Hochschule Amberg-Weiden
für angewandte Wissenschaften
University of Applied Sciences (FH)

Anforderungen an eine innovative Abwasseraufbereitung für nachhaltige Wasserwiedernutzung

Prof. Dr.-Ing. Franz Bischof

Frischwasser – nicht beliebig vermehrbar

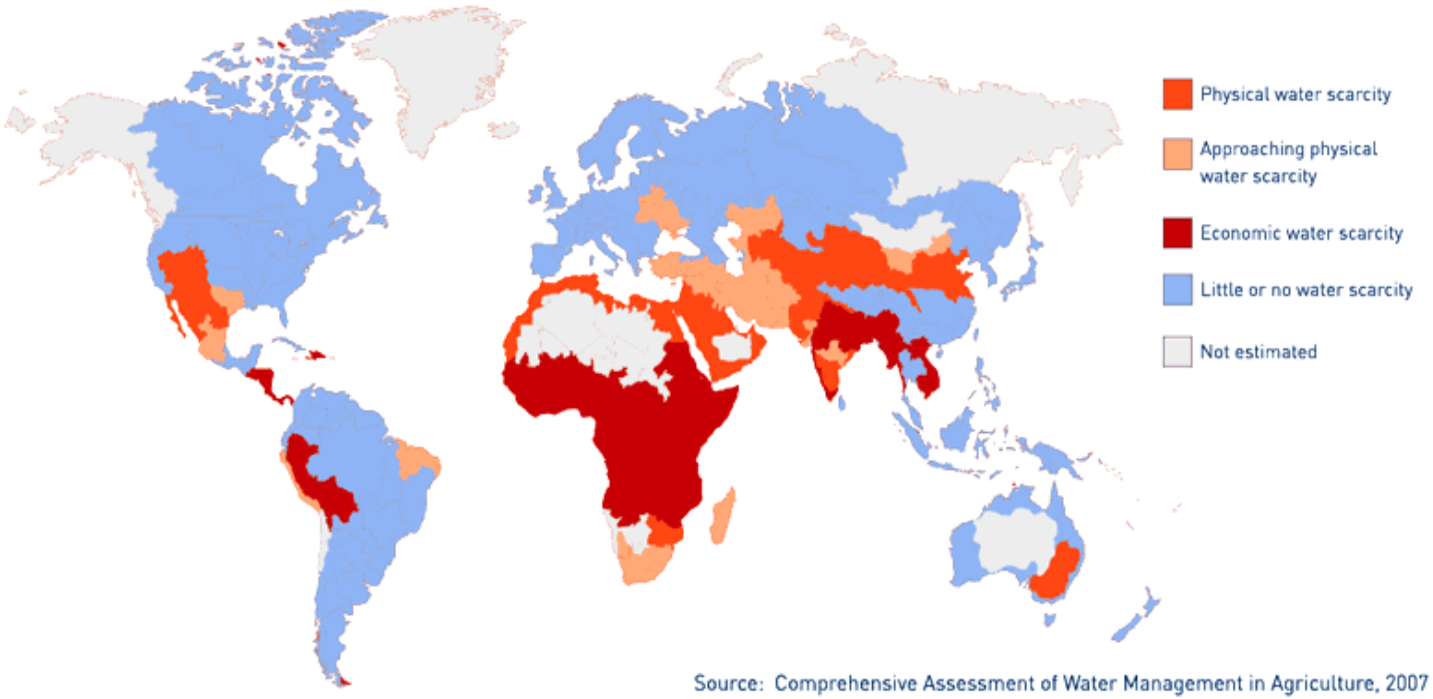
AREAS OF PHYSICAL AND ECONOMIC WATER SCARCITY

Physical water scarcity water resources development is approaching or has exceeded sustainable limits). More than 75% of the river flows are withdrawn for agriculture, industry, and domestic purposes (accounting for recycling of return flows). This definition—relating water availability to water demand—implies that dry areas are not necessarily water scarce.

Approaching physical water scarcity. More than 60% of river flows are withdrawn. These basins will experience physical water scarcity in the near future.

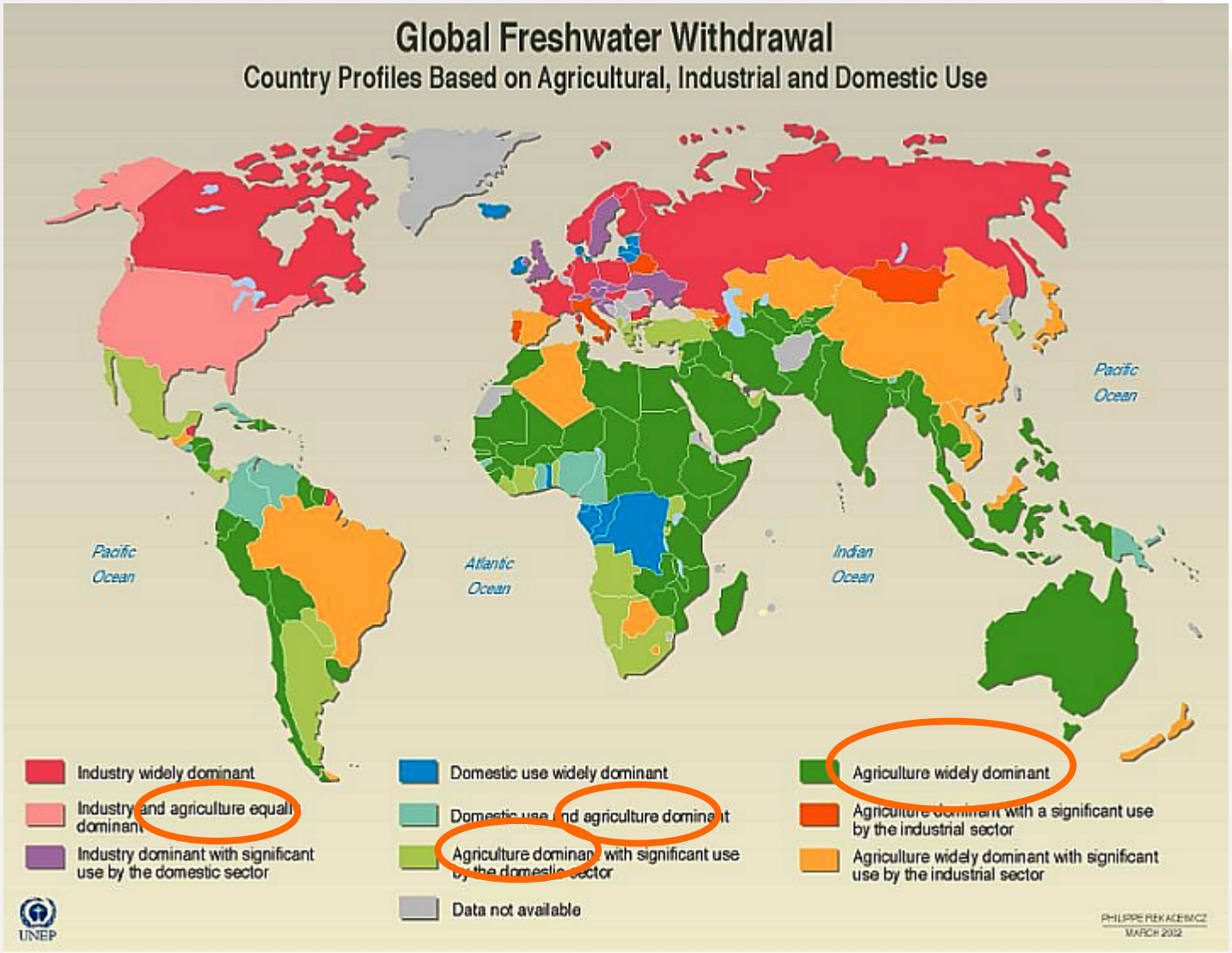
Economic water scarcity (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands). Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.

