

WaterBackpack "PAUL[®]" for **disasters** and for **permanent water supply**

General information about PAUL[®] and
PAUL[®] stations

sponsored by



Deutsche
Bundesstiftung Umwelt







www.dbu.de

Franz-Bernd Frechen, IWA Fellow

Chair, IWA Specialist Group „Membrane Technology“
2014-2017

Chair, DWA Committee on „Membrane Bioreactors“
until 2018



- Ü Some basics on water in the world
- Ü Principles of **PAUL®** 
- Ü **PAUL®** standard units in emergencies and for “simple” permanent water supply 
- Ü How does a **PAUL® station** look like? 
- Ü examples of **PAUL® station** for permanent supply 
- Ü economics 
- Ü rainwater ponds as a raw water source 



- Ü 7.8 billion people live worldwide
- Ü “Three out of ten people do not have access to safe drinking water.”
... this means: **2.3 billion** people
- Ü “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





SUSTAINABLE DEVELOPMENT GOALS

How important is clean water??



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



Rationale for PAUL

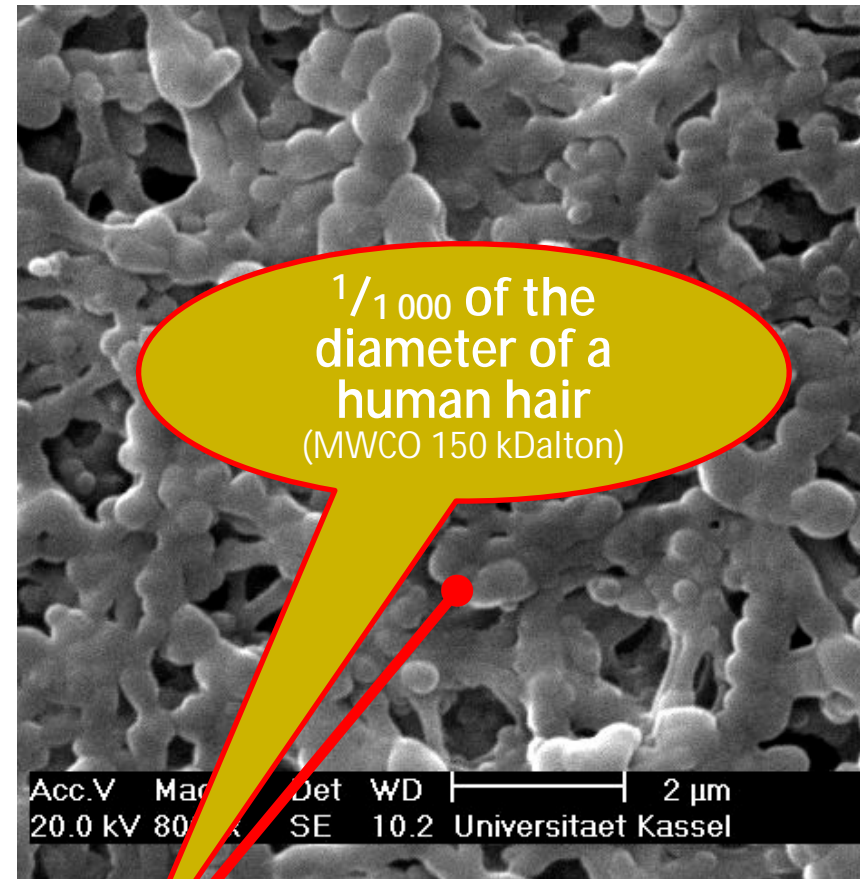
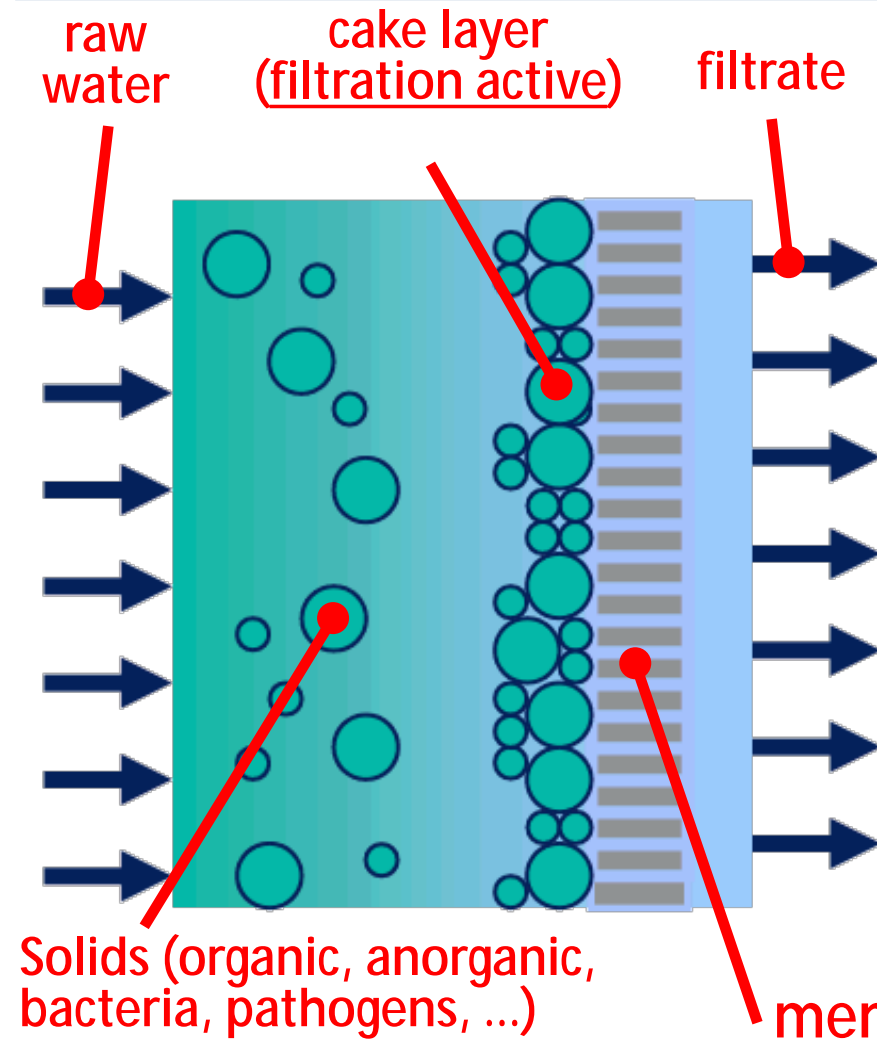
- Ü Membranes are able to retain **bacteria**. So why not use membranes to retain bacteria and pathogens, the most serious concern in disasters?
- Ü The original task of our research, starting in 2001, was to create a **small** unit that provides potable water in emergencies, characterized by
 - Ä No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



