIX 1: International Certification Bodies

Brief introductions of some of the international certification bodies are discussed below.

- **The International Organization for Standardization (ISO)**



The ISO is a non-profit global federation of national standard members based in Geneva, Switzerland, that works to develop standards. According to the ISO website, there are 164 member countries across the global federation. The members come from national authorities controlling the standardization of goods and products or private groups interested in standardization. The ISO technical experts from each ISO member country form a technical committee in a given subject area. The committee develops draft standards to meet a certain need, share among partners to test and provide feedback. ISO then works with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization to move towards standardization. The standards are compiled and put to vote. At least 75% of the ISO members must agree to recognize and adopt the standards from the votes cast before the standards are published. These documents are published in the format of ISO number. For example, ISO 24521 deals with broad activities related to drinking water and wastewater services and guidelines.

When approached for standards on rural water supply systems, ISO indicated that there were some guidelines on plastic pipes but none on pumping devices. Although not much is available on rural water supply pumps and spare-parts, ISO 1452-1, 1452-2, 1452-3, 1452-4 and 1452-5 lay some fundamental guides for using plastic pipes for conveying and distribution drinking water and wastewater, both above and below ground.

- **National Sanitation Foundation International (NSF, or ANSI or CAN)**

Formerly known as National Sanitation Foundation, NSF International is an independent accredited body established in 1944, headquartered in Ann Arbor, Michigan, USA. NSF metamorphosed into NSF International in 1990. With regional offices located in all continents, the organization has a mission to protect and improve global human health through facilitating development by setting standards, certifying products and systems, and providing auditing and risk management solutions for the environment and public health.

Certification Body	Certification Mark(s)		
NSF International			NSF-61-372 NSF-61-G NSF-372 NSF pw-G



Plumbing can bear several different marks for NSF. In this example, "NSF-pw" means that the pipe was certified for potable water use

- **American National Standards Institute (ANSI)**

The American National Standards Institute (ANSI) accredits the procedures of standards developing organizations in the United States private sector. The accreditation by ANSI means that the procedures taken by the standards developing organization meets ANSI's requirements for openness, consensus, balance and due process.



- **ASTM International**

Formerly known as American Society for Testing and Materials, ASTM international develops and publishes voluntary technical standards for various industries.



- **The International Association of Plumbing and Mechanical Officials (IAPMO)**

IAPMO coordinates the development and adaptation of several codes to meet the specific needs of individual jurisdictions both in the United States and abroad.

IAPMO develops and publishes:

- Uniform Plumbing Code (UPC)

- Uniform Mechanical Code (UMC)

	Website	Link to purchase Standards	Region
ANSI	https://www.ansi.org/	https://webstore.ansi.org/	USA
ASTM	https://www.astm.org/	https://www.astm.org/Standard/standards-and-publications.html	International
IAPMO	http://www.iapmo.org/	https://iapmomembership.org/index.php?option=com_virtuemart&Itemid=3&vmcchk=1&Itemid=3&redirected=1&Itemid=3	
ISO	https://www.iso.org/home.html	https://www.iso.org/standards.html	International
NSF International	http://www.nsf.org/	https://www.techstreet.com/nsf/	International

- Uniform Swimming Pool, Spa and Hot Tub Code (USPSHTC)
- Uniform Solar Energy and Hydronics Code (USEHC)



APPENDIX 2: National Certification Bodies

The certification marks of some of the national certification bodies are discussed below.

- **Bureau of Indian Standards (BIS)**

The *ISI Mark* certifies that a product conforms to the Indian standard (IS) that is developed by the BIS.



ISI Mark

- **Kenya Bureau of Standards (KEBS)**

The *Standardization Mark* certifies that a product conforms to the required standards. This is mandatory for all locally manufactured product.

The *Diamond Mark of Quality* is a voluntary product certification that is awarded to manufacturers that have demonstrated high degree of excellence in product manufacturing and quality.

The *Import Standardization Mark of Quality* is required for all imported products intended for sale in the local market.



*Standardization Mark
Quality*



Diamond Mark of Quality



*Import Standardization Mark of
Quality*

- **Ethiopian Standards Agency (ESA)**

The ESA authorizes the *Ethiopian Standard Mark* that are awarded to products that conform to the corresponding standards.



Ethiopian Standard Mark

- **Zambia Bureau of Standards (ZABS)**

ZAMS authorizes the use of the *Product Certification Mark* for products that meet the corresponding standards.



The Product Certification Mark

APPENDIX 3. List of Standards available from Ghana Standards Authority (GSA)

