Rural water quality improvement in Amazonian Peru – Developing effective household point-of-use drinking water treatment protocols

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Peru

- 29.2 million people
- Capital city is Lima, located on the central coast
- Official language: Spanish
- 25 administrative regions
- Covers 1,285,220 km² (496,193 sq mi)
- 3 geographic divisions:
  - Coastal – arid, plain
  - Sierra – mountains, highplain
  - Jungle – Amazonic lowlands

Access to Water in Peru

- Access to Improved Water:*
  - 64% of rural households
  - 90% of urban households

- Many households in rural and urban areas still depend on unimproved sources

- Water from an improved source may not be safe

- Quality can deteriorate during collection, transport, and storage

- Point-of-use treatment an appropriate intervention

Healthy Communities and Municipalities Project

Municipios y Comunidades Saludables
JUNTOS POR UNA VIDA SALUDABLE

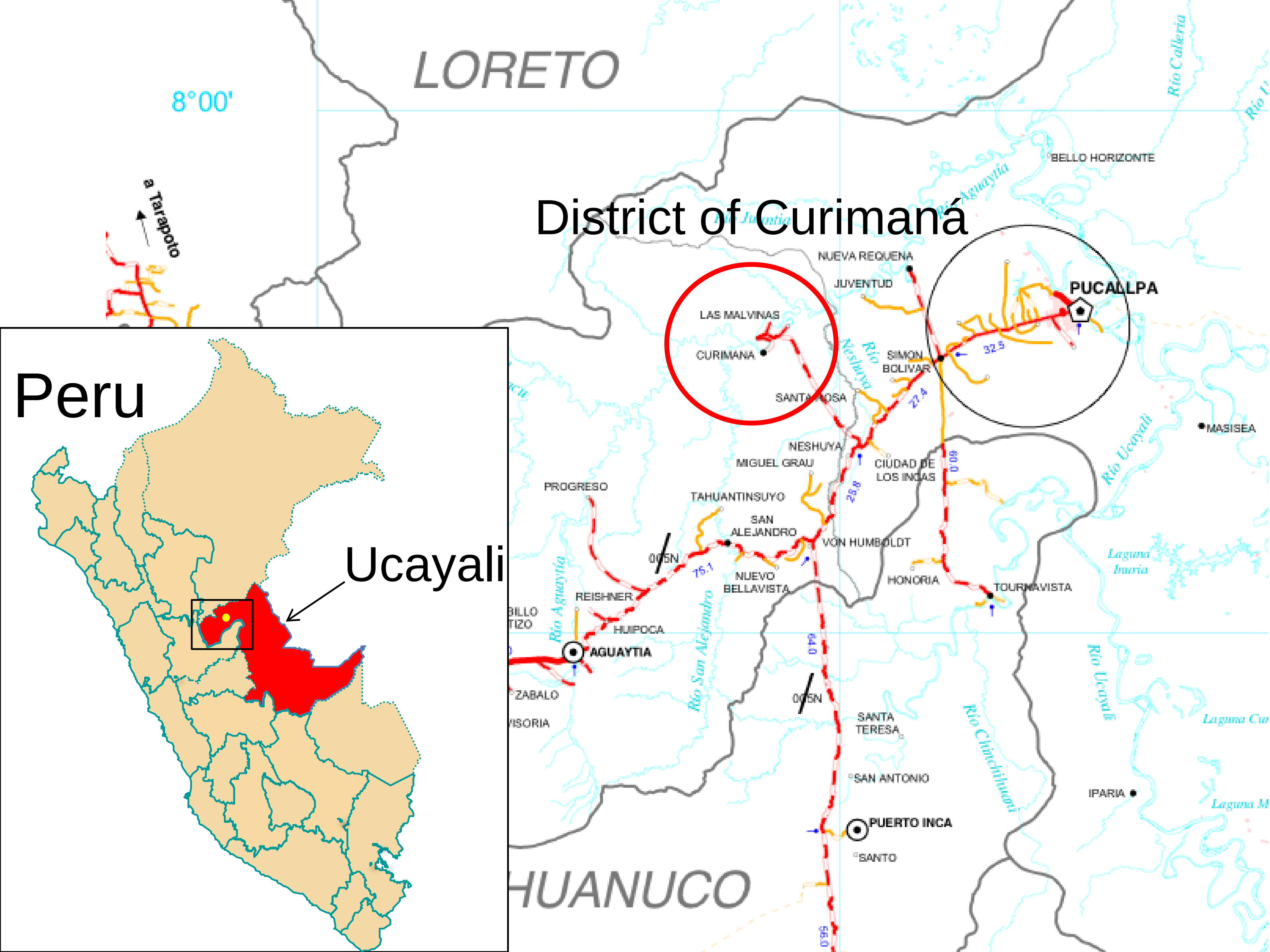
- Funded by the US Agency for International Development (USAID)
- Supervised by Management Sciences for Health
- Operates in 7 Amazonian regions of Peru
- Aims to improve maternal, child, and peri-natal health
- Employs “Champion Community” approach
- Uses participatory interactions with local leaders and household members to identify community health priorities
- Access to clean water a “top” community concerns
- No funding to address infrastructure issues related to water access