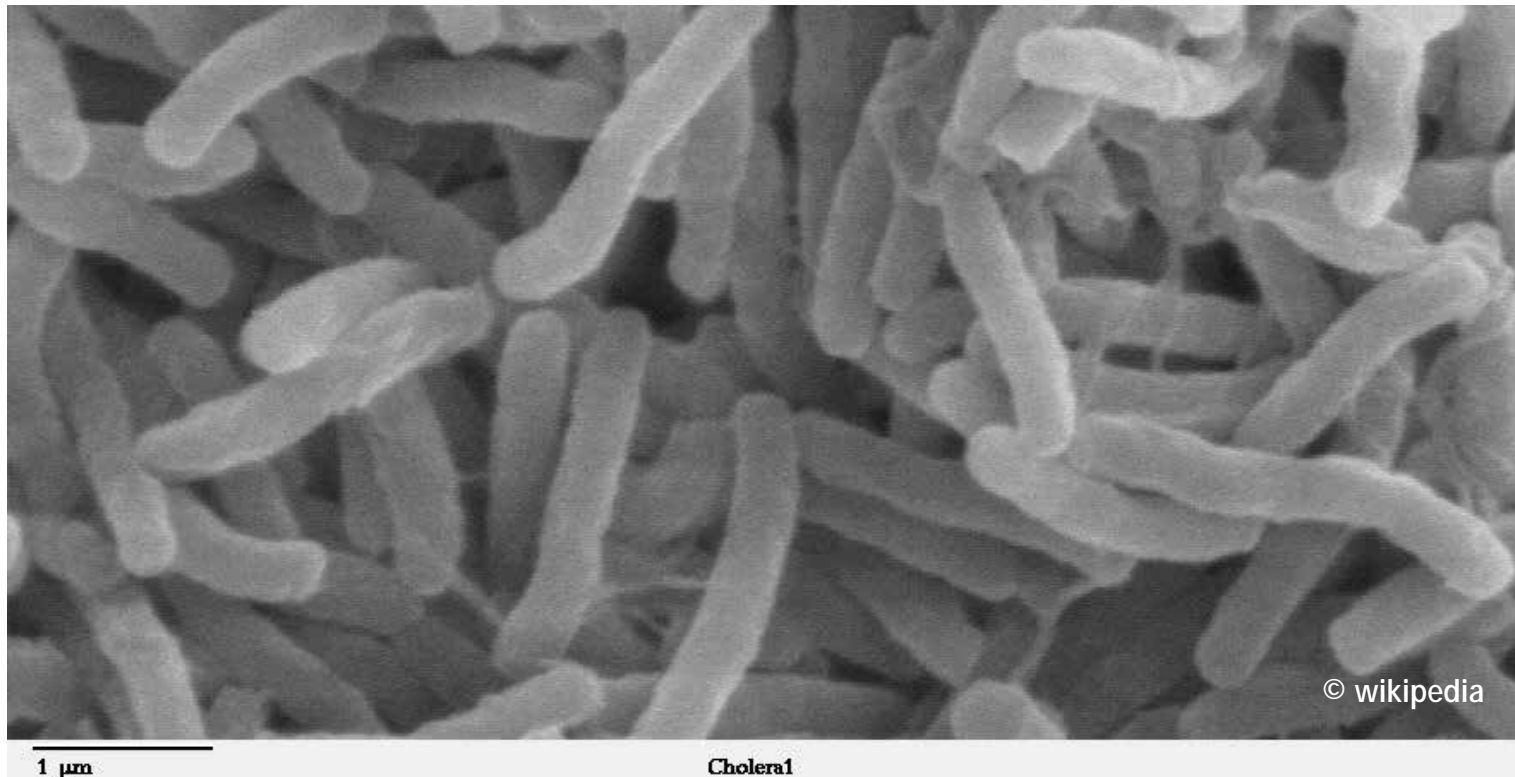
- Ü gravity driven dead end filtration with vertical flat sheet membranes
- Ü ULP-UF: ultra low pressure: max. 0.08 bar
- Ü $\approx 10 \text{ m}^2$ membrane surface area, lifetime 10+ years
- Ü Min. capacity 1,200 L/d, practical measurements from 2,000 to 6,000 L/d
- Ü extremely simple
- Ü no spare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



filtration is mostly done by the **cake layer**



typical pore width 20 to 100 nm (0.020 to 0.100 μm)

