Sandec Department of Sanitation, Water and Solid Waste for Development

Chlorination technologies for small piped supplies in Nepal: Practical implementation guide

Cartridge system

Dosing system

Globally, 2.2 billion people lack safely managed drinking water, largely due to faecal contamination. In Nepal, most people have access to an improved source, but fewer than one in five receive water free from contamination - especially in rural areas. Around half of rural households rely on piped systems, but only 47% of piped users are served by systems that include treatment to eliminate microbial contamination, posing serious health risks, particularly for young children.

Helvetas Nepal, in collaboration with Eawag and charity: water, has implemented system-level, low-cost chlorination technologies to reduce microbial contamination in rural piped water systems and ensure safe drinking water.

Aims of this Learning Brief

This learning brief is designed for practitioners and program implementers working in small piped supplies in Nepal. Drawing on Helvetas Nepal's practical experience and its collaboration with Eawag through the Water, Behavior Change and Environmental Sanitation (WABES) program, it summarizes low-cost, system-level chlorination technologies, providing guidance on installation, materials, and cross-cutting considerations.

The brief outlines two promising chlorination technology types: dosing units and cartridge systems.

Key Insights

- Proper installation and operation of injection and passive chlorinator systems, such as those implemented by Helvetas Nepal, depend on clear guidance and schematics for flow control, valves, and meters.
- In addition to technical design, effective chlorination requires routine monitoring, seasonal dose adjustment, centralized record keeping, and community engagement.

Government of Nepal
Department of Water and Sewerage Management

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Context

Microbial contamination remains a major challenge in rural piped water supplies in Nepal, posing significant public health risks **[1]**. Recognizing the importance of safe drinking water, the Department of Water Supply and Sewerage Management (DWSSM) within the Ministry of Water Supply (MoWS) have issued a nationwide Call to Action in 2025 to promote chlorination and ensure safe water supply across the country, in accordance with the National Drinking Water Quality Standards, 2079 B.S. **[2]**.

To maintain consistent chlorination and protect against recontamination, various low-cost chlorination options for small systems have been successfully implemented in Helvetas Nepal's programs, with technical support from Eawag **[3,4]**. To share research insights and lessons learned with the wider sector working in safe rural water supply, in accordance with the Call to Action, this brief describes various chlorination technology options suitable for small piped supplies, including detailed guidance on installation, materials and assembly/ connections required, schematic illustrations, and other cross-cutting considerations.

Two Strategies for Chlorination

Dosing units

Dosing units are semi-automated injection chlorinators that inject a precise amount of chlorine into a reservoir tank where mixing occurs, or directly into the main water line. A concentrated chlorine solution is prepared in a dosing tank using a motorized or manual agitator and dispensed at a controlled dose via pump or gravity.

Cartridge systems

One type of passive chlorinator works to dispense chlorine by slowly dissolving solid chlorine tablets or cartridges as water flows through the device. They do not require electricity and adjust dosing based on flow, making them suitable for systems with variable water flow.

Interim solution

Stopgap strategy: Manual chlorination in piped water supply schemes

For many rural schemes, a full chlorination system is a long-term investment. Manual chlorination offers an easy, quick, and low-cost way to boost drinking water safety before a chlorinator can be purchased. This "incremental improvement" focuses on small, practical adjustments to enhance treatment efficiency.

Although manual chlorination is generally more labor-intensive and susceptible to errors, simple measures can improve operator efficiency and dosing accuracy.

Pre-preparing a precise chlorine solution reduces operator time and ensures consistent strength and accurate dosing. The following steps should be followed, with solution strength and dosing adjustable to specific needs:

1. **Mix** 400 g of bleaching powder into a 20 L jerrycan filled with water in a central, controlled location using a measurement scale.
2. **Store** the concentrated chlorine solution properly in a cool, dry and secure space.
3. **Dose** the chlorine solution by measuring and pouring a consistent volume into the reservoir tank to reach the desired concentration (typically 1 mg/L, or 50 ml of this solution per m^3 of water).

