
the international water association

# Combat Poverty & improve Social Cohesion in Third World Countries with Membranes

AQUA AWARD 2017
AQUANET
BERLIN BRANDENBURG

GreenTec Awards
WINNER 2016
Water & Sewage

Prof. Franz-Bernd Frechen, IWA Fellow

Chair, IWA Specialist Group „Membrane Technology“ 2014-2017
Chair, DWA Committee on „Membrane Bioreactors“ until 2018

sponsored by
DBU
Deutsche Bundesstiftung Umwelt

www.dbu.de

Deutschland Land der Ideen
Ausgewählter Ort 2011

**Winner 2011 in the category „society“**



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German Water Partnership

dex
Deutscher Expertenrat für Umwelttechnologie und Infrastruktur eV

# Facts – World Water Development Report 2019 et al.

- **7.7 billion** people live worldwide

- "Three out of ten people do not have access to safe drinking water."
  ... this means: **2.3 billion** people

- "However, these global figures mask significant inequities between and within regions, countries, communities and even neighbourhoods"
  ... this means also: more than **80%** live in **rural areas** (www.washdata.org)

All phrases in quotes: **World Water Development Report 2019**


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# Sustainable Development Goals (SDG)


Quelle: http://www.un.org/sustainabledevelopment/sustainable-development-goals/



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# Rationale for **PAUL**

- Membranes are able to retain **bacteria**. So why not use membranes to retain bacteria and pathogens, the **most serious concern in disasters**?
- The original task of our research, **starting in 2001**, was to create a **small** unit that provides **potable water** in **emergencies**, characterized by
  - No **energy** needed – gravity driven
  - No **chemicals** needed
  - Simple & robust
  - No or nearly no **maintenance** needed
  - Operational even for **illiterates**
  - **easily transportable**, even hands-free as a **backpack**
  - Designed to help in **emergencies** and **disasters**
- The result was the waterbackpack **"PAUL"**, a **research project** financed by the **German Federal Environmental Foundation (DBU)**


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# result ....



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# Timeline of our work

- 2001: started tests
- 2002: first appearance in a television broadcast in Germany
- 2005:
  *Frechen & Waldhoff:*
  *Water supply from surface waters with a small gravity flow membrane filtration unit for use in cases of disasters*
  *IWA Specialty Conference "Wastewater Reclamation & Reuse for Sustainability (WRRS 2005)", Nov. 8-11.2005, Jeju, Korea*
- 2006: sample **PAUL** unit presented
- ... many presentations (but unfortunately not enough publications)
- 2010: NGOs start distribution of **PAUL** for emergencies
- 2013: creating the acronym "**ULP-UF**" for **Ultra Low Pressure Ultrafiltration**
- 2013: explaining **cake layer control** at the 7th IWA-MTC in Toronto
- 2014: beginning of usage for **permanent supply**: "**PAUL station**"
- 2019: **3,000** units in **85** countries, **500+ for permanent supply**


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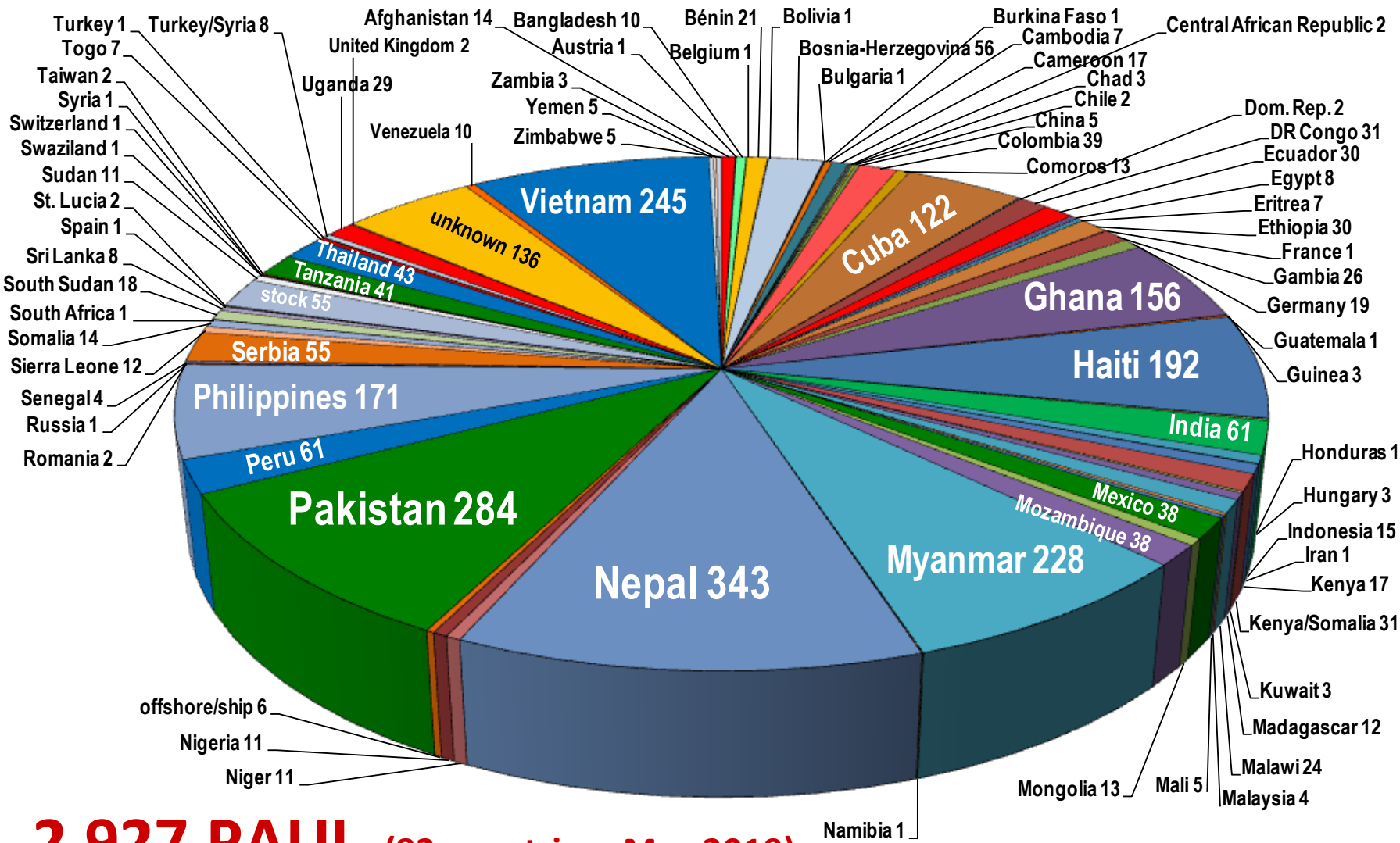
# Distribution