Little or no water scarcity. Abundant water resources relative to use, with less than 25% of water from rivers withdrawn for human purposes.



Source: Comprehensive Assessment of Water Management in Agriculture, 2007

Frischwasser – eine begrenzte Ressource



Source: Based on data fromTable FW1 in *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.

Wasserbedarf am Beispiel arabischer Staaten

	1990			2000			2025			Total demand		
Country	Domestic	Agriculture	Industrial	Domestic	Agriculture	Industrial	Domestic	Agriculture	Industrial	1990	2000	2025
Bahrain	86	120	17	169	124	26	230	271	73	223	319	574
Kuwait	295	80	8	375	110	105	670	140	160	[illegible]	590	970
Qatar	76	109	9	90	185	15	230	205	50	194	290	485
Oman	81	1,150	5	170	1,270	85	630	1,500	350	[illegible]	1,525	2,480
UAE	513	950	27	750	1,400	30	1,100	2,050	50	1,490	2,180	3,200
Saudi Arabia	1,508	14,600	192	2,350	15,000	415	6,450	16,300	1,450	16,300	17,765	24,200
Yemen	168	2,700	31	360	3,100	60	840	3,800	137	2,899	3,520	4,777
Total	2,727	19,709	289	4,264	21,189	736	10,150	24,266	2,270	[illegible]	26,189	36,686

Source: Compiled by ESCWA (Economic and Social Commission for Western Asia) secretariat from country reports and international sources, 1994 and 1995.

! 20

! 70

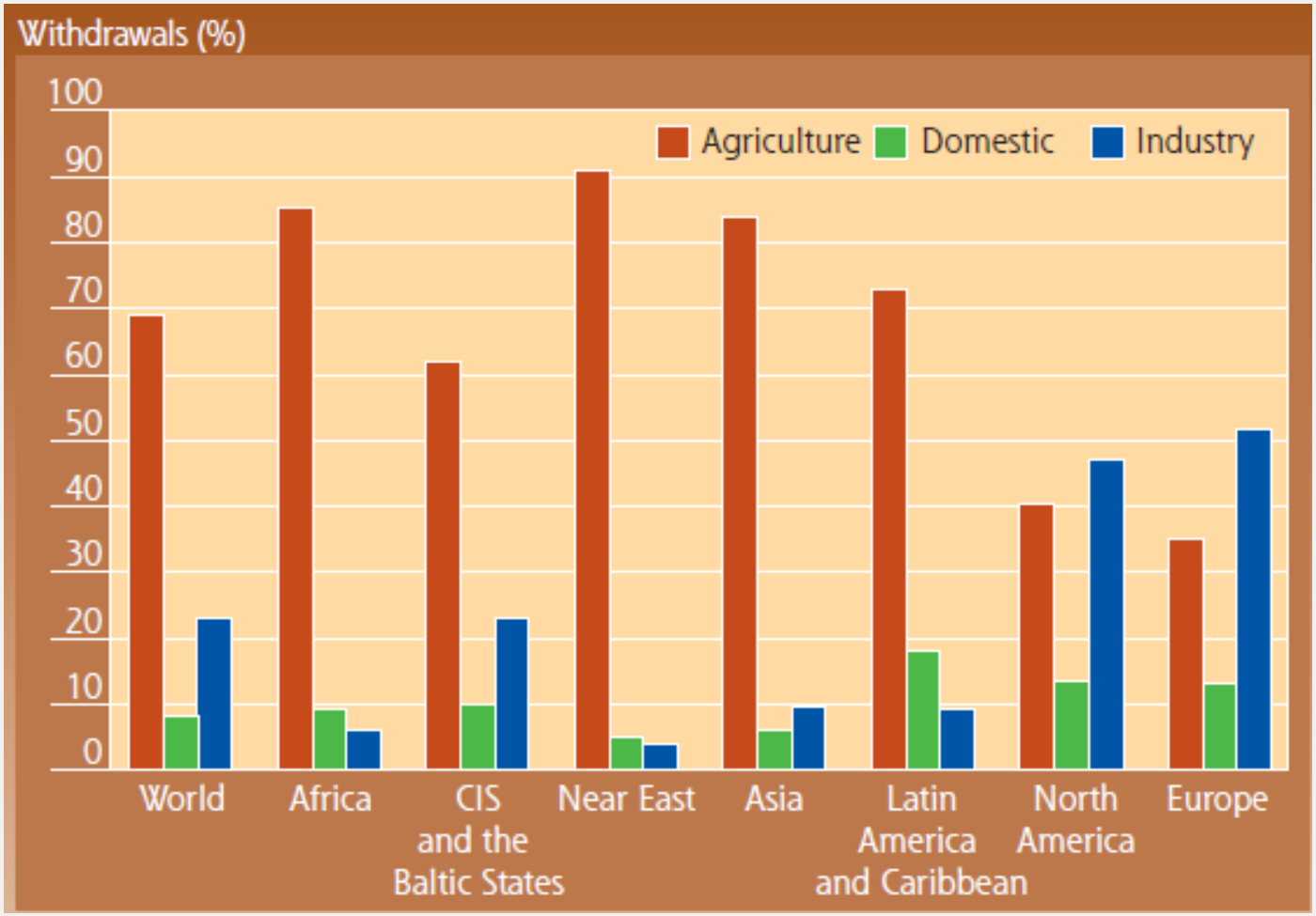
! 8

12 % **87 %** **16 %** **81 %** **28 %** **66 %**

Wasserbedarf weiterhin steigend

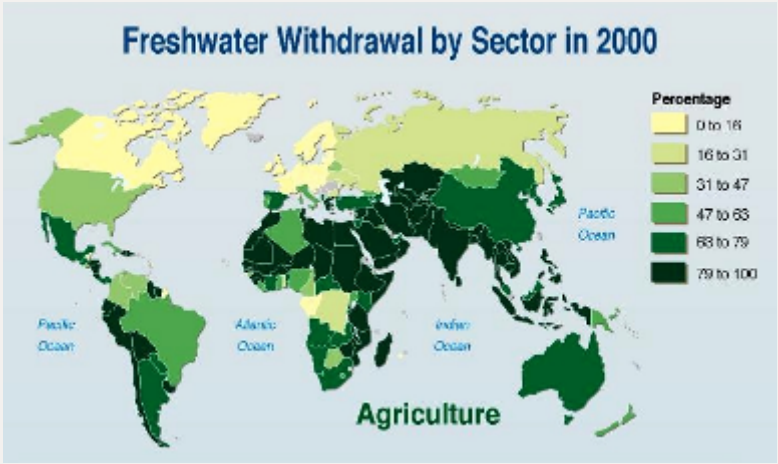
Weiterhin zunehmender Bedarf in der Landwirtschaft