Option 1: Dosing units (semi-automated injection chlorinators)

Semi-automated injection chlorinators, or dosing units, inject a controlled amount of a concentrated chlorine solution into a reservoir tank or main water line. These units can be installed at various points, including at reservoir tanks or along distribution lines. Using pipeline diagrams and mapping of served households helps identify the optimal installation site for effective coverage and operational efficiency.

While the following sections describe the two main approaches (gravity-fed dosing systems and pump dosing systems), **Table 1** outlines additional configuration considerations, including tank setup, water diversion into the dosing tank for easier chlorine solution preparation, chlorine type, and mixing methods. For example, using a pump to lift water to the mixing tank can ease the operator's workload for filling and cleaning tasks.

1A. Gravity-fed dosing system

In gravity-fed piped systems, the chlorine solution flows into storage structures by gravity through a valve or flowmeter, which must be adjusted to deliver the correct dose. Installation considerations include:

- ➔ **Place the dosing tank above the injection point** to ensure consistent flow without the need for pumps or electricity.
- ➔ **Use correct piping components**: The use of non-steel fittings, flow regulators, and Y-strainers facilitates reliable operation and maintenance while preventing reverse flow and floating.
- ➔ **Reduce contamination risks** by using secured dropping pipes and drain connections to pits.
- ➔ **Regularly inspect the site** every 2-3 days to ensure proper functioning.

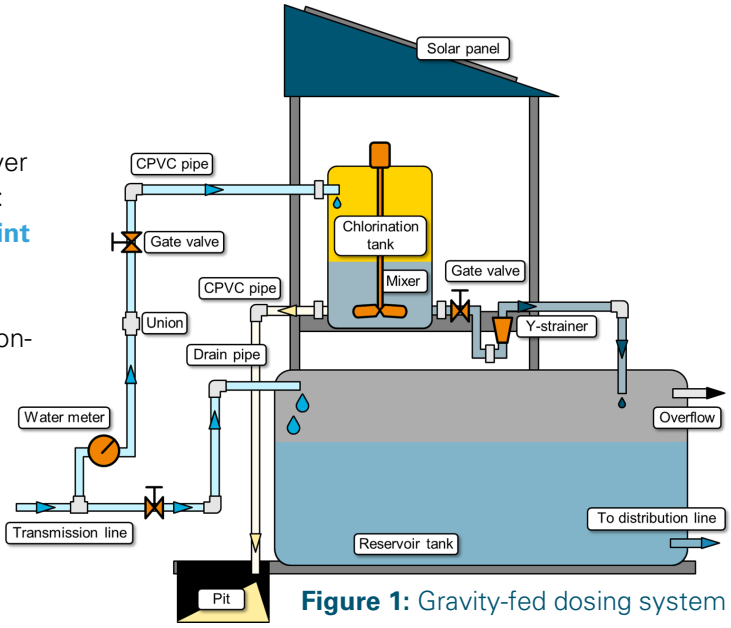

Figure 1: Gravity-fed dosing system

1B. Pump dosing system

In pump dosing systems, a small pump delivers the chlorine solution into storage structures or directly into transmission or distribution lines at a controlled rate. This allows precise dosing even when the dosing tank is below the injection point. Installation considerations include:

- ➔ **Choose flexible installation location** around storage structures or distribution lines to enable optimal site access while maintaining operational efficiency.
- ➔ **Check chlorine solution** to ensure the concentrated chlorine mixture contains minimal fine particles to avoid clogging the pump.
- ➔ **Ensure continuous electricity access** using solar or grid power depending on site suitability.
- ➔ **Protect the pump** by submerging the foot valve in fine chlorine solution, and avoiding valve pipes to interfere with the agitator propeller.
- ➔ **Ensure consistent dosing**, as sudden loss of power can cause air bubbles, disrupting dosing and requiring priming.
- ➔ **Ensure correct installation** by ensuring the dosing pump injects the solution into the main pipeline using an injection quill and saddle setup.
- ➔ **Enhance strength of chlorine solution** when dosing directly into distribution lines with intermittent supply, as a stronger chlorine solution may be required to account for occasionally high flow rates.