**2,927 PAUL** (83 countries - May 2019)



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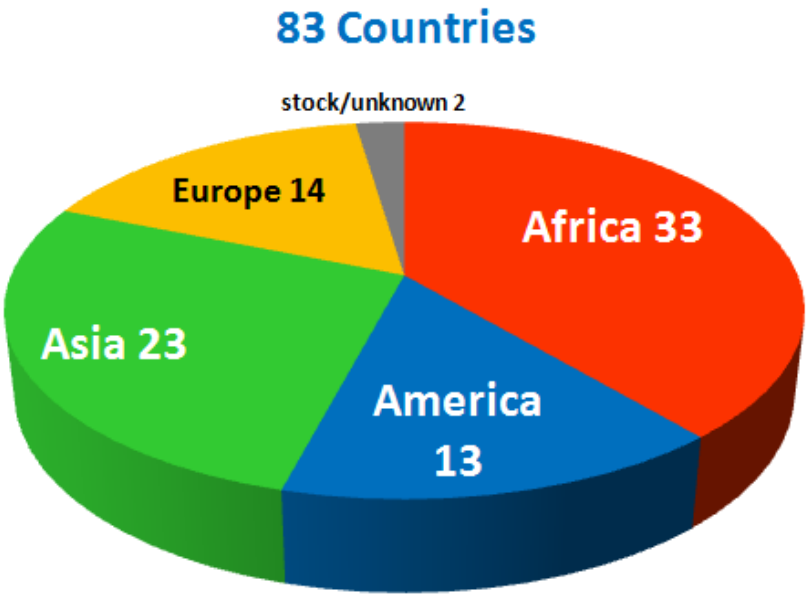


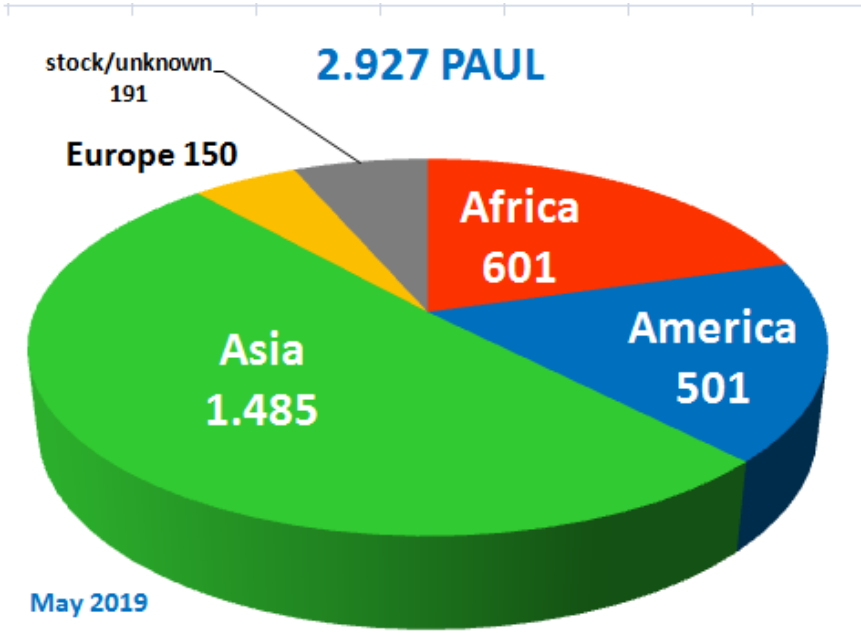




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# **Disasters:** e.g. Pakistan, flooding, July 2010