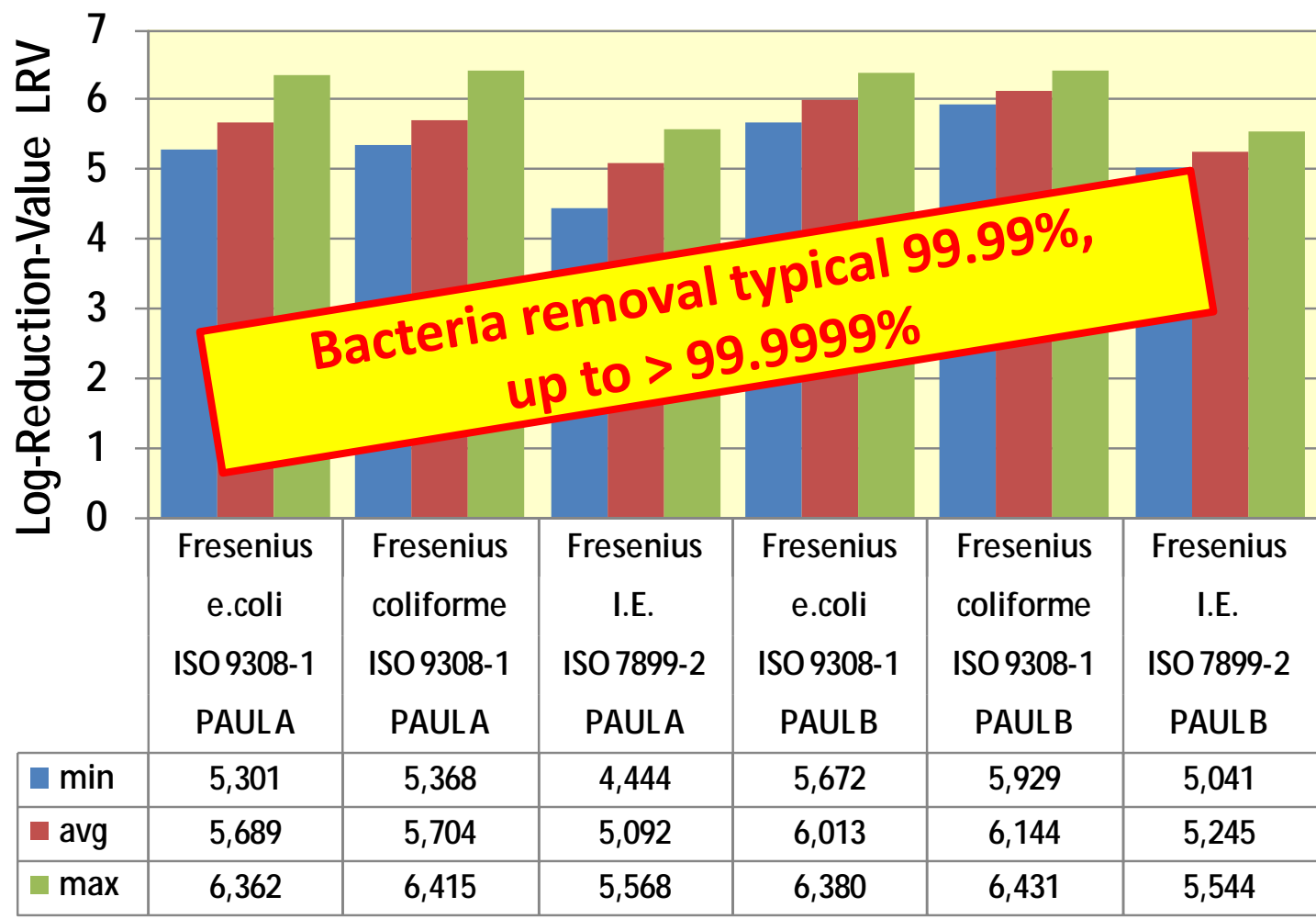


cholera bacteria

diameter 300 to 500 nm, length 2 000 nm (2 μm)

membrane

typical pore width 20 to 100 nm (0.020 to 0.100 μm)



analyzed by Institut Fresenius, Göttingen



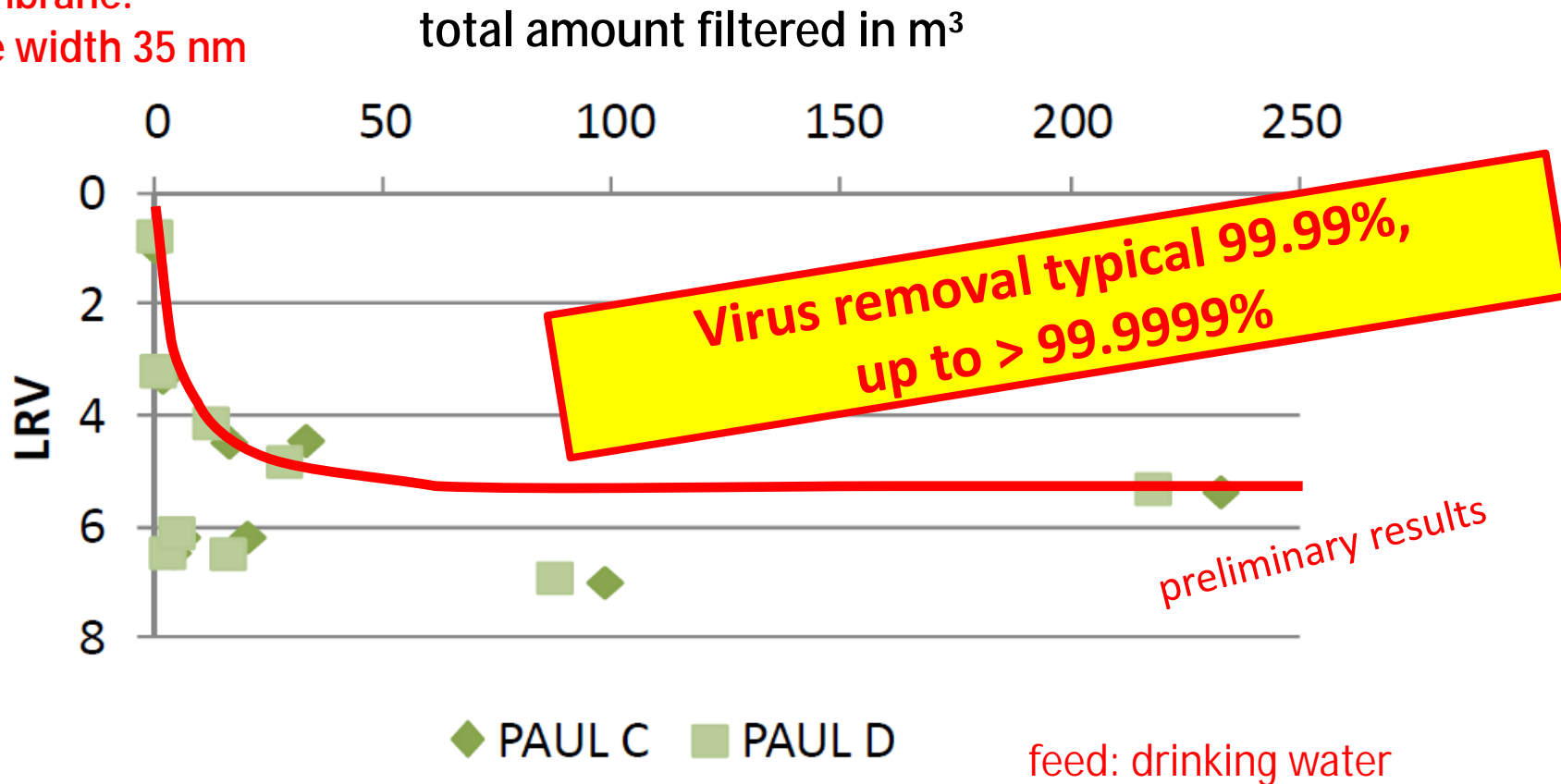
What about Cake layer filtration?