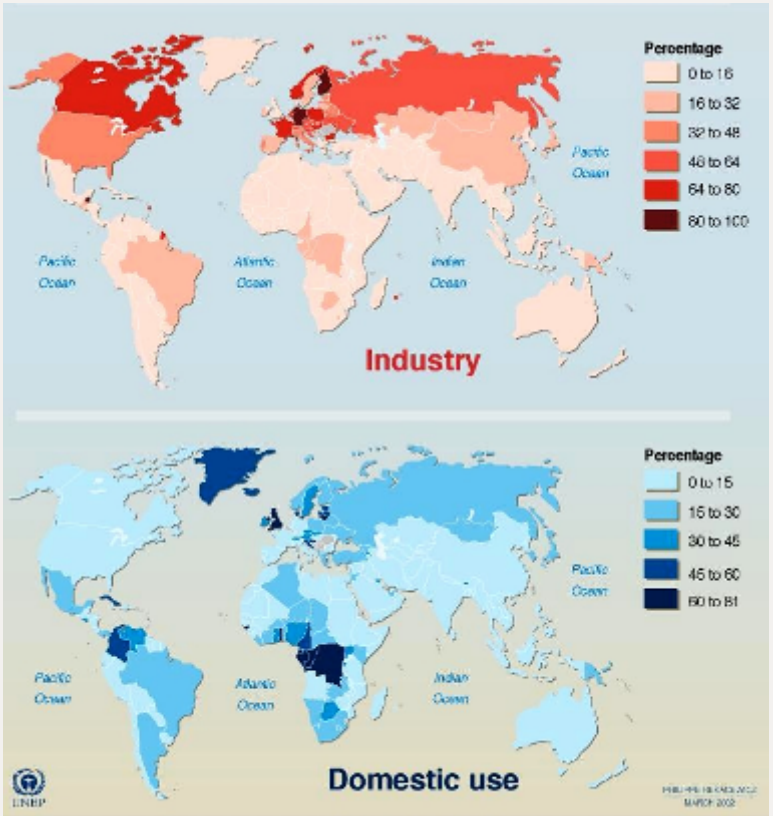
Wasserbedarf - weltweit

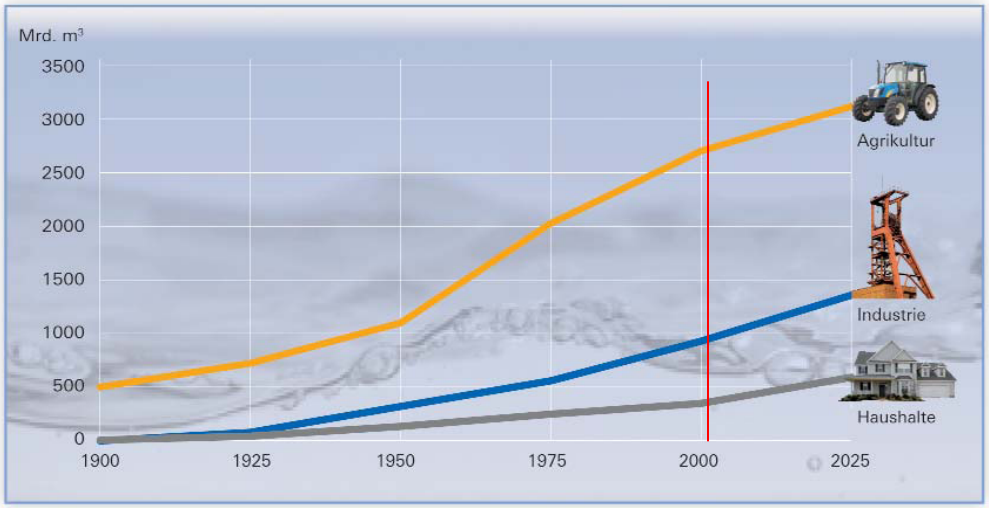


Quelle: Drops and Crops, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 2002

Frischwasser – eine begrenzte Ressource





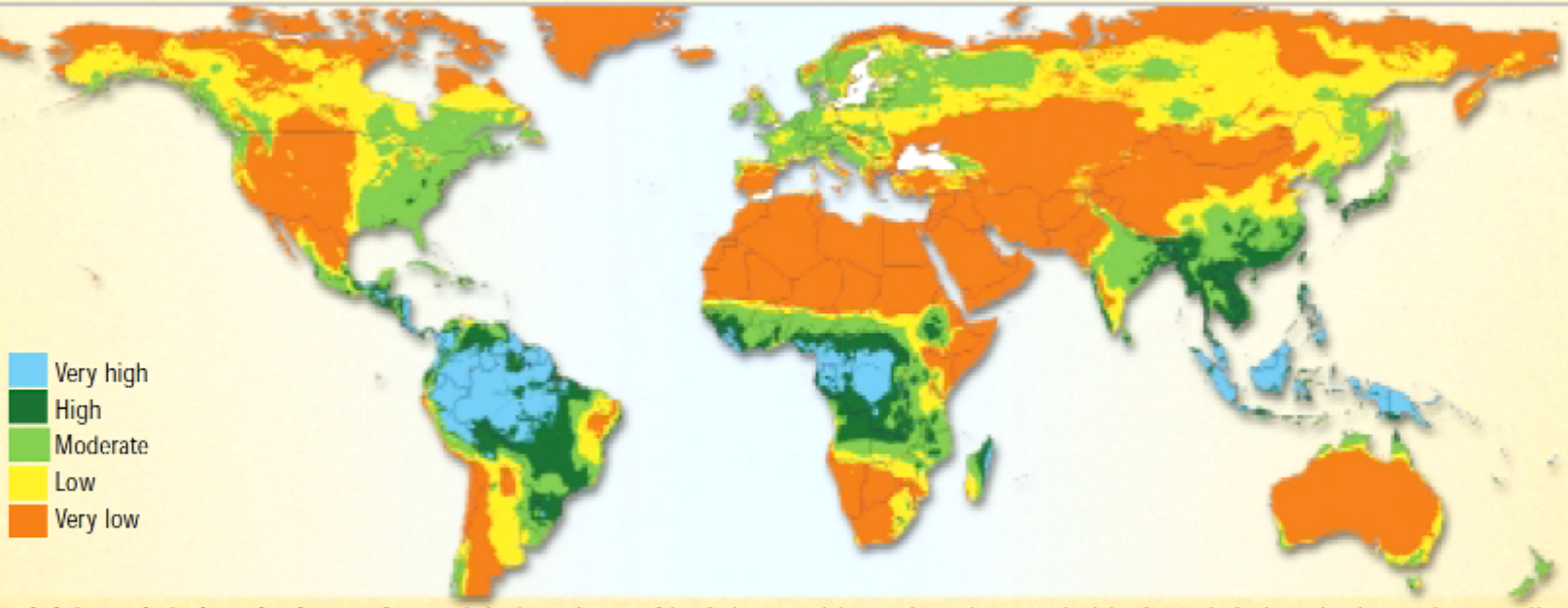


Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI) Washington DC, 2000.