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# Haiti, earthquake, follow-up Cholera, since mid 2010






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# Balkans, flooding, May 2014






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# operation principles **PAUL**

- gravity driven dead end filtration with **vertical flat sheet membranes**
- **ULP-UF: ultra low pressure: max. 0.08 bar**
- ≈ 10 m² membrane surface area, **lifetime 10+ years**
- Min. capacity 1,200 L/d, practical measurements from **2,000 to 6,000 L/d**
- **extremely simple**
- **no spare parts necessary**



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# From PAUL (disaster) to PAUL station (permanent supply)

- **PAUL** (assembled in Kassel Disabled Workshop) has a **lifetime of 10+ years**
- Thus, today, **PAUL** is used in two situations (also **consecutive**):

  - **first aid in emergencies**. This was the original purpose **PAUL** was developed for, and **PAUL** still is a perfect tool for this purpose.

  - **permanent water supply**: as **PAUL** has such a long lifetime, and as all those who went into emergencies were left onsite, we decided to pay additional attention to its use as a **permanent decentralized source of water**.


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# Tanzania – permanent supply




- installed March 2012
- since then, **no more cases** of diarrhea, cholera or other waterborne diseases according to locals



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# Ecuador – permanent supply







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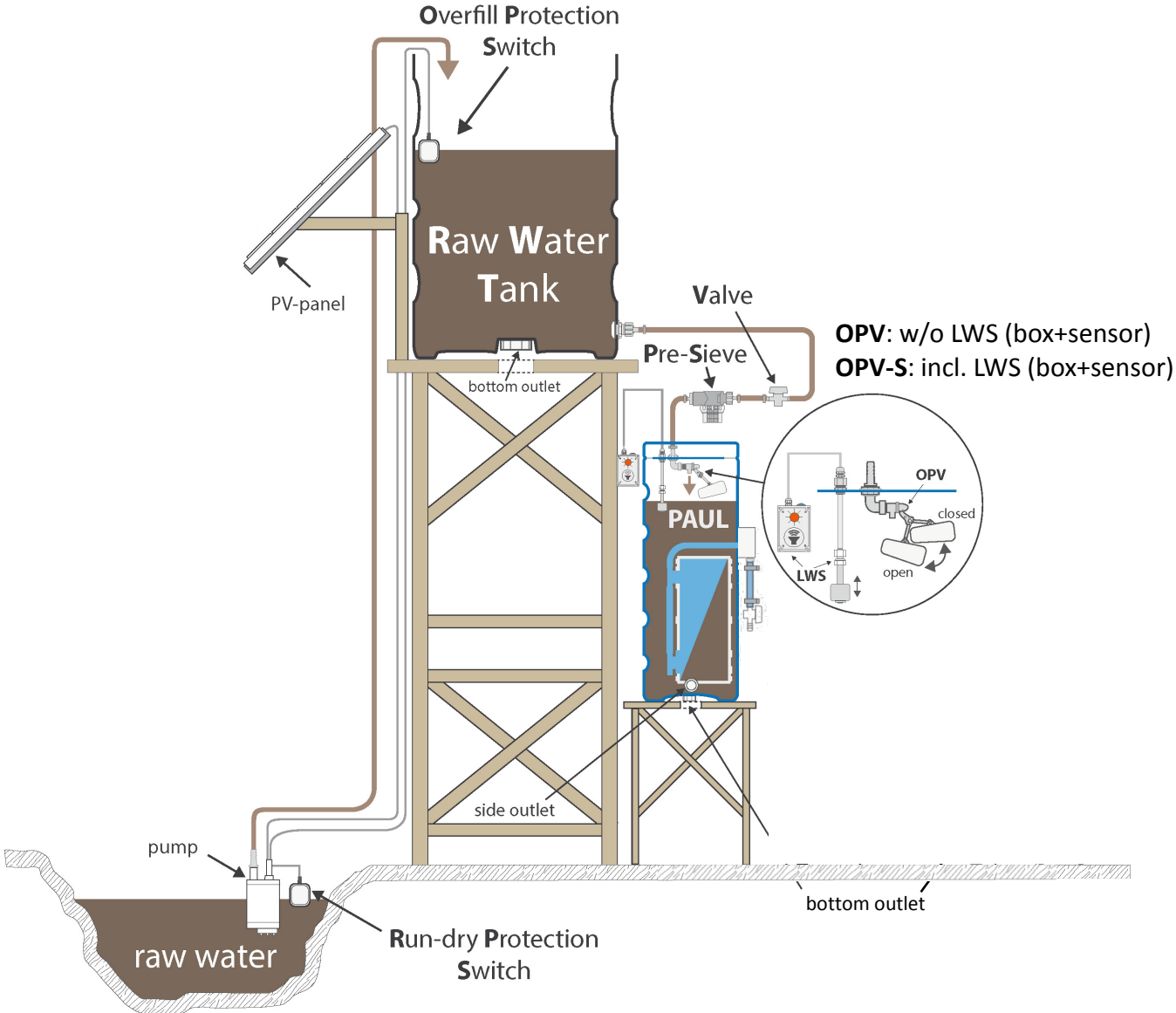
# PAUL Station as permanent water supply