Virus MS2 – 5 nm diameter

membrane:

pore width 35 nm

MS2



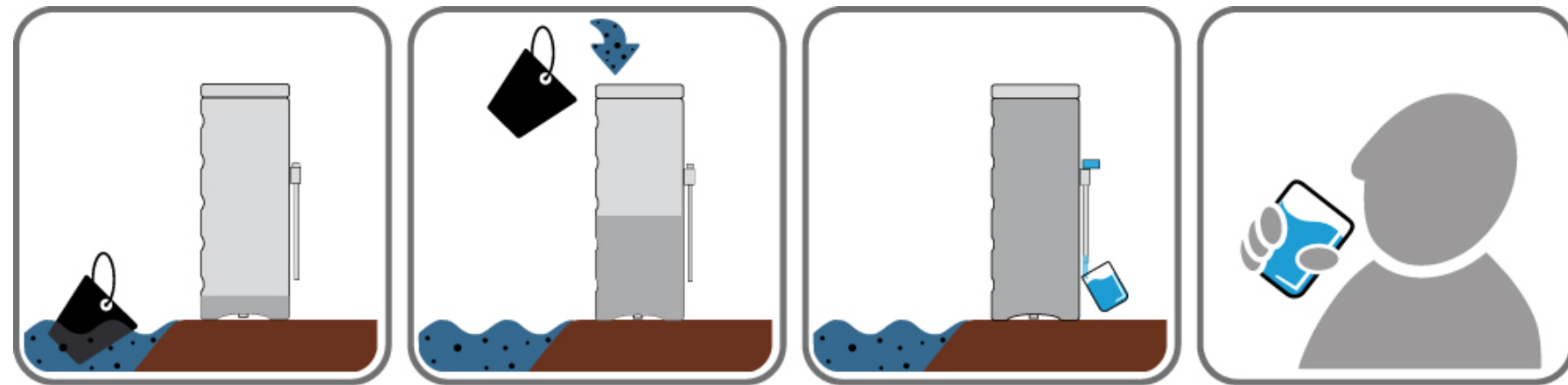
analyzed by Federal Environment Agency, Dessau/Roßlau



The complete operation manual (in emergencies)

WaterBackpack PAUL
13th July 2021

- Ü no moving parts, no energy, no chemicals, no maintenance , extremely robust, to be operated by anyone – even illiterates
- Ü See the complete operation manual!



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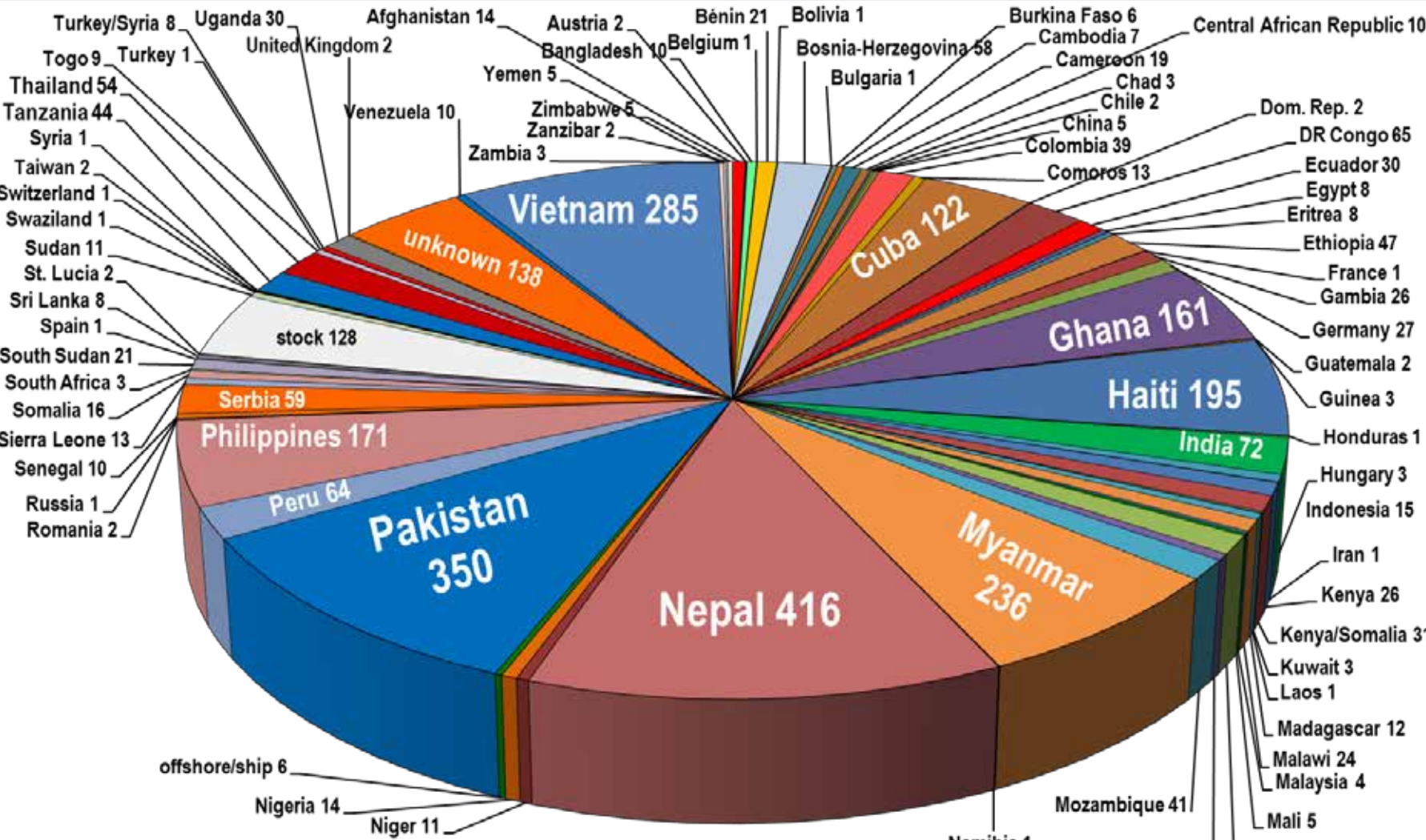
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Portable
Aqua
Unit for
Lifesaving

PAUL® is assembled at the
Kassel Disabled workshop





3,347 PAUL (85 countries - June 2021)



Some organizations who brought PAUL into use



PAUL[®] standard units in emergencies and for “simple” permanent water supply

In many locations, PAUL[®] standard units that originally were distributed due to a disaster or emergency situation are still in use for “simple” permanent water supply after the disaster or emergency situation is over.