Quelle: UNEP, 2002

Kein Verlass auf Regen

Potential for rainfed agriculture on a global scale



Potential for rainfed agriculture. On a global scale, 46% of the earth's surface is unsuitable for rainfed agriculture due to climatic constraints. This leaves approximately 7 billion ha with a potential for rainfed crop production, of which, 4.7 billion ha is classified as moderate to highly suitable. Researchers are currently refining this preliminary estimate taking into consideration non-climate related factors (e.g. areas not available for conversion to agriculture).

http://www.iwmi.cgiar.org/WAtlas/brochure.pdf

Abwasser – Wertwasser - kalkulierbar

500.000 E – 120 l/E*d
– 20% Verlust

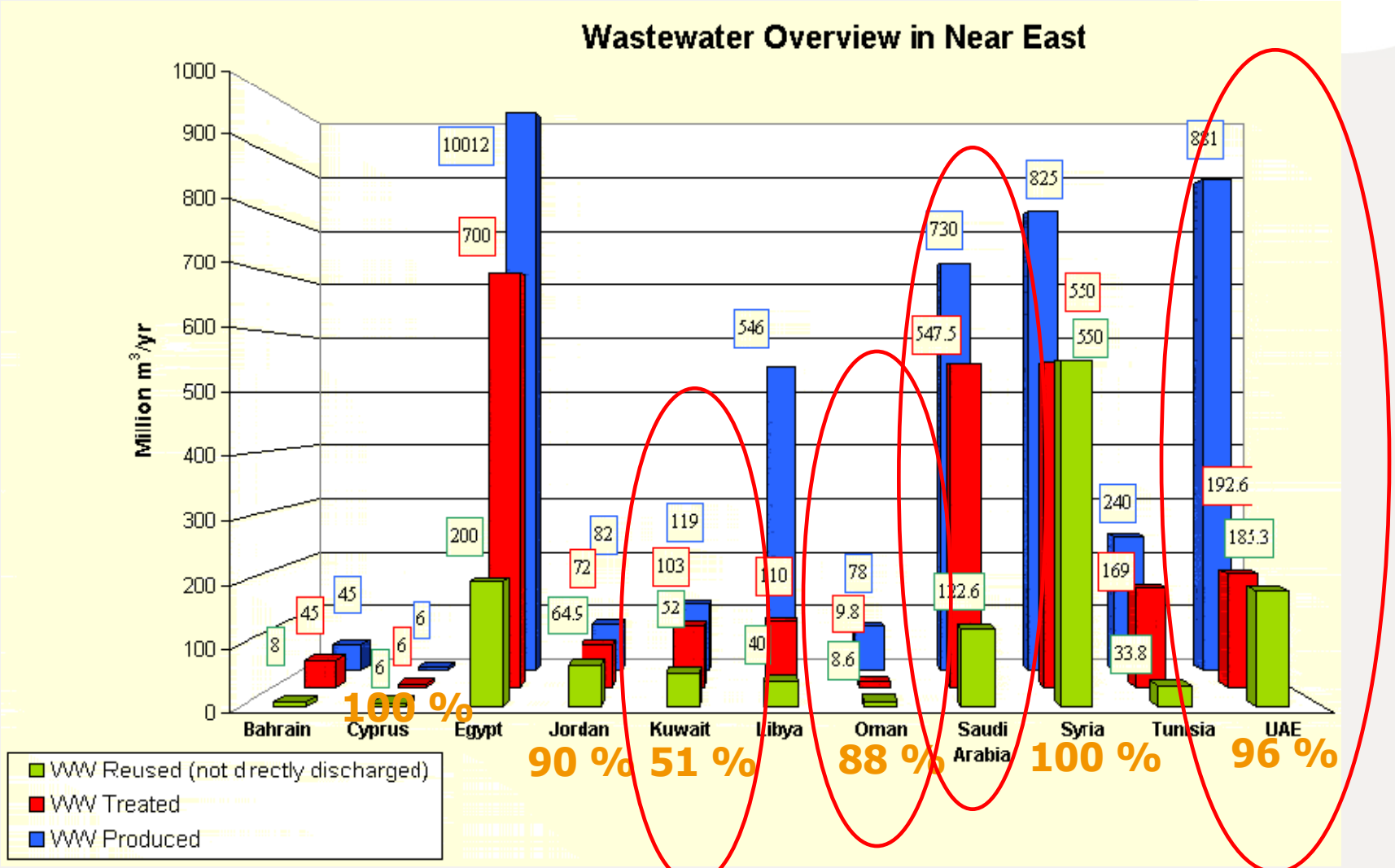
48.000 m³ / d

N: 50 mg/l
P: 10 mg/l
K: 30 mg/l

N: 250 kg/ha
P: 50 kg/ha
K: 150 kg/ha

Quelle der Daten: Drops and Crops, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 2002

Abwasser – vielfach genutzt



http://www.fao.org/nr/water/art/2007/wastewater/wastewater_near_east.html

Abwasser – weltweit genutzt

The Database information is sorted by region and country containing fields on wastewater production, treatment technologies, and financial/economical parameters by country. For each data field, original Reference is available as well as the Data Reference Year which corresponds to the year of data collection, not necessarily the reference publication year. A Glossary containing the definitions of each data parameter is also given. A Comments/Notes field contains additional information pertinent to the data.

- ○ **General Information I**
  Population, Total area, Irrigated area
- ○ **General Information II**
  Improved water sources, Improved sanitation facilities
- ○ **Water Withdrawal**
  Total, domestic, industrial, agricultural
- ○ **Wastewater Production**
  Total, domestic, industrial, others
- ◉ **Wastewater Treatment**
  Treated volume, Number of treatment plants, Total treatment plant capacity
- ○ **Treatment Processes**
  Preliminary, Primary, Secondary, Tertiary/advanced, Natural/biological, Disinfection, Effluent storage, Others
- ○ **Wastewater Reuse I**
  Treated volume reused, % irrigated area, Irrigation methods
- ○ **Wastewater Reuse II**
  Crops irrigated, Health/environmental impact
- ○ **National Organizations**
  Institution, Focal points, Guidelines, Facilities
- ○ **Projects**
  Planned population to be served, Planned treatment plants and reuse, Research and monitoring programs
- ○ **Financial/economic Data**
  Freshwater price, Wastewater price, Financial/economic studies

http://www.fao.org/nr/water/infores_databases_wastewater.html

Abwasser – weltweit genutzt

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Wastewater Production (no drainage water from agriculture)

Country	Produced wastewater volume Total (Million m3/yr)	Produced wastewater volume Domestic (Million m3/yr)	Produced wastewater volume Industrial (Million m3/yr)	Produced wastewater volume Others (Million m3/yr)	Year	Reference
Cyprus	6	-	-	-	2001	6

Wastewater Reuse (II)

Country	Crops irrigated with wastewater	Year	Reference	Wastewater use other than irrigation	Year	Reference	Reports on adverse health and / or environmental impact due to reuse of wastewater	Reference
Cyprus	Industrial crops, animal feed	2003	8	Enrichment aquifers, gardening	2003 (Ref 8) 2001 (Ref 51)	8, 51	-	-

Projects

Country	Planned population to be served by sanitation facilities	Reference	Planned treatment plants and reuse	Year	Reference	Research and monitoring programs	Year	Reference
Cyprus	All communities with population equivalent of more than 2000 would be served with treatment plants by the year 2012	6	Treated wastewater 2012: 30 MCM , irrigated agriculture expanded by 10% and 10 new treatment plants planned. Future use: golf courts	2001	6, 51	-	-	-