Program Objectives

"RECOMAP"

Community Network to Improve the Quality of Drinking Water

- Develop simple protocols and training materials to:
  - Protect quality of source water
  - Ensure safe transport and storage of drinking water
  - Produce bacteriologically safe water
- Protocols must:
  - Provide effective barrier to fecal-oral transmission route
  - Utilize locally available and affordable products or materials
  - Be easily implemented by a busy rural head of household
- Establish sustainable local water quality monitoring capacity


LORETO
8°00'
a Tarapoto
District of Curimaná
NUEVA REQUENA
JUVENTUD
LAS MALVINAS
CURIMANA
SANTA ROSA
SIMON BOLIVAR
PUCALLPA
BELLO HORIZONTE
MASISEA
NESHUYA
MIGUEL GRAU
CIUDAD DE LOS INCAS
PROGRESO
TAHUANTINSUYO
SAN ALEJANDRO
VON HUMBOLDT
NUEVO BELLAVISTA
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HUIPOCA
AGUAYTIA
ZABALO
SANTA TERESA
SAN ANTONIO
PUERTO INCA
SANTO
IPARIA
HUANUCO
Río Aguaytía
Río San Alejandro
Río Neshuya
Río Chinchihuani
Río Ucayali
Laguna Imiria
Peru
Ucayali

Community Assessment Activities

- Identify community water sources
- Evaluate physical, chemical, and biological parameters of source waters
  - pH
  - Temperature
  - Conductivity, Total Dissolved Solids
  - Turbidity (visual test, laboratory in Pucallpa)
  - Chlorine demand
  - Bacteriological
    - Thermotolerant (fecal) coliforms
    - Total coliforms

Community Assessment Activities

- Interviews with Female Heads of Households
  - Water collection, storage, and treatment practices
  - User perceptions of water quality and the risk of disease
- Effectiveness of water treatment practices and safety of water storage
  - Sampling of household stored water
- Visit local markets, stores, and clinics
  - Cost and suitability of local products for water storage
  - Cost and quality of local materials for water treatment

Community Assessment Activities

- 20 Communities Visited
- Most accessible by road
- 12 – 121 households
- Most households concentrated centrally