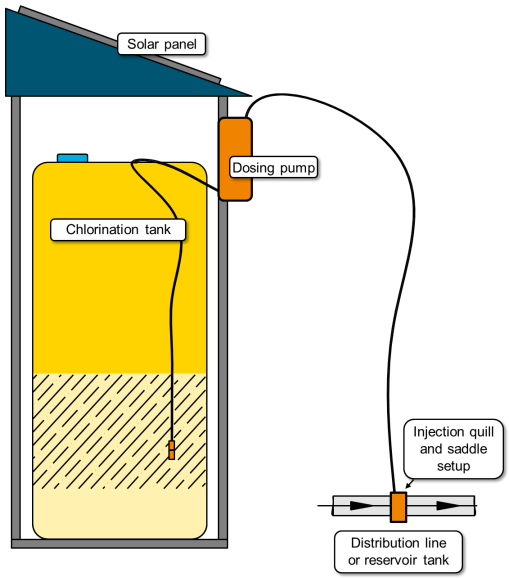

Figure 2: Pump dosing system

Table 1: Dosing unit configurations and key considerations

System Element	Options	Description	Notes
I. Tank Setup	Single	One chemical-resistant tank (100 - 200 L) for mixing and distributing chlorine	Ensure slaked lime ($Ca(OH)_2$) is washed out from the tank before the next preparation
	Double	Two tanks in cascade: one for mixing, the other for storing and distributing chlorine	Additional cost and space requirements
II. Water Supply to Tank	Manual	Water collected manually in bucket to fill the chlorination tank	Labor-intensive cleaning and preparation of solution may lead to discontinuation of dosing
	Transmission Line	Water diverted to the chlorination tank through a valve setup in the transmission line	A valve and pipe fittings (as shown in **Figure 1**) can supply water to the chlorination tank
	Pumping	0.5 horsepower (HP) pump pumps water from reservoir tank to chlorination tank	Requires electricity to lift water
III. Raw Material for Chlorination	Liquid	Liquid solutions (NaOCl or electrolysis of NaCl)	Not commonly practiced in Nepal, yet could address pipe clogging and mixing challenges
	Granular	Highly concentrated chlorine granules (TCCA, 90% active chlorine)	Limited availability in Nepal
	Bleaching Powder	Chlorine in powder form ($Ca(OCl)_2$, 30% - 35% chlorine)	Most commonly used chlorine source in Nepal. Cost-effective, but requires careful storage, handling, and residue management
IV. Mixing	Manual	Manual mixing of powder and water using a bearing-based mixer	Selection of material is crucial to avoid corrosion (CPVC or PVC)
	Motorized Agitator	Motor-driven chemical-resistant agitator (0.5 kW) for efficient mixing	Ensure proper depth and positioning of the agitator for effective mixing
V. Dosing Method	Gravity-fed	Chlorine solution continuously supplied to storage structures via gravity using a valve or flowmeter	Dosing tank should be located above drip point
	Pumped	0.03 kW dosing pump injects chlorine solution into the storage or transmission/ distribution pipeline	Requires continuous electricity for operation, suitable for consistent dosing in pressurized lines. For high flow periods when reservoir tanks overflow, dosing can be done in the distribution line.