http://www.fao.org/nr/water/infores_databases_wastewater.html

Abwasser – unverzichtbar

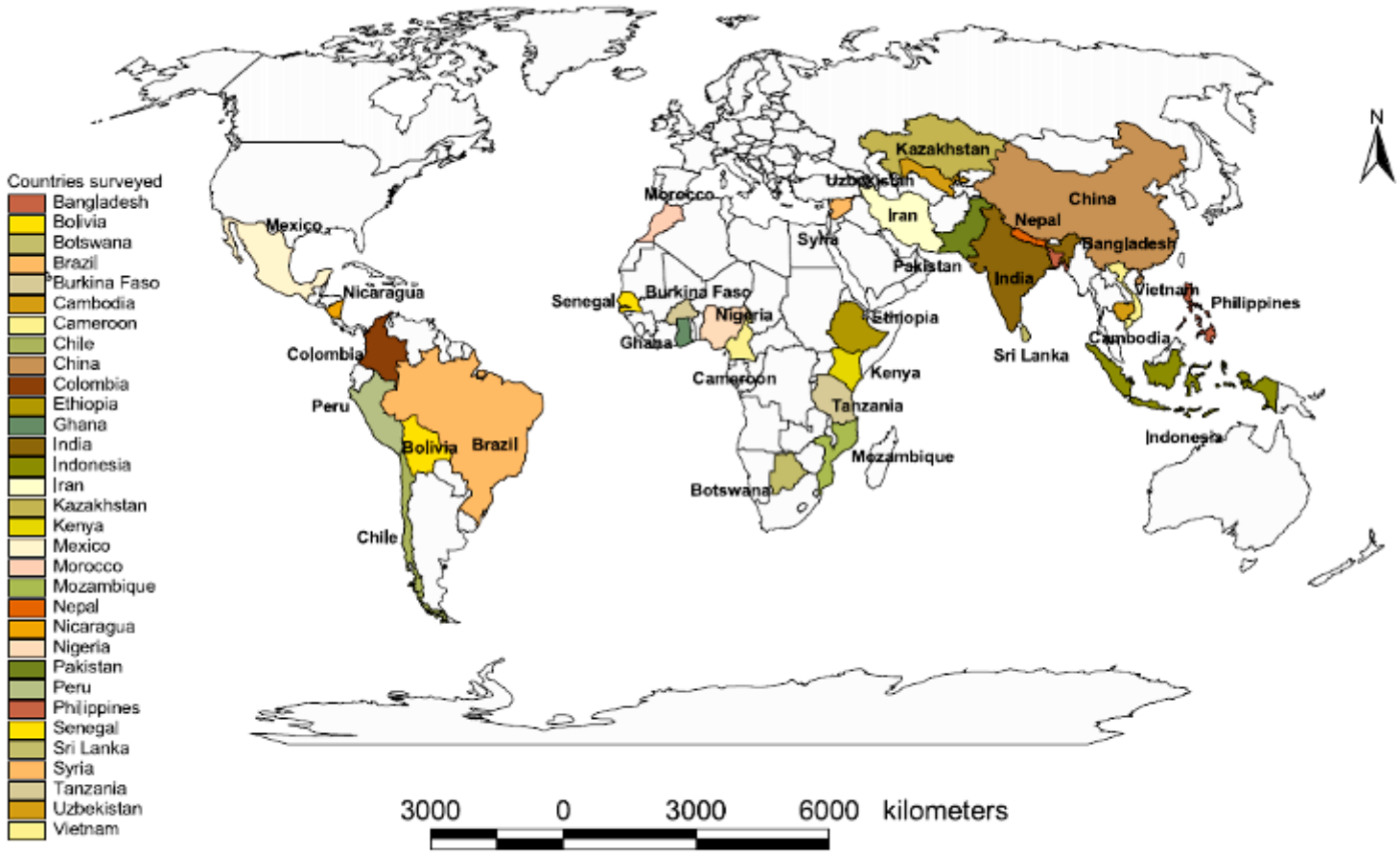


FIGURE 1. Regional distribution of 53 selected cities/countries for the global survey.

Raschid-Sally, L.; Jayakody, P. 2008. Drivers and characteristics of wastewater agriculture in developing countries: Results from a global assessment. Colombo, Sri Lanka: International Water Management Institute. 35p. (IWMI Research Report 127)

Abwasser – Wertwasser mit Gefährdungspotential

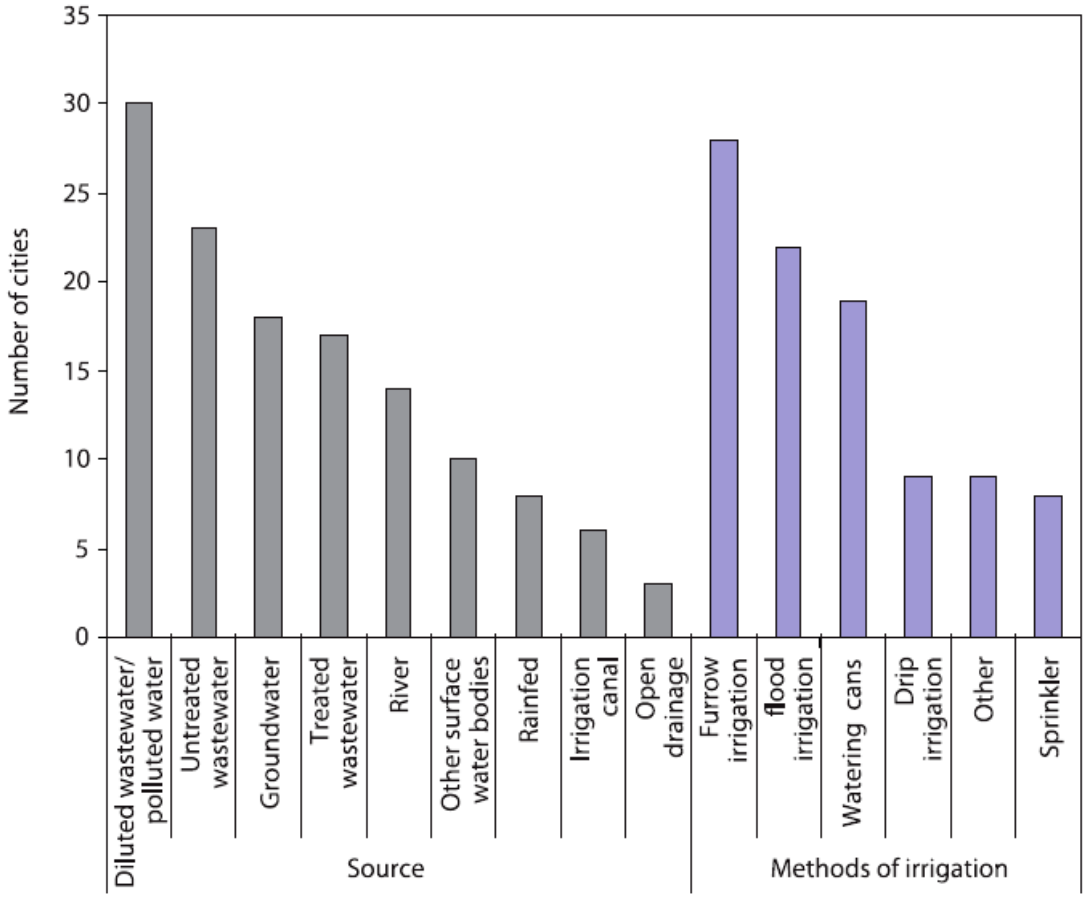


FIGURE 13. Water sources, quality and methods used in wastewater agriculture.