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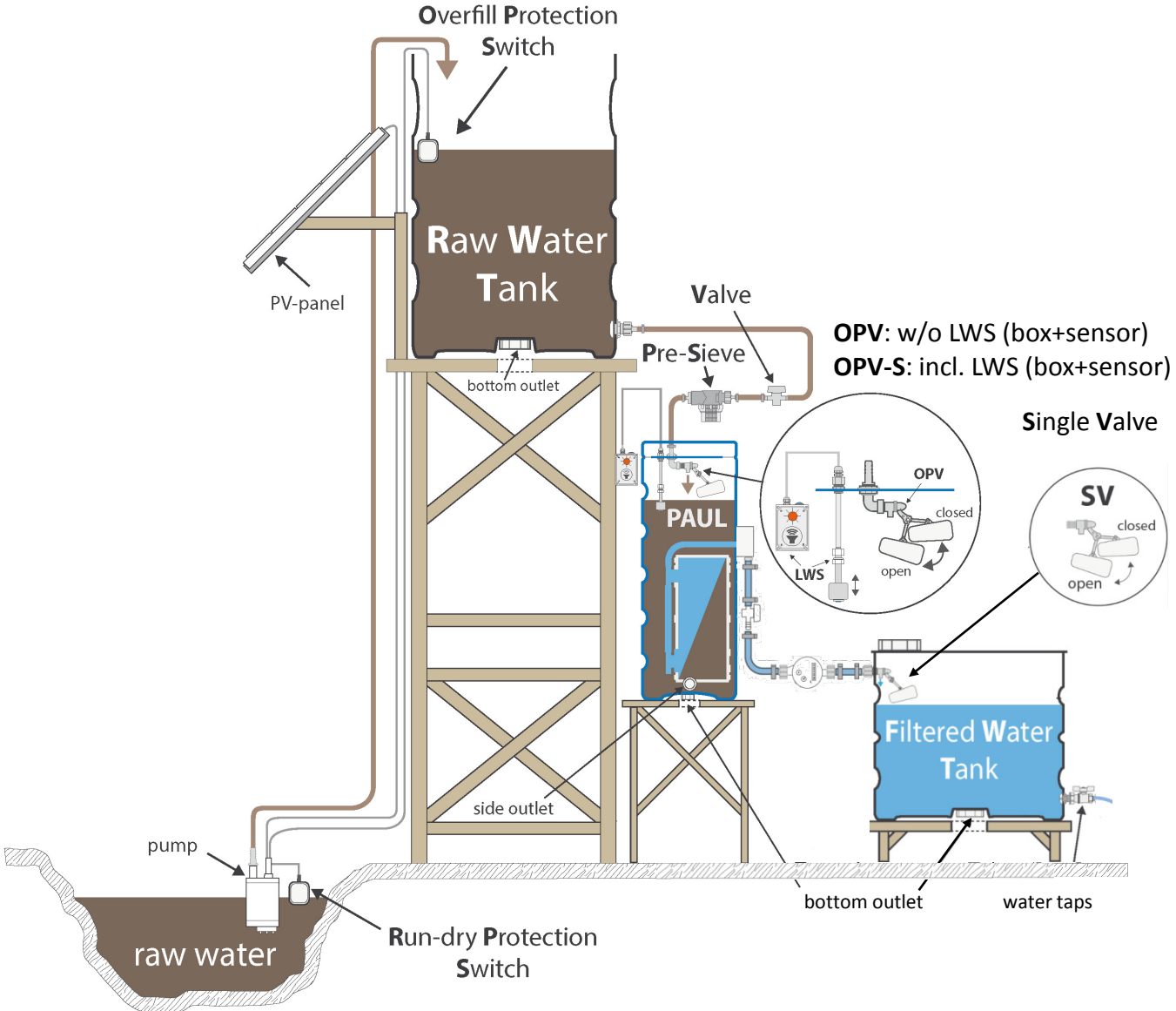
# PAUL Station as permanent water supply



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# Ghana – permanent supply







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# Ghana – permanent supply



Ghana (Tamale/Kulaa) © 2015 Eugen Müller/Zürich


Ghana (Tamale/Kulaa) © 2015 Eugen Müller/Zürich



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# Colombia – permanent supply