Operating steps for dosing units

- **Verify power supply and inspect fittings**: Check electrical connections; close all supply line valves to isolate system.
- **Partially close main pipe valve**: Fill chlorine tank to halfway mark for controlled initial volume.
- **Run agitator for 1 minute, then start washout cycle**: Open washout valve until the chlorine tank is empty, close, repeat until residues are removed, ensuring thorough cleaning.
- **Add bleaching powder**: Close water supply; add 3.3 kg for a 200 L dosing tank to achieve required concentration (corresponds to 7-8 days of use, disinfecting approximately 150 m^3/day at 1 mg/L).
- **Fill with water to propeller level**: Open water supply briefly, then close to avoid overflow during mixing.
- **Mix for 10 minutes:** Run agitator continuously for uniform chlorine solution preparation.
- **Fill tank completely with agitation**: Reopen water supply while agitator runs to fill the chlorine tank to final volume.
- **Stop agitation and open main supply**: Close water supply to the chlorine tank; allow system integration.
- **Settle for 30 minutes and then dose**: Gradually open chlorine valves based on experience for optimal dosing. Note that a trial-and-error method may be necessary to determine optimal dosing.

Option 2: Cartridge systems (passive chlorinators)

Passive chlorinators automatically dose chlorine as water flows through the system. One common type, cartridge systems, slowly dissolve chlorine tablets or cartridges as water passes through. They require no electricity and automatically adjust the dose to match variable flow rates. Passive chlorinators available in Nepal, including PurAll, Aquatabs Flo, and Aquatabs Inline, can be installed at different locations within a piped water supply system. General installation considerations are summarized in the box below, with additional guidance for different system levels provided in the following sections.

2A. Installed before the reservoir tank

In this configuration, the passive chlorinator is installed at a central level on the transmission pipe before water enters the reservoir tank. The steps for installation include:

- ➔ **Install unit on the transmission pipe** to chlorinate the main transmission line.
- ➔ **Use existing valve chamber** to install the chlorinator; alternatively, construct additional chamber or metal safety cage if needed.
- ➔ **Create a cartridge supply branch** to tap supply from transmission pipe; control flow with globe valve to ensure accurate dosing.
- ➔ **Inject chlorine solution** by returning treated water back into the transmission line for full system chlorination (closed end) OR delivering the chlorinated water directly into the reservoir tank (open end).
- ➔ **Refer to system diagram** in **Figure 3** for correct positioning and connections (open or closed end).

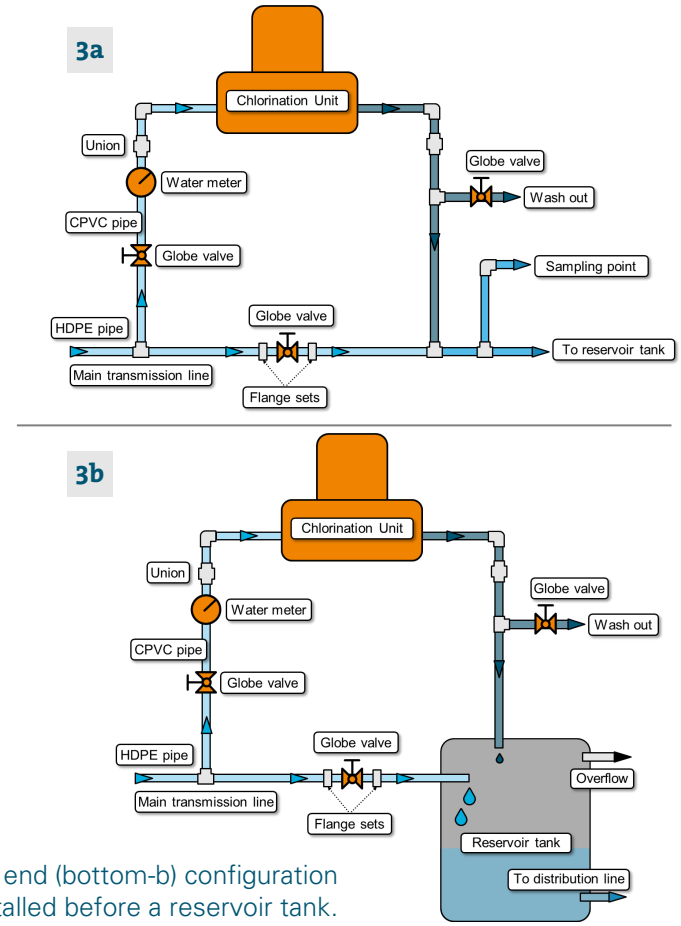

Figure 3: Closed end (top-a) and open end (bottom-b) configuration of a passive chlorinator installed before a reservoir tank.