Ergebnis der Studie:

ca. 20 Mio ha

ca. 50% unbehandeltes Abwasser

Einfache Bewässerungs-technologien

Raschid-Sally, L.; Jayakody, P. 2008. Drivers and characteristics of wastewater agriculture in developing countries: Results from a global assessment. Colombo, Sri Lanka: International Water Management Institute. 35p. (IWMI Research Report 127)

Abwasser – Gefährdungspotential

Table 2.4 Global mortality and DALYs due to some diseases of relevance to wastewater use in agriculture

Disease	Mortality (deaths/year)	Burden of disease (DALYs/year)	Comments
Diarrhoea	1 798 000	61 966 000	99.8% of deaths occur in developing countries; 90% of deaths occur in children
Typhoid	600 000	N/A	Estimated 16 million cases per year
Schistosomiasis	15 000	1 702 000	Found in 74 countries; 200 million people worldwide are estimated to be infected, 20 million with severe consequences
Ascariasis	3 000	1 817 000	Estimated 1.45 billion infections, of which 350 million suffer adverse health effects
Hookworm disease	3 000	59 000	Estimated 1.3 billion infections, of which 150 million suffer adverse health effects
Lymphatic filariasis	0	5 777 000	Mosquito vectors of filariasis breed in organically polluted water; does not cause death but leads to severe disability
Hepatitis A	N/A	N/A	Estimated 1.4 million cases per year worldwide; serological evidence of prior infection ranges from 15% to nearly 100%

N/A, not available
Sources: WHO (2000c, 2002, 2003b, 2003c, 2004b).

Bilharziose

Spulwurmbefall

Hakenwurm

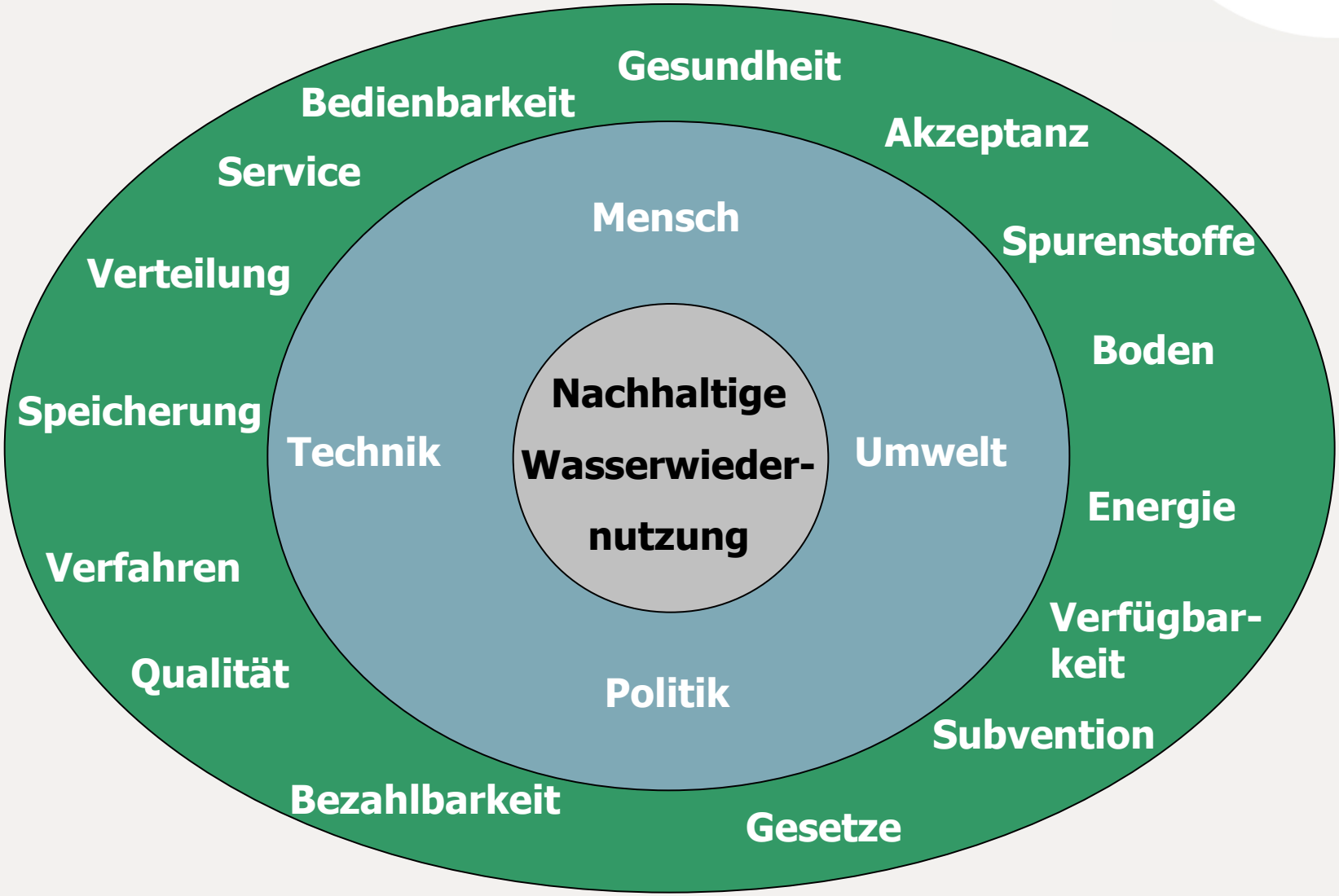
Nematoden (Fadenwurm)

Elefantenmann-Syndrom

http://www.liverpool.nsw.gov.au/onsitesewagemanagement.htm

DALY ist eine Abkürzung aus dem Englischen mit der Bedeutung **disability-adjusted life years** oder auch **disease-adjusted life years**.
Mit diesem Konzept soll die Bedeutung verschiedener Krankheiten auf die Gesellschaft gemessen werden. Auch soll die Effizienz von Vorbeugung und Behandlung messbar werden. Mit DALY soll nicht nur die Sterblichkeit sondern auch die Beeinträchtigung des normalen, beschwerdefreien Lebens durch eine Krankheit erfasst werden und in einer Maßzahl zusammengerechnet werden.