In several other situations not related to disasters, PAUL[®] standard units are introduced for “simple” permanent water supply.

In both cases, however, PAUL[®] standard units are filled with buckets, in contrary to the PAUL[®] station arrangement that is shown later.









Pakistan 2010 © Humanity Care Foundation



Myanmar Flooding © 2015 Oliver Esser Soe Thet (esserrene@aol.com)





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Niger © TAMAT e.V.





Niger © TAMAT e.V.

11/03/2016 05:40:01







Jemen © 2018 Humanity Care Foundation



Nepal © April 2017 Nepali Rotznäschchen- Med. Hilfsprojekte



12/04/2017

Nepal © April 2017 Nepali Rotznäschchen- Med. Hilfsprojekte





2016-04_Nepal (Kohl-Kollmer) 01 2016-04-04





Nepal © 2015 Dr. Anne Schöpa, GFZ Potsdam



Nepal © 2015 Dr. Anne Schöpa, GFZ Potsdam





Cameroon © 2013 Liebe in Aktion





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



© Trottman, Location: Ecuador



© Trottman, Location: Ecuador



Ecuador © 2014 Roland Trottman





© 2014 Freundeskreis Christliche Sozialarbeit Uganda / Manfred Wardin



Gambia © ChildFund 2016





Somalia 2020 © Rene Brosius



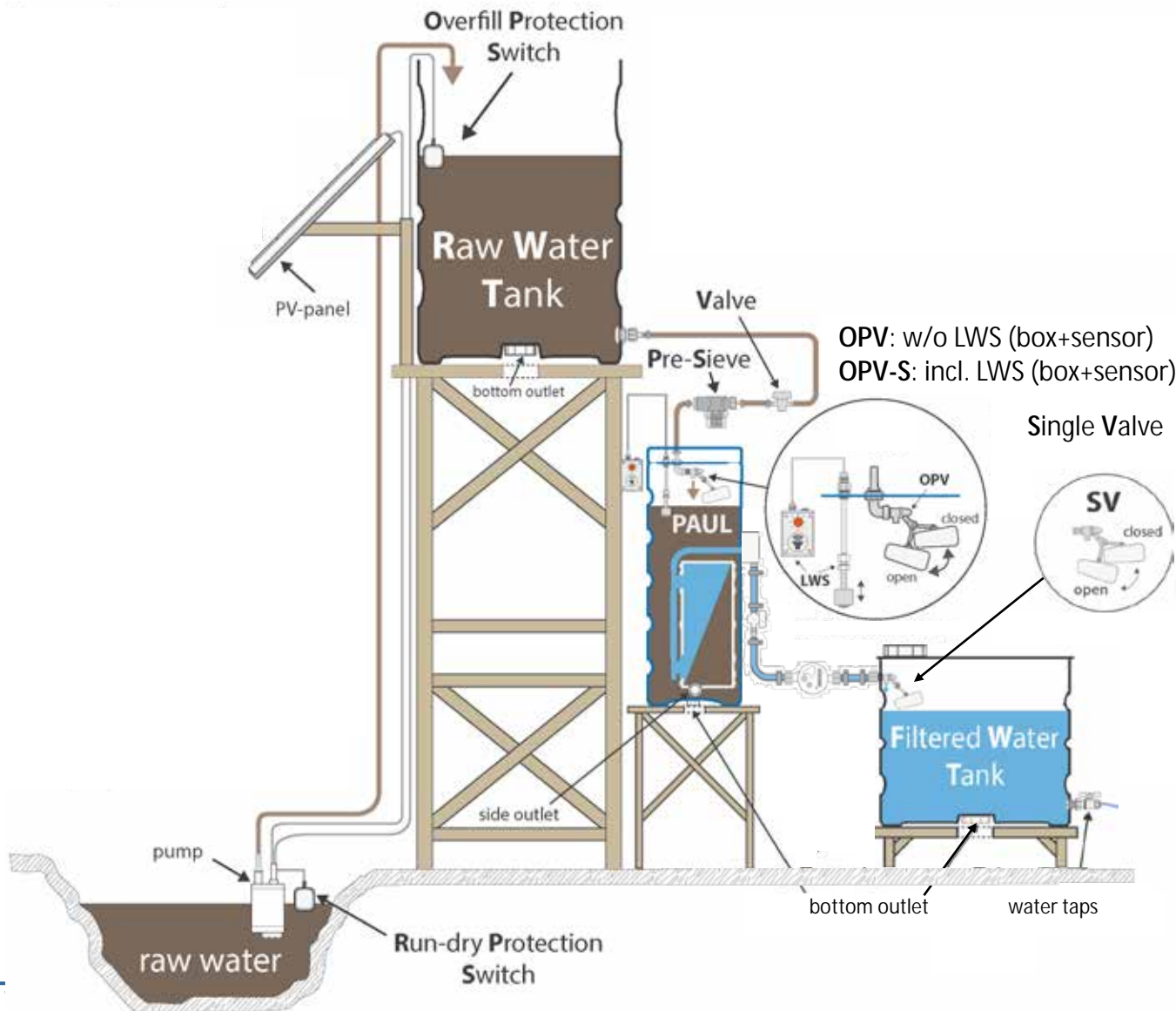


Somalia 2020 © Rene Brosius



How does a **PAUL[®] station** look like?





examples of **PAUL[®] station** for permanent supply





Ghana (Assin/Fosso) © 2014/2015 Eugen Müller/Zürich



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







Ghana © Eugen Müller 2019



Ghana © Eugen Müller 2019





Nepal © Birgit Kirsch 2018





Tanzania © Hans-Ludwig Rau 2019







© Stadt Baruth/Mark, Location: Mongolia



Nepal © Birgit Kirsch 2019









Ecuador © Cromphout Jan. 2019



Ecuador © Cromphout Jan. 2019





Total cost of local
installation:
600 Euro (2020)



Myanmar 2020 © Dieter Schlatter

Myanmar 2020 © Dieter Schlatter





Nepal 2020 © Sten Linnander

examples of PAUL® station

Total cost of local installation (no stands, no pump necessary):
380 Euro (2016)
(this & next slide)



Indien © FG SWW



Indien © FG SWW 18.03.2016 13:29:28



examples of PAUL® station



Total cost of local installation (no stands, no pump necessary):
380 Euro (2016)
(this & previous slide)