## La Guajira


## Cundinamarca


## Nariño


| Einsatzort | E.coli [KbE/100ml] | | Trübung [NTU] | | Färbung [Pt/Co] | |
|---|---|---|---|---|---|---|
| | Rohwasser | PAUL | Rohwasser | PAUL | Rohwasser | PAUL |
| C/marca | 20 | 0 | 8,90 | 0,01 | 7 | 1 |
| Cauca | 6.000 | 0 | 7,83 | 0,01 | 39 | 1 |
| La Guajira | 3.000 | 0 | 40,70 | 0,01 | 28 | 11 |
| Nariño | 52 | 0 | 11,40 | 0,50 | 100 | 50 |



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# Nepal – permanent supply






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# Vietnam – permanent supply at schools






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# India – permanent supply







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# PAUL Station – expenses estimated

## External cost (to be paid only once)

| | |
|---|---|
| PAUL Station Kit (includes PAUL unit and essential accessories): | 1,600 € * |
| Transportation (ship/plane?): | 100 € |
| | **1,700 €** |

## Local cost (build & operate 10 years)

| | |
|---|---|
| Customs – depending upon country: | 300 € |
| Build up PAUL Station: | 800 € |
| ➢ incl. local transport, RWT, FWT, stands for RWT, FWT & PAUL, hoses and parts, construction, pump, painting, start-up, wages, instructions for usage | |
| **maintenance for 10 years** | 600 € |
| | **1,700 €** |
| Total cost (**10 years**): | **3,400 €** |
| | (**50% local**) |

* Only valid for humanitarian usage!


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# PAUL Station – revenue and profit

## Payback time (just an example):

- 60 families, paying 2 €/mon/family
- Lifetime revenue 60 x 2 x 12 x10 = 14,400 €
- Lifetime profit 14,400 € - 3,400 € = 11,000 €
- **Payback time = 2.4 years**

## Water price (under the above conditions):

- Min. lifetime production: **1,200 L/d** x 365 d x 10 a = **4,380,000 L**
- Results in a price of 0.0**033 €/L**
- Currently (Sept. 2016), one 20 L water can at the Tamil Nadu coastline (India) costs 30 Rs:
  1.5 Rs/Liter = 0.0**200 €/L** (more than **6 times** more)


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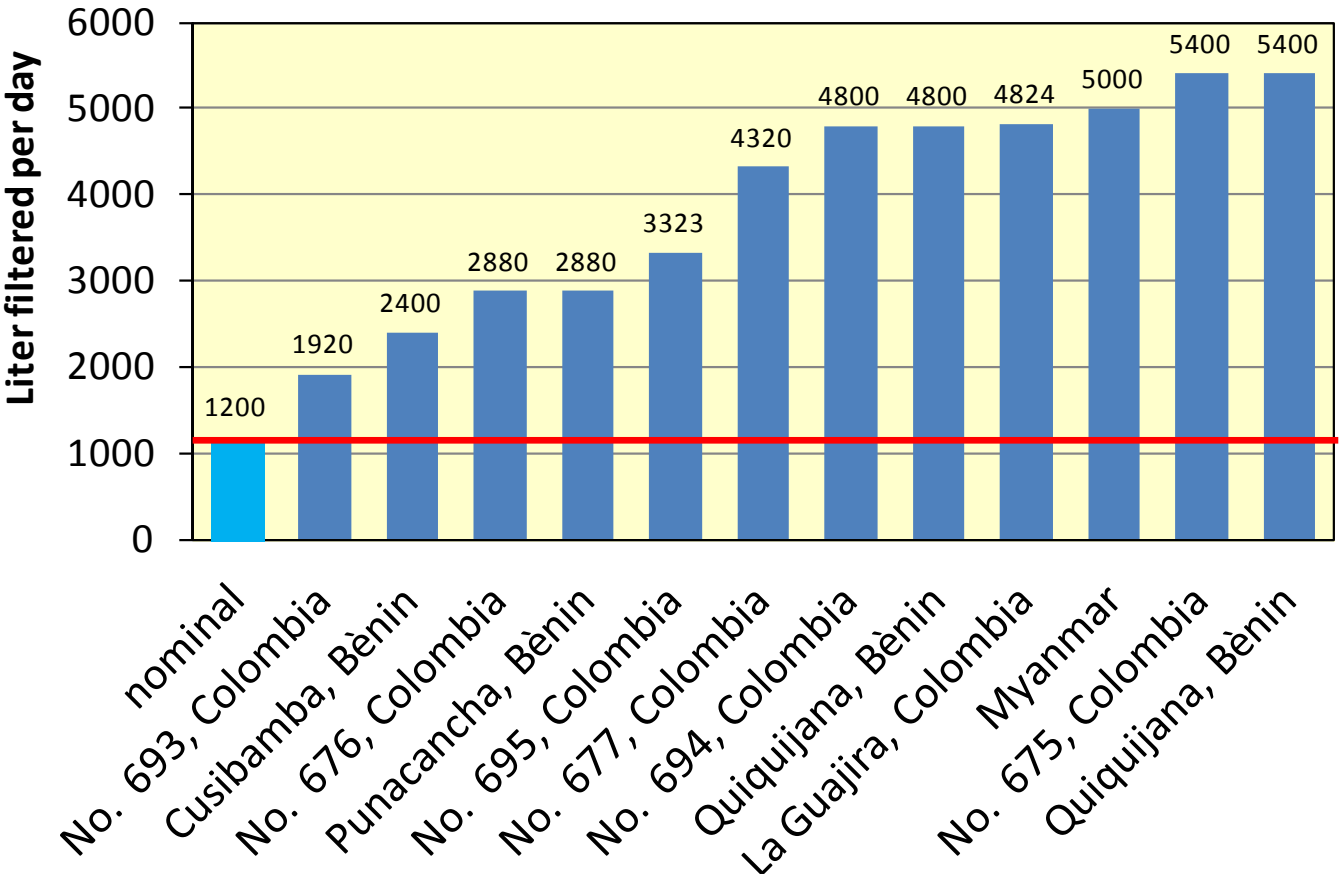
# Remark on field inspections of **PAUL**