LIST OF STANDARDS

- 1) uPVC, PE and Stainless-steel pipes for well construction and piping water (for both below and above ground systems)
 - i. **ISO 15877-1:2009** Plastics piping systems for hot and cold-water installations — Chlorinated poly (vinyl chloride) (PVC-C) — Part 1: General
 - ii. **ISO 15877-2:2009** Plastics piping systems for hot and cold-water installations — Chlorinated poly (vinyl chloride) (PVC-C) — Part 2: Pipes
 - iii. **ISO 1452-1:2009** Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Un-plasticized poly (vinyl chloride) (PVC-U) — Part 1: General
 - iv. **ISO 1452-2:2009** Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Un-plasticized poly (vinyl chloride) (PVC-U) — Part 2: Pipes
 - v. **ISO/TR 4191:2014** Plastics piping systems for water supply — Un-plasticized poly (vinyl chloride) (PVC-U) and oriented PVC-U (PVC-O) — Guidance for installation
 - vi. **B36.10M – 2018** - Welded and Seamless Wrought Steel Pipe
 - vii. **ASTM A999/A999M – 18** - Standard Specification for General Requirements for Alloy and Stainless-Steel Pipe
- 2) Drilling muds (e.g. bentonite) and additives; lubricants, cement; gravel pack for well Construction;
 - i. **NSF/ANSI 60-2016** – Drinking Water Treatment Chemicals
 - ii. **ISO 10426-1:2009** - Petroleum and natural gas industries — Cements and materials for well cementing- Part 1: Specification
 - iii. **GS 1118: 2016**- Building & construction materials –Composition, specifications and conformity criteria for common cements.
- 3) Hand and Submersible pumps
 - i. **ISO 5199:2002**- Technical specifications for centrifugal pumps — Class II (Reaffirmed in 2018)
 - ii. **ISO 9908:1993**- Technical specifications for centrifugal pumps — Class III (Reaffirmed in 2017)
 - iii. **ISO 9905:1994**- Technical specifications for centrifugal pumps — Class I (Reaffirmed in 2017)
 - iv. **ISO 3069:2000**- End-suction centrifugal pumps — Dimensions of cavities for mechanical seals and for soft packing (Reaffirmed in 2018)
 - v. **ISO 9906:2012**- Rotodynamic pumps — Hydraulic performance acceptance tests — Grades 1, 2 and 3
 - vi. **IAPMO TS 15-2006**- Hand actuated water pumps
[IAMPO- International Association of Plumbing and Mechanical Officials]
 - vii. **DIN 5437:1987**- Hand pumps; semi rotary pumps; sizes, performance and dimensions
 - viii. **GB/T 2816-2014e** - Submersible pumps for deep well

- 4) Water overhead tanks/water storage tanks
- i. **AWWA D100 / AWWA D102 / AWWA D103** - Steel Water Storage Tanks Package [AWWA: American Water Works Association]
 - ii. **AWWA D102-2017**- Coating Steel Water-Storage Tanks
 - iii. **ISO 1496-3:2019**- Series 1 freight containers — Specification and testing — Part 3: Tank containers for liquids, gases and pressurized dry bulk
 - iv. **AS/NZS 4766-2006**- Polyethylene storage tanks for water and chemicals
 - v. **BS 8007: 1087** – Code of practice for design of concrete structures for retaining aqueous liquids.
 - vi. **Eurocode 2** – Design of concrete structures – Part 3- Liquid retaining structures
 - vii. **BS 8010** – Code for pipelines.

APPENDIX 4. Toxic Metals

Toxic metals have the following impact on human health:

- 1) **Antimony** is known to be a carcinogenic and causes lung diseases, diarrhea, severe vomiting, heart problems, and stomach ulcers. Antimony is found in natural deposits in the form of ores. Antimony can leach from plumbing materials, mining wastes, manufacturing effluent, fertilizers, landfills, and fossil fuel combustion products.
- 2) **Arsenic** is widespread in the environment due to its natural occurrence and former extensive use in pesticides. Symptoms of chronic arsenic poisoning are weight loss, hair loss, nausea, white lines across the toenails and fingernails, depression, and general fatigue. Long-term exposure to inorganic arsenic causes skin pigmentation change and lesions and eventually may lead to cancer. Arsenic occurs naturally in groundwater thorough underground mineral deposits but may be released in nature due to industrial activities, pesticides, and industrial waste, smelting of copper, lead, and zinc ore.
- 3) **Barium** at high doses can cause damage to the heart, blood vessels, and nervous system. Barium is found naturally in nature in some limestone.
- 4) **Cadmium** poisoning has been associated with kidney disease, hypertension, and possibly genetic mutation. Cadmium is a naturally occurring element but cadmium contamination in groundwater may be due to industrial discharge, mining waste, metal plating, water pipes, batteries, paints and pigments, plastic stabilizers, and landfill leachate.
- 5) **Chromium** may cause lung tumors when inhaled and has adverse effects on aquatic life. Chromium may contaminate groundwater from old mining operations runoff, fossil-fuel combustion, mineral leaching, and waste incineration. It is also used in metal plating and as a cooling-tower water additive.
- 6) **Copper** in large doses is dangerous to infants and people with certain metabolic disorders. On the other hand, lack of copper intake causes anemia, growth inhibition, and blood circulation problems. Copper seldom occurs naturally in the water supply, but it is usually detected in drinking water. Corrosion of pipes, faucets and other plumbing fixtures is the most common source of copper in drinking water.
- 7) **Iron** in water is not a health hazard by itself but it may increase the hazard of pathogenic organisms, since many of these organisms require iron to grow. Iron may leach into the water supply as galvanized iron pipes are susceptible to internal and external corrosion especially where galvanized steel or iron piping is connected to dissimilar materials, such as copper alloy (brass) in taps and valves. High concentration of iron in drinking water causes an undesirable taste and unsightly precipitation of iron salts on clothes.
- 8) **Lead** has multiple targets in our body and is deposited mainly in bones teeth, and bones. Children absorb four to five times as much lead as adults and may suffer from neural diseases and anemia. Sources of lead in water supply include the internal and external corrosion of lead pipes, faucets, plumbing fixtures and faucets soldered with lead.

- 9) **Manganese** in large doses causes headaches, apathy, irritability, insomnia, and weakness of the legs. Long-term heavy exposure may result in a nervous system disorder. Manganese can seep in groundwater through mineral deposits or from mining and industrial waste contamination.
- 10) **Selenium** in large doses causes growth inhibition, and may also cause skin discoloration, bad teeth, and some psychological and gastrointestinal problems. A small amount of selenium has been shown to protect against poisoning by such metals as mercury, cadmium, and silver. It can be found naturally in nature from geologic sources, sulfur, and coal.
- 11) **Strontium** may cause anemia and oxygen shortages, and at extremely high concentrations it is even known to cause cancer as a result of damage to the genetic materials in cells. Strontium is a naturally occurring element and can seep into groundwater as it dissolves from mineral deposits.