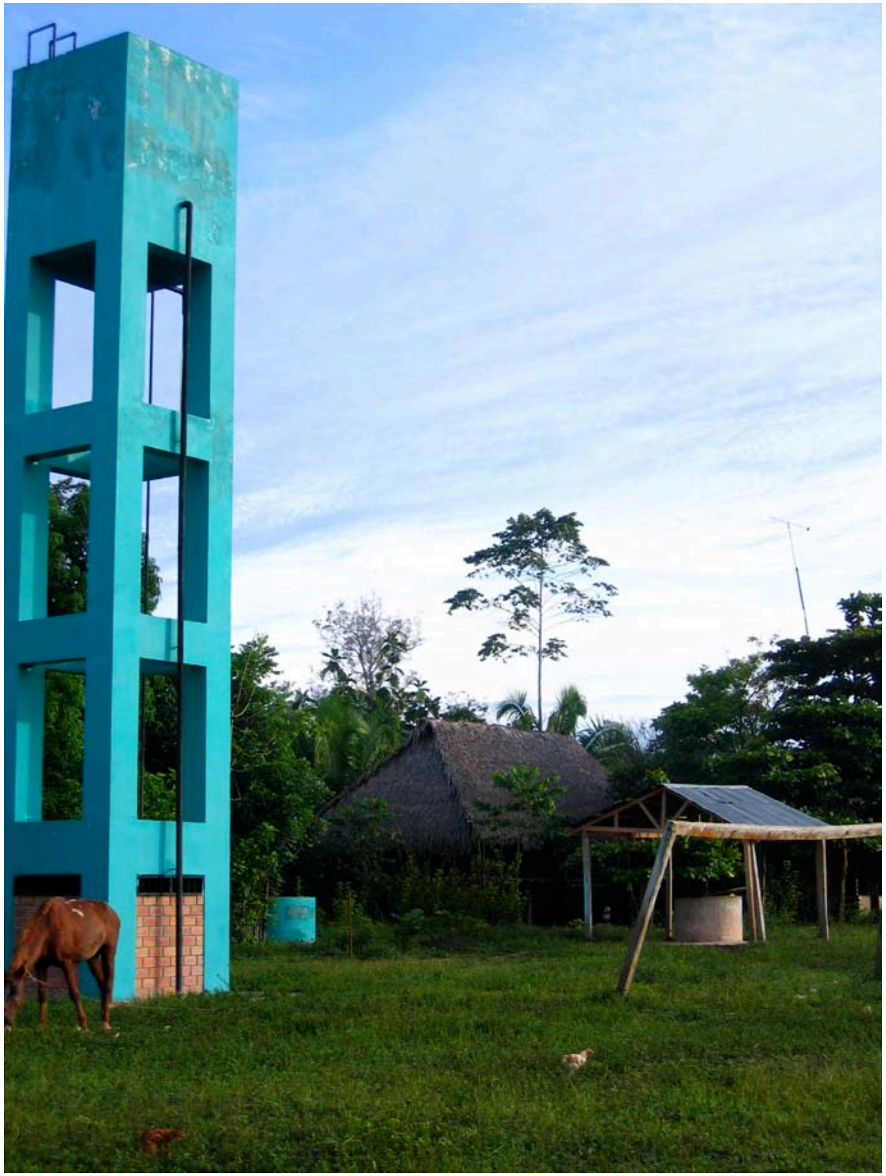
Surface Water Sources

- Identified by observation and conversation
- Sources actually used by residents
- 52 sources evaluated

Surface sources:
Highly turbid Aguaytía River (above)

Small stream
(notice the yellow color)

System Water Sources



- 13 potable water systems built in 2005 by USAID
- Varying construction quality
- Community-led maintenance and operation problematic

Groundwater Sources

- "Artisan" wells (right) frequently encountered
  - Construction quality and design varied
- Hand-dug, shallow wells
  - Little or no protection
  - Varying depth
  - Present in communities with and without water systems

Source Water Evaluation Results

Ranges of Fecal Coliform Bacteria Contamination of Water Samples

Type of water source	Number of Samples	Range (cfu/100mL)	Risk Level*
River	2	2,040 – 36,000	Very High Risk
Stream	2	60 – 900	High Risk
System – Deep Well	8	100 – 28,200	High Risk
System – Tapstand	5	20 – 40,400	High Risk
Artisan Well	6	200 – 30,000	Very High Risk
Hand-dug Well	6	200 – 4,500	Very High Risk

*WHO risk classifications based on median fecal coliform counts detected in water sources.