2B. Installed after the reservoir tank

In this configuration, the passive chlorinator is installed at the outlet of the reservoir tank on the distribution line. Installation steps include:

- ➔ **Install unit in valve chamber** on the distribution line.
- ➔ **Use closed end configuration** to ensure proper flow through the cartridge and back into the distribution line.
- ➔ **Use gate valve** installed on the distribution line to regulate flow of chlorinated water.
- ➔ **Install a water meter** to monitor flow; position carefully to prevent chlorine stagnation.

Operating steps for cartridge systems

1. **Clean cartridges and install unions:** Rinse cartridges before use; add unions for easy replacement and maintenance.
2. **Add washout, non-return valves, ventilation:** Install washout setup, non-return valves, and open space to prevent gas buildup and reverse flow.
3. **Start minimal dosing with water meter:** Begin low dosing, monitor flow with meter to verify performance and adjust gradually.
4. **Protect from turbidity:** Close valves before rainfall to shield cartridges from high-turbidity water.

2C. Installed further in the distribution line

In long distribution networks, chlorine residuals can decline unevenly, resulting in nearest households receiving overdosed water, while furthest households risking recontamination from residuals below target values. While chlorine decay depends on several factors, residuals generally decrease with distance from the chlorination point **[5]**. Strategic placement of the passive chlorinator at mid-segment can balance dosing across the network, ensuring consistent protection throughout the distribution system.

Installation considerations include:

- ➔ **Determine the optimal installation location** based on the pipeline diagram and household distribution, targeting areas with low residuals.
- ➔ **Use closed end configuration** as the standard installation method.
- ➔ **Install unit in a chamber accessible to the operators**; construct an additional safety chamber if required.

2D. Installed at the household level

This is the most decentralized configuration, where the passive chlorinator is installed at a household water storage tank, after the tap connection. A small portion of the incoming water is diverted through a cartridge unit for chlorination. The chlorinated water then flows directly into the storage tank, while the main supply line continues to fill it. An overflow pipe prevents overfilling and ensures safe, continuous operation. **Figure 4** illustrates a schematic overview of this setup (e.g., Aquatabs Flo). Installation considerations include:

- ➔ **Assess tank dimensions** by measuring storage tank size and structural capacity before installation to ensure adequate space and support for the unit. Cylindrical 500 - 1000 L tanks are generally suitable.
- ➔ **Install valve network**; Main gate valve controls main raw water inlet; Globe Valve I directs flow through chlorination cartridge; Globe Valve II regulates precise cartridge flow for dosing control.
- ➔ **Use corrosion-resistant, non-steel piping** inside tank to prevent rust contamination, such as CPVC or PVC.
- ➔ **Add union on cartridge branch** to facilitate easy initial installation and quick cartridge replacement during maintenance.
- ➔ **Include bypass arrangement** to allow continuous raw water supply to tank during chlorination unit servicing or repairs.
- ➔ **Position overflow pipe and float valve** below main supply line; float valve automatically cuts off water at overflow level to prevent spillage and optimize efficiency.