- in practice, the daily flow is far beyond our design value of 1,200 L/d, mostly in the range **between 1,900 L/d and 5,400 L/d**) which gives a **shorter payback time** and a **lower water price**

Recent results:
2 installations,
March 2016
in India:

- Measured 19 Sept. ’16 in Puthanthurai: **2,500 L/day**
- Measured 20 Sept. ’16 in Pallam: >6,000 L/day





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# paradigms to be shifted

1. “one size fits all” (one solution for the whole world)



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# paradigms to be shifted

~~1. "one size fits all" (one solution for the whole world)~~

**WRONG:**

only appropriate solutions work



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# paradigms to be shifted

2. cost = investment



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# paradigms to be shifted

~~2. cost = investment~~

**WRONG:**

total cost (cost of financing, running and operations cost) are the only relevant benchmark

i.e. **only** cost per unit produced (liter of water)



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# do‘s and dont‘s

## conventional

- Operate with fixed flow rate, TMP is the observed phenomenon
- Minimize investment cost by choosing small membrane area
  - high and rising TMP
  - increasing pore blocking
  - membrane is filtration active
  - high running cost
- Cake layer control by
  - Cross flow
  - Backflush
  - chemical celaning

## appropriate

- Operate with fixed (limited) TMP, flow rate is the phenomenon
- Minimize cost per unit by investing in membrane area
  - cake layer is filtration active
  - minimal pore blocking
  - membrane replacement after years
  - minimal running cost
- Cake layer control by gravity
  - see next slide
  - gravity due to low TMP
  - no backflush


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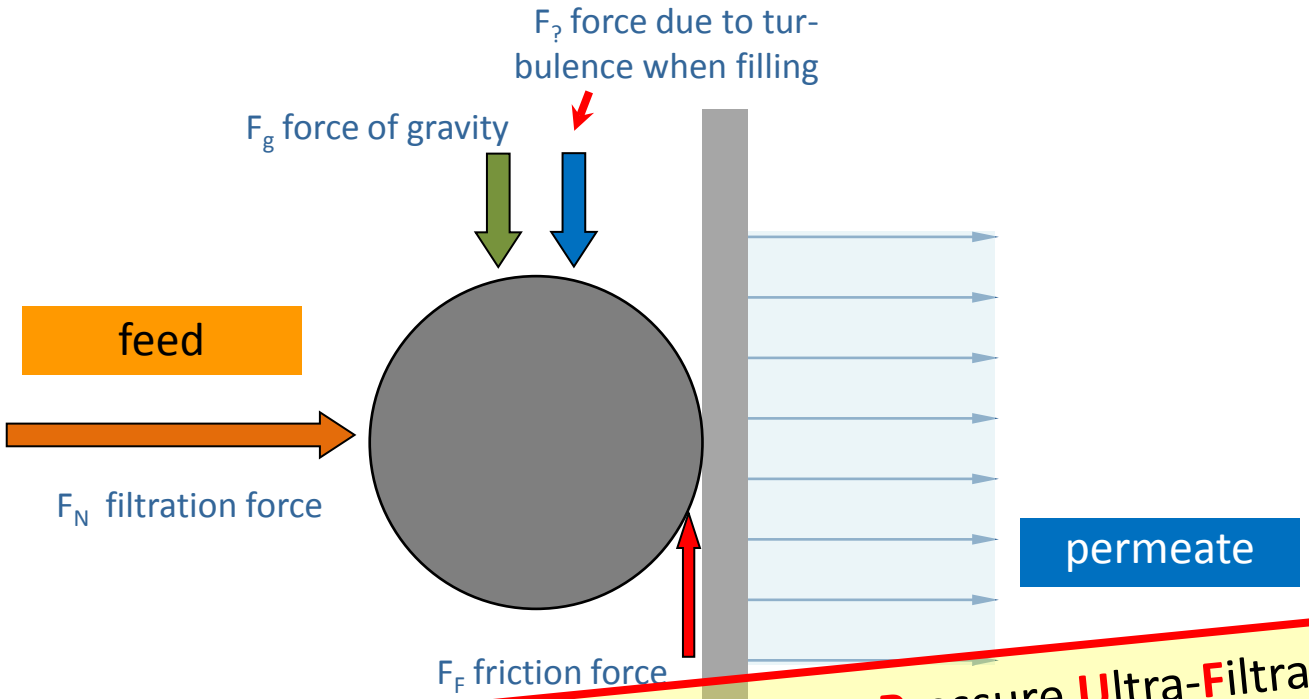
- Dead end filtration must have vertical membranes