Additional Findings:

- Problems with high turbidity
- Problems with high iron levels
- Acceptable pH levels
- Measured chlorine demand in line with CDC findings:
  - Negligible turbidities: 1.875 mg/l
  - Noticeable (not “hot chocolate-like”) turbidities: 3.75 mg/l

Household practices and water quality

- Collection
  - Water collected daily
- Storage
  - Low household storage volume
  - Unsafe storage conditions:
    - Stored in transport containers
    - Accessible to children and animals
    - Only covered to protect from insects, leaves, and dirt
- Treatment
  - Knowledge existed
  - Irregularly practiced
  - 50% respondents reported using boiling, chlorine, or bleach
  - Some sedimentation or straining only
- Sampling and testing of HH stored water indicated that existing practices did not make water safe

Household Perceptions

- Water safety attributed to source
- Water considered safe if free of detritus and insects
  - Turbid surface sources dirty
  - Clear groundwater sources clean
- Children’s diarrhea attributed to water and consumption of dirty things
- Cleanliness more frequently reported than water treatment for preventing diarrhea

Existing household chlorination protocol

- Users complained of unpleasant taste and odor
- Problems with protocol:
  - Dosage for emergency situation
  - Variations in drop size from different containers
  - Too few drops, enough, or too many?
  - Inconsistent sodium hypochlorite concentrations in locally available household bleach products

Cost, suitability, and quality of local products for water treatment and storage

3 Brands of bleach available:

Brand	Country	Advertised Percent	Actual Percent	Price (USD)	Size (g)
Clorox	Peru	5.25%	5.0% 5.0%	0.19	230
Sapolio	Peru	6%	4.2% 4.3%	0.22	230
Reluciente	Peru	6%	6.3% 6.3%	0.13	140

- Purchased for laundering clothes
- Clorox and Reluciente suitable concentration and consistent quality
- Reluciente cheaper than chlorine solution of varying quality produced and sold in local clinic (USD 0.16)

Cost, suitability, and quality of local products for water treatment and storage

- Suitable dropper bottle not available
- Stock solution storage container available
  - Several yogurt products sold in Curimaná
    - One liter
    - HDPE
    - 10mL cap
- Improved 10-20 L storage containers available

Protocol Design

- Protocols had to adhere to the “small, doable action” tenet
- Action protocols designed to:
  - Protect quality of source water
  - Ensure safe transport and storage of drinking water
  - Produce bacteriologically safe water
- Turbidity a critical issue for source protection and treatment

Some Small Doable Actions for Protecting Wells

- Locate latrines at least 15 meters from the well
- Deepen well during dry season
- Construct a lip and cover
- Provide dedicated bucket and rope for the well and keep out of contact with the ground
- Divert contaminated surface runoff
- Keep area around well clean and animal free

Protocol for well disinfection with chlorine developed but discarded

- Unsure of efficacy
- Variability of well sizes
- Removing and discarding super-chlorinated water too laborious
- Might supersede POU treatment

How do we take care of our drinking and cooking water?

- Options presented in stepwise sequence:
- Transport:
  - Carry your water home in a container with a lid
- Serving:
  - Pouring
  - Dedicated dipper
  - Spigot
- Storage
  - Easiest and least expensive –
    - Put a tight-fitting lid on your bucket
  - Use a narrow mouthed container for storage
  - Most expensive option –
    - Purchase container with narrow mouth and spigot
- Cleaning protocols for storage vessels

Household treatment protocols to produce bacteriologically safe water

- Evaluated wide range of technologies
- Three treatment methods were considered locally-appropriate:
  - Boiling until large bubbles appear
  - Solar disinfection (SODIS)
  - Chlorination using locally-sold bleach product

How Do We Boil Water?