India 2016 © CARE-T / terre des hommes





India 2016 © CARE-T / terre des hommes



India 2016 © CARE-T / terre des hommes





Indien © FG SWW 23.03.2016 11:46:56



India 2020 © CARE-T / terre des hommes

Visit onsite
in Jan. 2020
revealed
that locals
still are
extremely
happy with
the
installation

Total cost of local installation incl. stand, tanks,
electric AC pump etc. :
790 Euro (2016)



Total cost of local
installation:
810 Euro (2016)



Indien © 2016 terre des hommes





usage for permanent supply: how to set up a local business



some additional but very important facts

- Ü PAUL is assembled at **Kassel Disabled Workshop**
- Ü No **spare parts import** necessary, as no cartridges etc. must be replaced on a regular basis
- Ü No **waste of resources** concerning firewood, as boiling the water for disinfection is not necessary anymore
- Ü **Waste minimization**, as water will no longer be supplied in **plastic bottles**
- Ü Dramatically reduced **cases of illness**, thus
 - Ä less **cost** due to **illness**
 - Ä less **cost** due to **inability to work**
 - Ä less **absence from school** = **improved educational opportunities**
- Ü **Local added value** by **creation of employment** as plant manufacturer/water vendor/plant operator/maintenance worker – **perfect for micro financing**



PAUL Station – expenses estimated

Ü External cost (to be paid only **once**)

Ä PAUL Station Kit (includes PAUL unit, PCU, SV, V, OPS, PS, freshwater meter and installation material):

115,000 Rs *

Ä Transportation (ship):

5,000 Rs

Ü Local cost

Ä Customs – depending upon country: 30,000 Rs

Ä Build up PAUL Station: 60,000 Rs

Ø incl. local transport, RWT, FWT, stands for RWT, FWT & PAUL, hoses and parts, construction, pump, painting, start-up, wages, instructions for usage

Ø incl. Maintenance **10 years** 30,000 Rs

Ä Total cost: 240,000 Rs = 3,000 €

(50% local) = 25 €/month

* Only valid for humanitarian usage!



PAUL Station – earnings and profit

- Ü Lifetime production: 1,200 L/d x 365 d x 10 a = **4,380,000 Liter**
- Ü One 20 L water can at the Tamil Nadu coastline costs 30 Rs:
1.5 Rs/Liter = **0.02 €/Liter**
- Ü Sell PAUL Station water for 1/4 of that price = **0.005 €/Liter**
- Ü Lifetime value feasible: 4,380,00 x 0.005 = **21,900 €/10 yrs**
- Ü Lifetime profit feasible: 21,900 – 3,000 = **18,900 €/10yrs**
- Ü Or **158 €/month** (183€/month minus 25 €/month payback)

- Ü Why not operate 20 PAUL Stations (and become a water businesswoman / businessman) ??



Section of Filter Element

Outer Shell - Micro Filtration

Anti-Bacterial formula within the ceramic matrix kills pathogens

Activation carbon takes out chlorine and organics improving taste and odour

Also contains heavy metal removal media, which takes out toxic lead



HANDS is a one of the largest & leading NPO of country, working since 1979 in health, education, poverty alleviation, water and sanitation, infrastructure development, emergency response through social mobilization, advocacy & capacity building. HANDS is benefiting more than 19000 villages in 24 districts of Pakistan.

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Portable Ceramic Water Filter



HANDS Infrastructure Development, Energy, WASH and Shelter (IDEAS) Program

140-C, Block II, PECHS, Karachi. Tel: (021) 34532804, 34527698 Fax: (021) 34559252
Email: info@hands.org.pk Web: www.hands.org.pk



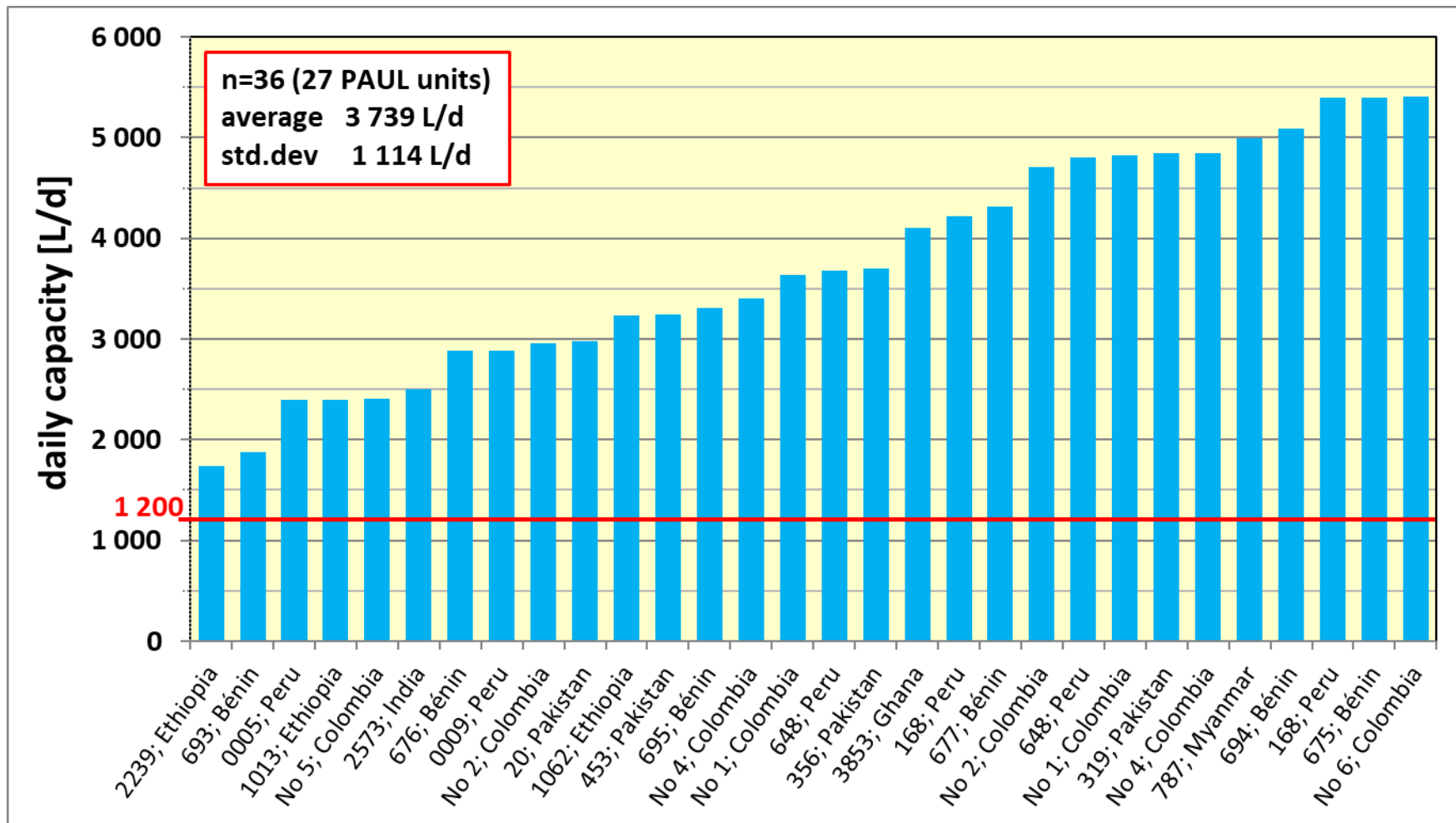
This filter is cheaper (only 20 €) ... or??