More on the theory of the **U**ltra **L**ow **P**ressure **U**ltra-**F**iltration (**ULPUF**) process can soon be found on **www.waterbackpack.org**



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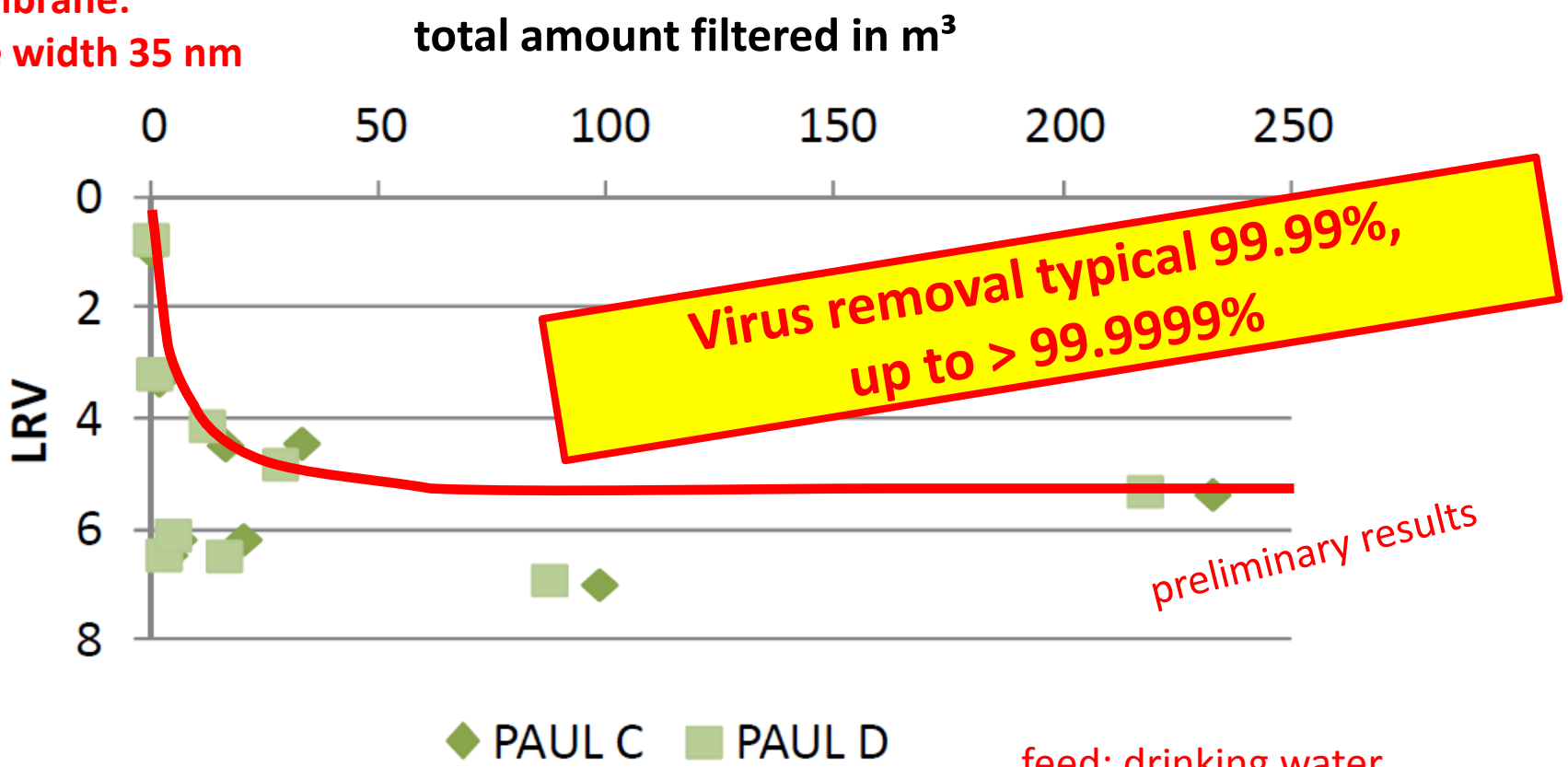
# virus removal (Federal Environment Agency UBA)

**What about Cake layer filtration?**
**Virus MS2 – 5 nm diameter**
**membrane:**
**pore width 35 nm**




feed: drinking water

analyzed by Federal Environment Agency, Dessau/Roßlau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# Lessons learned from India (and Myanmar)