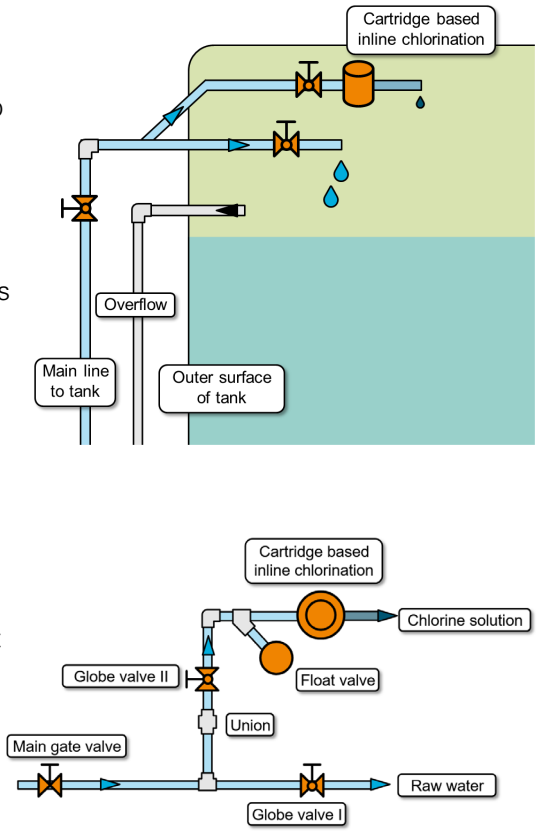

Figure 4: Configuration of a passive chlorinator installed at the household level (e.g., Aquatabs Flo)

Calculating CT: Chlorine Dose for Effective Disinfection

The CT value represents the *concentration of free chlorine residual (C) and the time of contact (T).* The CT value must meet or exceed regulatory requirements for specific microorganisms. It is calculated as: **CT (mg·min/L) = free chlorine residual concentration (mg/L) × contact time (min)**. For effective chlorination, WHO recommends a target CT of **15 mg·min/L**, equivalent to **0.5 mg/L for 30 minutes** at pH < 8.0. In Nepal's gravity-fed rural systems, experience shows that chlorinating at the storage tank before water is released generally provides adequate CT, but overflow events may result in significant chlorine loss. In larger piped networks with rapid chlorine loss, post-tank or distribution-line dosing may be more effective for maintaining chlorine residual at taps, provided sufficient CT is achieved before the first consumer. Ultimately, chlorination location depends on scheme-specific factors, such as supply intermittency, tank and network size, overflow conditions, and operator capacity, alongside promoting safe household storage and handling practices.

Cross-cutting considerations

Scheme-specific chlorination strategy

Chlorination strategies must be tailored to the specific water quality and seasonal variations of each scheme, considering source type, treatment structures, turbidity, pH, and microbial levels. For water sources with turbidity above an acceptable level (> 5 NTU), pre-treatment such as roughing sand filtration should be considered. Seasonal flow variations may require dosing adjustments. In schemes with high rainy-season flows and limited storage, chlorinating water upstream of the reservoir can lead to chlorine losses due to overflow. Scheme size and network length can affect chlorine decay. Accounting for these factors enables accurate dosing and chlorinator placement to address seasonal fluctuations and maintain chlorine residual within national standards. This approach supports safe, effective water treatment throughout the year.

Monitoring considerations

To address under- and over-dosing caused by temporal water quality variations, chlorine storage conditions, or operator errors, regular chlorine measurements are essential. Measure chlorine residual at least twice weekly at key points: dosing point, nearest tap and household, and furthest tap and household. This verifies effective chlorination across the system. Monitoring ensures consistent dosing, compliance with national guidelines (typically 0.1–0.5 mg/L at the point of use) **[2]**, and early contamination detection.

Record keeping considerations

Nepal's National Water, Sanitation and Hygiene Management Information System (NWASH MIS) platform enables real-time visibility of local water quality within a national platform, strengthening operational compliance, and adherence to chlorination guidelines **[6]**. Immediate data uploads by trained operators using smartphones for turbidity, pH, and chlorine residual testing, combined with laboratory validation, strengthen oversight and citizen science participation. Centralized data tracking facilitates resource allocation decisions, trend analysis, and proactive management of safely delivered water across schemes.

Figure 5: NWASH MIS platform showing WASH status across Nepal.

Community inclusion and sensitization

User Committee awareness campaigns and household chlorine testing enable communities to link safe chlorine levels to health protection. Chlorination can face acceptability challenges, as users may dislike the taste or odor and perceive it as unsafe, turning to alternative sources. To build trust, community leaders and water users need to be engaged. Regular household chlorine monitoring builds user confidence. It visually connects the proper dosing to pathogen protection and improved palatability, reducing complaints.