- Ü 1 year lifetime
- Ü 20 € per Filter
- Ü In order to replace 1 **PAUL**:
- Ü 30-60 units (to provide 1,200 L/d)
- Ü 300-600 units (for 10 years)
- Ü That's an invest of **6,000 € to 12,000 €**
- Ü **PAUL**: only **3,000 €** incl. maintenace, tanks, pump, solar panel and maintenance – all in all for **10 years**

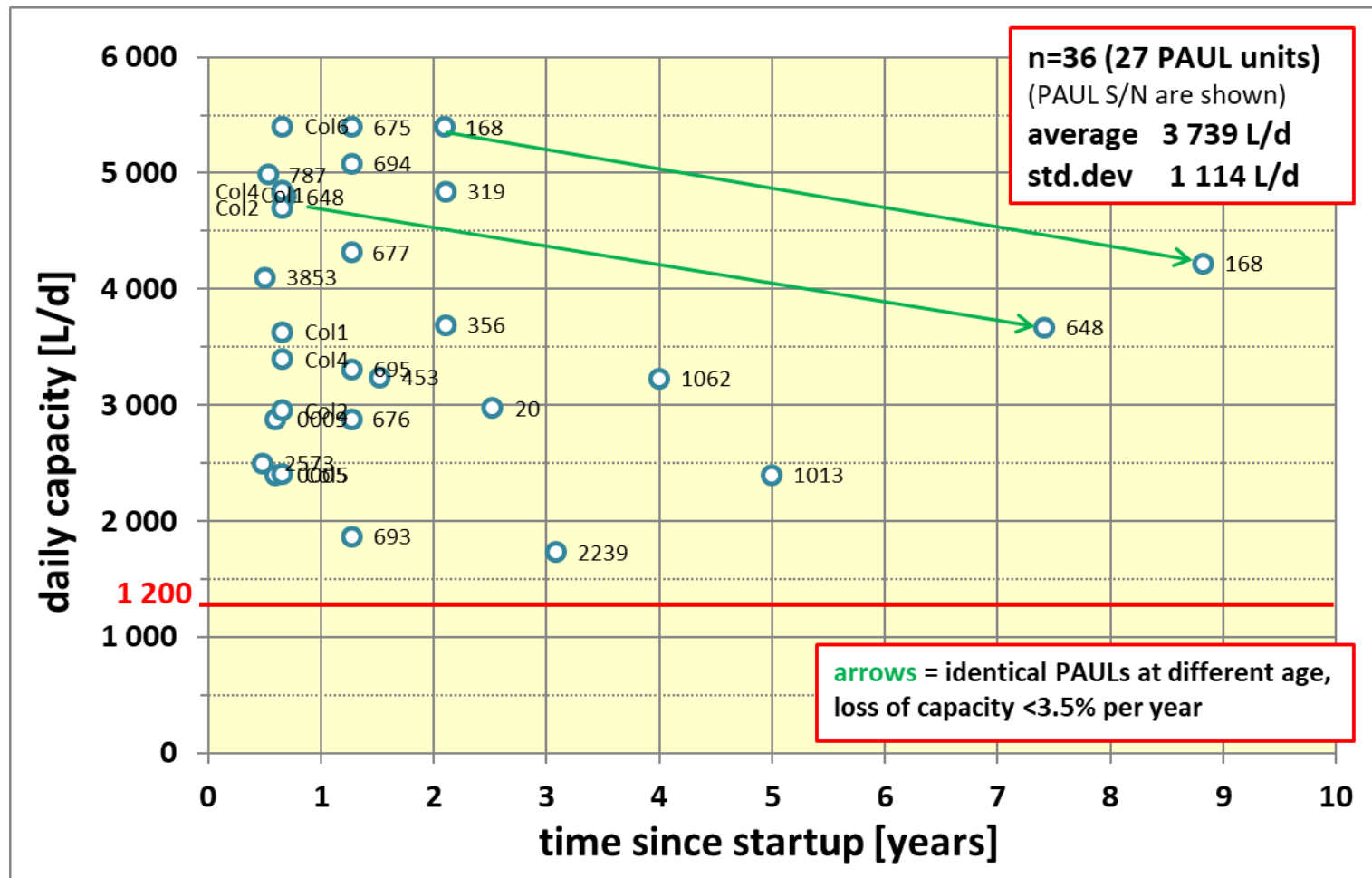
TECHNICAL DETAILS

Element Type	9"
Output Per Day	20 - 40 liters
Capacity of each container	16 & 25 liters
Net weight without filter elements	1.5 Kg.
Weight of one element.....	390 grams
Diameter of container	10.5" & 12.5"
Total height ready for use	28 inch
Total height ready for transportation	15 inch
Absolute filtration (To 0.9 Micron)	> 99.99%
Cyst Reduction	> 99.99%
(including Cryptosporidium and Giardia)	
Turbidity reduction.....	> 99.69%
For particles between 0.5 and 0.8 Micron	> 99.69%
Reduce harmful bacteria.....	> 99.99%
(E.coli, cholera, shigella, Salmonella, klebsiella)	