1) Turbid water: Let it settle until it is clear and pour it into a new container, leaving the dirt behind
2) Boil the water until LARGE BUBBLES appear
3) Store boiled water in a safe container (with a tight fitting lid and, if possible, a spigot)
4) Keep boiled water for only 24 hours

SODIS Method To Treat Water

1) Use clean, transparent plastic bottles that hold no more than 2.5 liters.
2) Fill the bottles with clear water and screw the lid on tightly
3) Lay the bottles out in the sunlight. If it is sunny leave the bottles for 6 hours. If it is cloudy, leave the bottles for 2 days.
4) Before consuming the water, let it cool in the same bottles.
5) Store the water in the same bottles. Do not change containers.
6) DO NOT use SODIS when there is continuous rain. Use another method such as boiling or chlorination.

How Do We Chlorinate Our Water?

(in the absence of a commercial product and without any complicated measuring)

1) Obtain a 1-liter Yogurt Gloria or Pura Vida bottle.
2) Remove the label and wash the bottle.
3) Fill the cap with Clorox or Reluciente brand bleach and pour it in the bottle. Repeat this step until there are 4 capfuls of bleach in the yogurt bottle.
4) Add water to the bleach until the bottle is filled up to its neck. Screw the lid on.
5) Shake it.

How Do We Chlorinate Our Water?

(addressing the turbidities of different water sources)

6) If your water is CLEAR, add 2 capfuls of the water-and-bleach solution to a 20-liter container of water.
7) If your water is TURBID (but not as dark as chocolate), add 4 capfuls of the water-and-bleach solution to a 20-liter container of water.
8) Close the container and shake it.
9) Let the water sit for half an hour.
10) The water is ready to drink. Store it in the same container.
11) Remember: Keep your 1-liter bottle of water and bleach out of the reach of children and in a dark place. This solution can be used for one month.

Two Turbidity Removal Protocols

- Widespread reliance on surface sources - particularly turbid river
- Turbidity a challenge for treatment methods

- **Improved clarification methods based on existing practices:**
  - Overnight settling and decanting
  - Coagulation and flocculation method adapted from “Mi Agua” program and local practices:
    - 1.5 tablespoons (~32g or one packet) of crushed aluminum sulfate added to 20 liters of water
    - Stir 100 times
    - Leave for 3 hours
    - Decant water to another container

Challenges

- Turbidity –
  A challenge for this or any
  chlorine-based point-of-use protocol
  - Visual test to determine dosage critical but complicated because of subjectivity
  - Significant time devoted to developing turbidity related protocols

“hot chocolate”

Putting Protocols into Practice

- Protocol development appears easy, until…
  - What exactly is a “drop?”
  - What is a “1 liter container?” Is it soft plastic? Hard plastic? Glass?
  - What does “agitate” mean? How to agitate water in an open bucket?
  - What does “to clean” mean? Soap? Bleach? Scrubbing? Rinsing?
  - Are the products or materials that you need for your protocol economically available in the local market?
  - How is the practice of the protocol sustained after the program ends?
  - What if households lose or break a key product or material?
  - SUSTAINABILITY?

IS IT DOABLE?

- Moving protocol from the desktop to the field
  - Materials
  - Behaviors
- Ability of poor households to implement ALL aspects of protocol
  - Measuring
  - Cleaning
  - Storing at proper light and temperature
- Importance of small, doable actions cannot be overemphasized

Local water quality monitoring system

- Assessment analyzed:
  - Policies
  - Norms
  - Logistical capabilities of local villages and districts
  - Capacity of local individuals to administer system
- District lacked capacity:
  - Collect and transport samples
  - Analyze the results of quality testing
  - Staff to follow-up with implications of results
- Decision made to back away from monitoring system
  - Concerns about sustainability

…to non-sustainable project activities.

Lessons Learned:

- CDC Safe Water System recommendations on treatment concentrations apply to the Peruvian Amazon
  - With the exception of clear but yellow-stained waters
- Intensive assessment of chlorine demand of water from multiple sources not recommended
  - Test enough types to capture variety and visual characteristics
- Assessment of locally available products and materials in addition to local water management and use practices is critical
- Interdisciplinary team with continued “back and forth” on protocol designs
  - Environmental engineer
  - Behavior change specialist
  - Curricula development specialist
  - Field assessment and survey specialist
  - Master trainer/facilitator

Questions?

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