- With **total cost** of 3,500 € (micro-loan!) it is possible to erect a **PAUL** station and **operate it for 10 years**
- 50% of this sum is **local created value**
- A **water committee** constituted and since operates the **PAUL** station
- 60 families are served, and with a fee of **2 € per family per month**, total cost of 10 years is collected within 2.5 years – payback time 25%
- During 7.5 more years, the **community** earns money for their own purposes
- In addition, the **water price for the locals** drops down to **less than 20%** of the actual cost. Same is reported from **Myanmar**
- Organizing a local water committee improves the community, thus resulting in a **positive social impact**.
- Most important: the technology **does not require import of spare parts on a regular basis**.
- Technologies that do require this are **completely useless and unfeasible**



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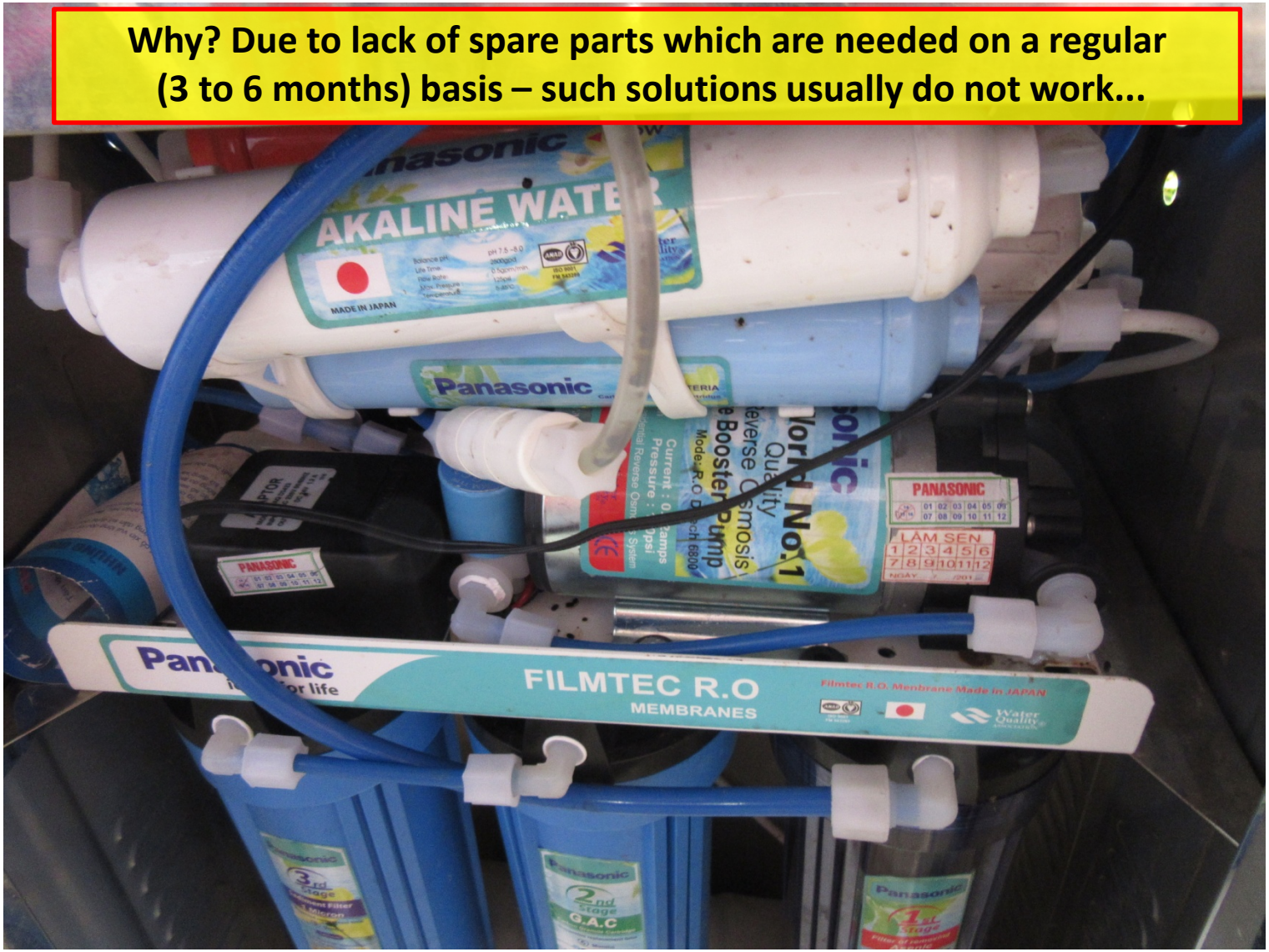
# seen in Vietnam: high tech ... not in use anymore !!

**Why? Due to lack of spare parts which are needed on a regular (3 to 6 months) basis – such solutions usually do not work...**



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# Essential:

**It is essential that local people can improve their health and wealth by themselves after a simple introduction – no dependency on import of spare parts/consumables!**

**Independently providing water and creating local jobs is the best way to improve conditions and prevent migration.**

**CAPACITY DEVELOPMENT!**



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