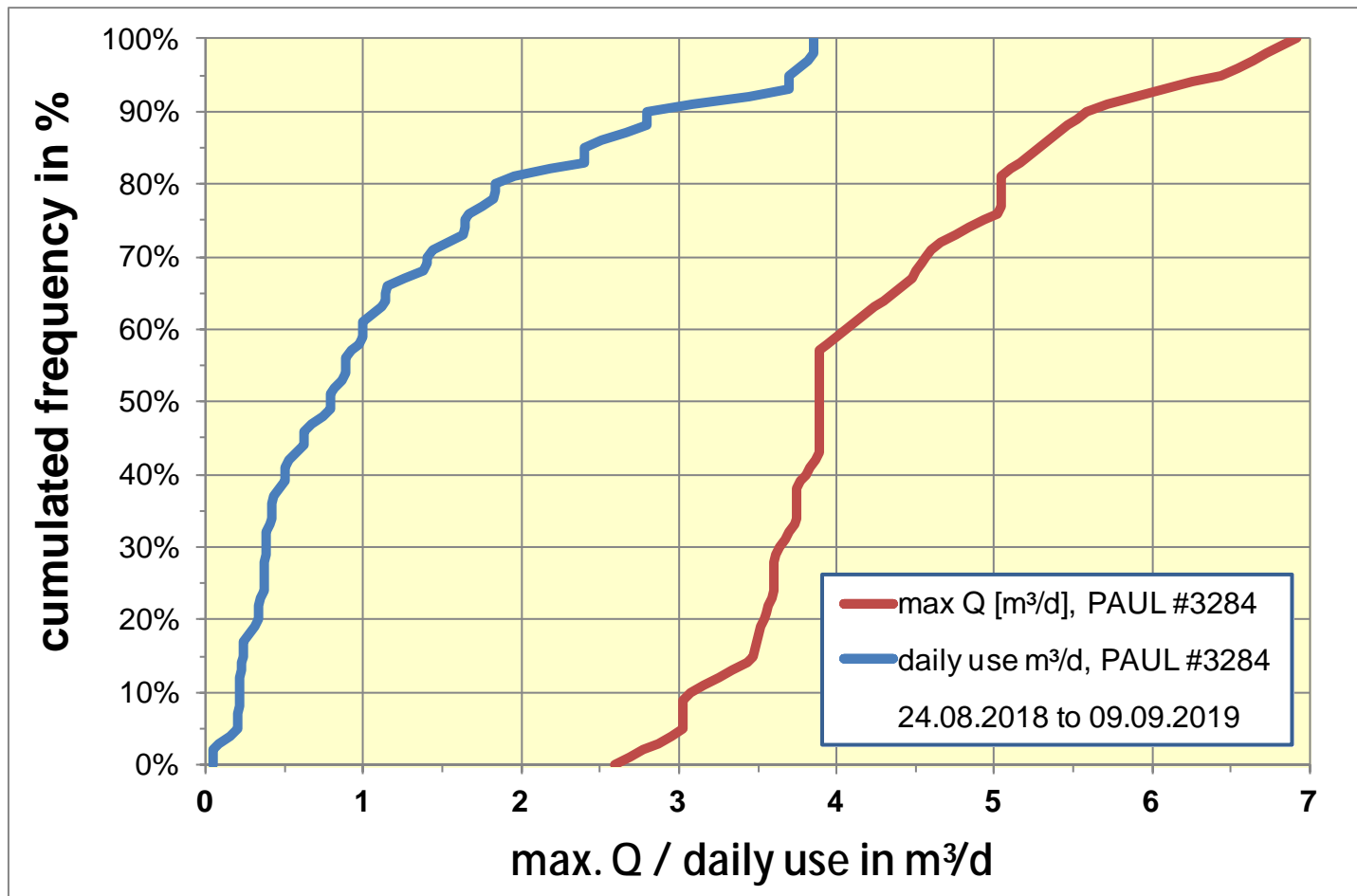




Data source: University of Kassel (sponsored by DBU); private measurement by Mr. Koscheny, Ms. Brandl, Mr. Andres



Data source: University of Kassel (sponsored by DBU); private measurement by Mr. Koscheny, Ms. Brandl, Mr. Andres



Data source: private measurement by Mrs. Duangkaew Tawee (Thailand)

rainwater ponds as a raw water source

PAUL® can be used with rainwater, groundwater from wells or river water and maybe even other sources. However, the best source for raw water is **rainwater**, most likely from a pond, see examples hereafter, as rainwater usually is free from

- Ø geologic load (e.g. arsenic, other heavy metals)
- Ø industrial pollution
- Ø pollution from farming (e.g. nitrate)

The solids that usually cause the brown color of most ponds (see examples) will be removed perfectly by PAUL®

If water is scarce, the only solution seems to be drilling wells. However, this is costly, success is not guaranteed, sometimes the well operation is not sustainable, or drilling may fail in general.

Thus, always also consider the possibility for **rainwater harvesting**. Storage in a cistern, tank or simply a reservoir/lagoon/pond. This usually is cheaper and the quality of the water might be better as outlined above. See a sample on the next slides.





Myanmar

© Frechen

IMG_2358_1280_720 11.06.2013, 10:58:00





IMG_2568_1280_720 11.06.2013, 13:37:20

Myanmar

© Frechen





IMG_2574_720_1280 11.06.2013, 13:40:34

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Myanmar

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Myanmar

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Colombia 2014 ã Jose Ordonez





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



This pond was created for rainwater harvesting for a **PAUL®** station at a cost of 2 500 €.
This picture shows the pond immediately after filling ... The water is very murky But see pictures later



Uganda 2019 © Steger





Uganda 03/2019 © Steger





Transportation (150 km from Kampala) and work of the excavator was < 2,200 €

Uganda 03/2019 © Steger





Uganda 03/2019 © Steger





Uganda 03/2019 © Steger





PAUL® station under construction
Uganda 03/2019 © Steger



This picture shows the pond in use today. Rainwater is to be used as raw water for **PAUL**® station (background), and cattle directly drink from the pond

Uganda 03/2019 © Steger





Balkans, May 2014: Also this water is excellent as raw water for **PAUL®**

© spiegelonline, Location: Balkans



Credits and awards

PAUL® was developed at the

Research was sponsored by

PAUL® is assembled at the
Kassel Disabled workshop

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The WaterBackpack Company

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V E R S I T Ä T



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The
WaterBackpack
Company GmbH
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Selected awards
won by PAUL®



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



2019 Melvin Jones Fellow



The WaterBackpack Company GmbH
Prof. Dr.-Ing. F.-B. Frechen
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