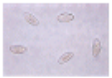
Nachhaltigkeit

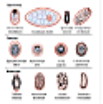


Abwasser – „Unerwünschte Begleitstoffe“

Wurm|eier

E *helminth eggs; worm e.*





von weiblichen bzw. hermaphroditischen Helminthen in den Wirtsorganismus ausgestoßene Eier, deren – z.T. von Dotterzellen umgebene – Eizellen sich bei manchen Arten erst nach Abgang mit den Ausscheidungen, bei anderen schon im Wirt weiterentwickeln. Die Entwicklung der geschlüpften Larven geht meist in 1 oder 2 Zwischenwirten weiter, führt im Endwirt zur Geschlechtsreife („adulte Würmer“). – Merkmale (s.a. Abb.): **1)** Ancylostoma duodenale: oval, 50 (60) : 35 (40) µm, frisch (im Stuhl) mit glasklarer Hülle; mit 2–8 Furchungszellen. – **2)** Ascaris lumbricoides: ovulär; befruchtet 54–60 µm, mit bräunlicher Außen- u. farbloser Innenhülle; unbefruchtet 75–85 µm, farblos, mit Tröpfcheneinschlüssen; erst die Larve ist invasionsfähig. – **3)** Clonorchis sinensis: 16 : 30 µm, bauchig flaschenförmig, mit Deckel, am Gegenpol evtl. winzige Haken; enthält bei Ablage das Miracidium. – **4)** Dicrocoelium dendriticum: oval, 26 : 40 µm, dunkelbraun, dickschalig; enthält bei Ablage das Miracidium. – **5)** Diphyllobothrium latum: 45 (50) : 67 (70) µm, dicke, braune Schale, an den Polen Deckel bzw. kleiner Knopf; zentrale Eizelle mit Dotterzellen; Embryonalentwicklung im Wasser unter Bildung einer zweiten, inneren Hülle u. einer Epithelschicht (später Zilien tragend). – **6)** Diphyllidium caninum: kugelig, 20 : 30 µm, zweischalig; der Embryo mit 6 paarig angeordneten Haken; um die durchscheinende Innenhülle dünne bläschenartige Membran (dadurch 26 : 50 µm). – **7)** Enterobius vermicularis: doppelt konturiert, farblos, asymmetrisch oval; 4-schichtige Schale; mit schlupffähigem Embryo. – **8)** Fasciola hepatica: oval, 80–140 µm, gelbbraun, mit Deckel u. deckelnaher Eizelle (mit Dotterzellen). – **9)** Fasciolopsis buski: ovalär, 83 : 138 µm, Pole leicht konisch mit Deckel; unreif farblos/gelblich, später bräunlich, klebrig; Eizelle (mit Dotterzellen) deckelwärts exzentrisch. – **10)** Hymenolepis nana: elliptisch, 40 : 50 µm; 2 Hüllen, dazwischen – polnahe – fädige Gebilde. – **11)** Necator americanus: ähnlich wie Ancylostoma-Ei, länglicher, 35 (40) : 64 (72) µm. – **12)** Paragonimus westermani: oval, unterschiedlich groß (ca. 55 : 90 µm), goldbraun; Deckel mit Kragen; 1 Eizelle mit 5–10 Dotterzellen (auch reifere Stadien). – **13)** Schistosoma: alle Arten mit Miracidium; Sch. haematobium: längs-ovulär, 45–60 : 120–160 µm, durchsichtig, Stachel an einem Pol; Sch. japonicum: plump-oval, 50 : 100 µm, gelblich; rudimentärer Stachel; Sch. mansoni: asymmetrisch-ovalär, 60 : 130–180 µm, seitlich Stachel. – **14)** Strongyloides stercoralis: oval, 30 : 50–70 µm, glatte, dünne, durchsichtige Schale; Larve (aus embryoniert abgelegtem Ei) schlüpft im Darm, manche Eier nur Morula- bis Larvenstadien enthaltend. – **15)** Taenia saginata, T. solium (voneinander kaum unterscheidbar), rund mit Randwall, 20 : 40 bzw. 30 : 50 µm; dünne Schale, Larve (Sechshakenlarve mit 3 Hakenpaaren) von radiär gestreifter Embryophore umgeben. – **16)** Trichostrongylus: 30–80 µm; ähnlich wie Ancylostoma-Ei (aber viele Furchungszellen). – **17)** Trichuris trichiura: 20 (25) : 50 (55) µm, doppel- u. dickschalig, gelblich/braun, zitronenförmig; Eizelle ungefurcht; an bd. Polen heller Schleimpfropf.

Verwandte Themen:

Ascaris lumbricoides; Cestoda; Clonorchiasis; Diphyllobothrium latum; Ei; Enterobius vermicularis; Fasciola hepatica; Helminthen; Hymenolepis nana; MIFC-Methode; Miracidium; Necator; Paragonimus; Sechshakenlarve; Taenia saginata; Trematoda; Trichuris trichiura; Zestoden; Zwischenwirt

http://www.tk-online.de/rochelexikon/ro40000/r41815.000.html

100%-ger Rückhalt

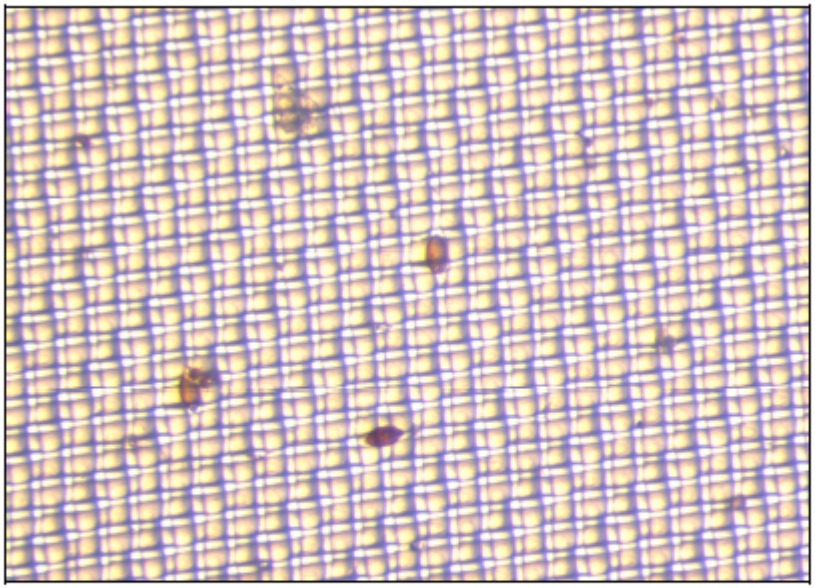
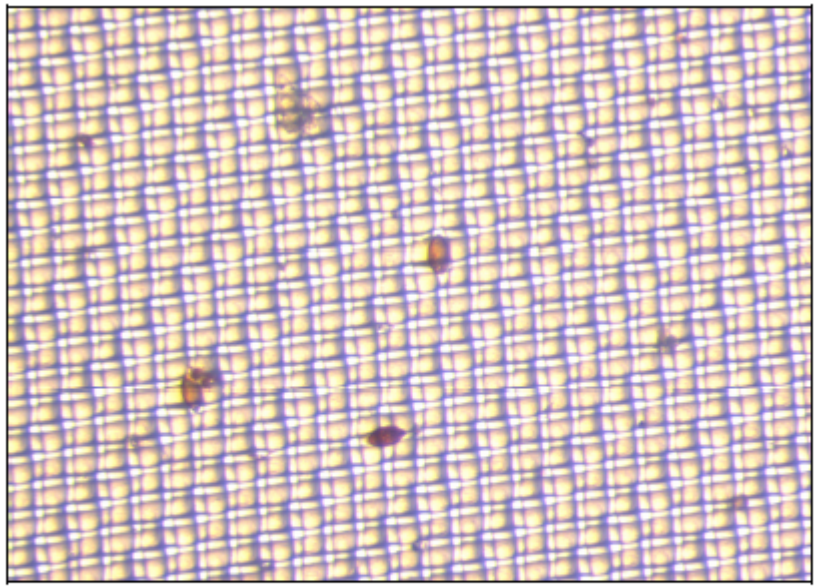


Figure 5: Close view of *Trichuris suis* eggs blocked on a 10 µm pore size filter cloth. Note that the threads in the filter cloth have a thickness of approx. 35 µm and therefore are thicker than the 10 µm openings. This gives an approx. 5% open area in the filter cloth. The picture was taken by optical microscope and subsequently enlarged.