Handling and occupational risks

For all chlorination methods, avoid direct skin contact when preparing chlorine solutions or replacing tablets. Additional safety considerations are method-specific:

Dosing units: Exercise caution with electrical lines, especially since installations are often in remote forest areas. Poorly connected transmission lines or support structure wiring increase the risk of electrocution.

Cartridge systems: Cartridges installed in valve chambers are challenging to access for maintenance or repair. Open the sealed chamber carefully to avoid inhaling chlorine gas.

Manual chlorination: Improper handling can reduce chlorine effectiveness and pose health hazards, including skin or clothing exposure and inhalation of chlorine gas.

Disposal: Residual chlorine from cartridges or bleaching powder must be safely collected and disposed of to prevent contamination or health risks. Residuals should be dechlorinated, and highly alkaline $Ca(OH)_2$ neutralized. Avoid direct release into water bodies or farmland. Safe disposal areas include soakaways, drainage pits, or areas away from people, animals, and water sources where soil can buffer alkalinity.

Cost considerations

While manual chlorination requires minimal upfront investment, dosing units or cartridge systems offer more systematic and less labor-intensive long-term solutions. Upfront costs are typically up to around US$ 1'000 (NPR 150'000), including chlorinators, pipes, fittings, and electrical components, depending on system design and materials. Operational chlorine costs are low for manual chlorination and dosing units using bleaching powder with < US$ 0.01/m³ (< NPR 1/m³), but higher for passive chlorinators using tablets or cartridges, typically US$ 0.1–0.3/m³ (NPR 10–50/m³). However, passive chlorinators reduce operator workload and eliminate electricity needs.

Conclusions and opportunities

This brief offers practical guidance for NGOs, government agencies, and implementing partners on installing commonly used chlorination technologies, covering dosing setup, water quality monitoring, and routine maintenance. While it is specific to the Nepal context, many aspects can be adapted to similar settings elsewhere. This brief is not a detailed selection guide and factors such as flow rate, beneficiary size, operator skills, costs, and long-term upkeep should also be considered when selecting a chlorinator.

While installation guidance is essential for scaling chlorination in rural piped supplies in Nepal, other key factors include selecting context-appropriate technologies to reduce operator workload, developing local supply chains, and strengthening operator training and community awareness.

Glossary

CPVC / HDPE	Chlorinated Polyvinyl Chloride / High-Density Polyethylene: Materials used for manufacturing the pipes
Flange sets	Kit of bolts, nuts, washers, gaskets and circular rims to join two pipe ends
Gate valve	A shut-off valve used to fully start or stop water flow using a sliding gate
Globe valve	A regulating valve used to adjust and control the amount of water flow
Horsepower (HP)	A common term used with pumps to estimate pump power
Injector quill and saddle setup	An Injector Quill and Saddle Setup is a fitting where a quill (hollow tube) is inserted into a saddle on a pipe to accurately inject chemicals, like chlorine, into a water system
Non-return valve	A one-way valve that automatically prevents water from flowing backward through a pipe
NWASH MIS	National WASH (Water, Sanitation, and Hygiene) Management Information System
Slaked lime ($Ca(OH)_2$)	A slurry leftover after preparing the chlorine solution from bleaching powder ($CaOCl_2$)
TCCA	Trichloroisocyanuric acid: High-concentration chlorine compound
Transmission / distribution line	While a transmission line delivers water from source to reservoir tank, a distribution line delivers water from reservoir tank to community homes
Union	A pipe fitting union is a three-part connector that joins two pipes and allows for quick, non-rotational disassembly for maintenance or replacement of system components
Washout setup	A drain valve and pipe setup used to release accumulated sediment from the drinking water system
Y-strainer	A filter shaped like the letter "Y" that uses a mesh screen to trap and remove solid debris from water

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WABES water

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