Helminth eggs removal by microscreening for water reclamation and reuse

S. Quinzaños#*, C. Dahl*, R. Strube** and R. Mujeriego***, 2008

100%-ger Rückhalt



µm spherical latex particles, used as surrogates for helminth eggs. During the second phase, a 7.6 cm filter disc of a 10 µm pore size filter cloth, like those used in drum and discfilter microscreens, achieved a 100 % helminth eggs removal efficiency, using a 1000 eggs/l suspension of the *Trichuris suis* species. The similarity of pore

Helminth eggs removal by microscreening for water reclamation and reuse

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Mikrosiebung als Voraussetzung für effiziente Bewässerungstechnologien

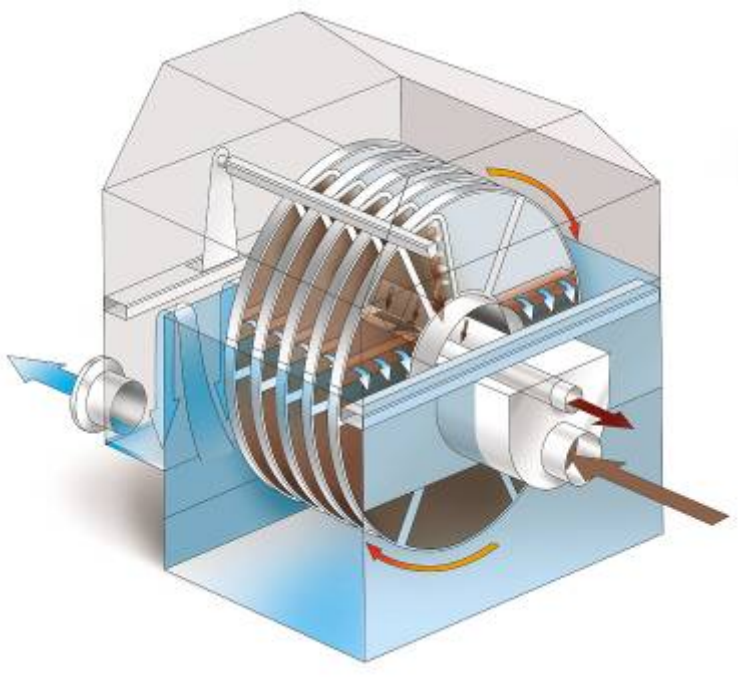
Drip systems, which cost in the range of US$1 200–2 500 per hectare, tend to be too expensive for most small-scale farmers and for use on low-value crops but research is under way to make them more affordable. One drip system has been developed that costs less than US$250 per hectare. The keys to keeping costs down are simple materials and portability: instead of each row of crops getting its own drip pipe, a single pipe moved every hour or so can be used to irrigate as many as ten rows. Bubbler irrigation is another cheap variation which eliminates the need for emitters, pressure regulators and other fittings; instead, water is allowed to bubble out of short lengths of pipe placed vertically and connected to underground lateral distributor pipes.

Quelle: http://home.howstuffworks.com/irrigation3.htm

Bubbler Irrigation

Quelle: Drops and Crops, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Rome, 2002

Innovative Aufbereitung



Durchsatz: 450 m³/h

Maschenweite: 10µm

AF_{zulauf}: ~ 250 mg/l

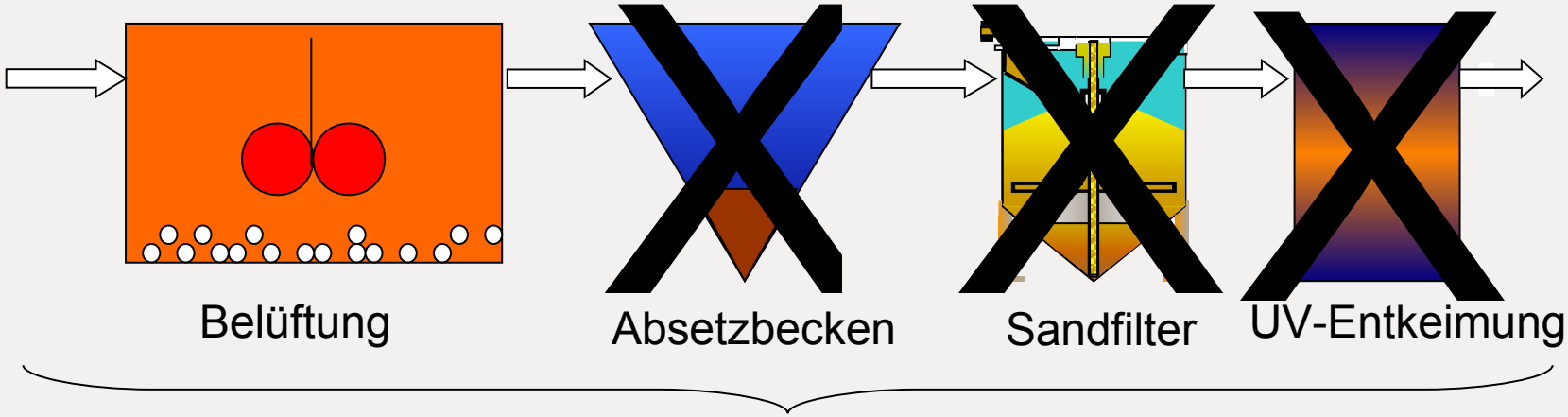
AF_{ablauf}: < 10 mg/l

Reduktion: > 96%

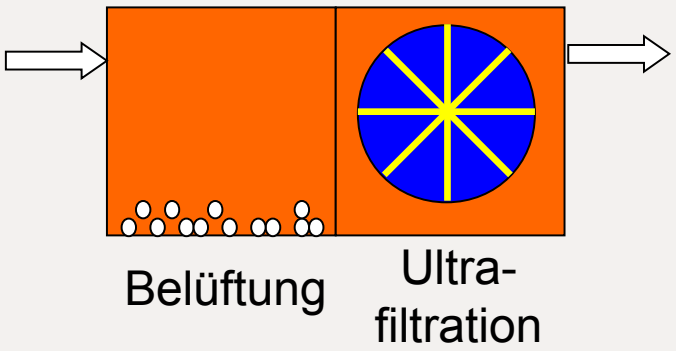
Bild: Hans Huber AG

Ohne Chlornebenprodukte

Konventionell



Membranbioreaktor



Innovative Aufbereitung

Ohne Chlornebenprodukte, VRM-Verfahren

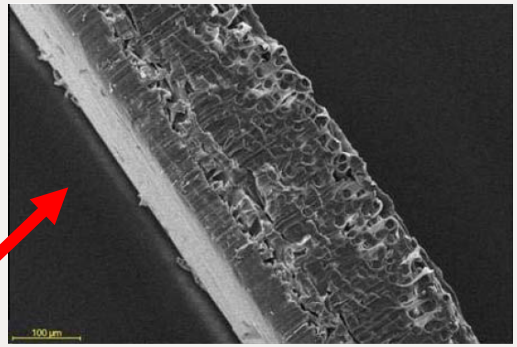
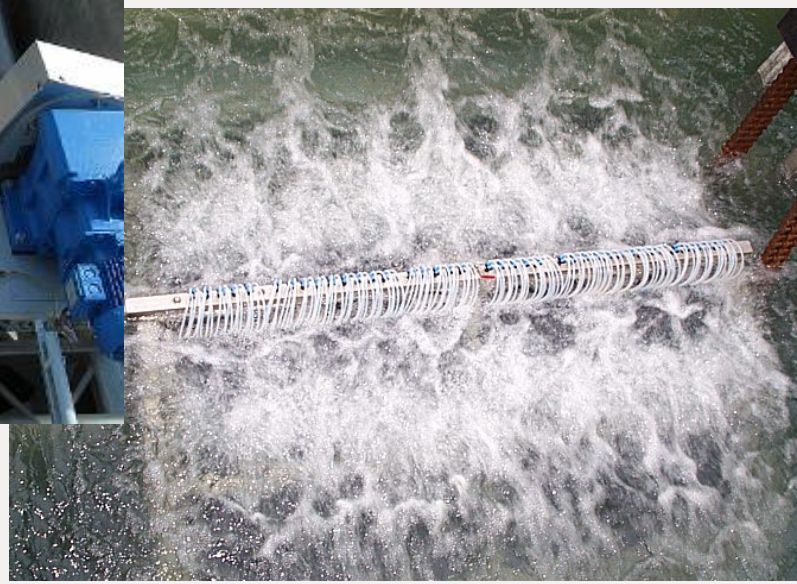


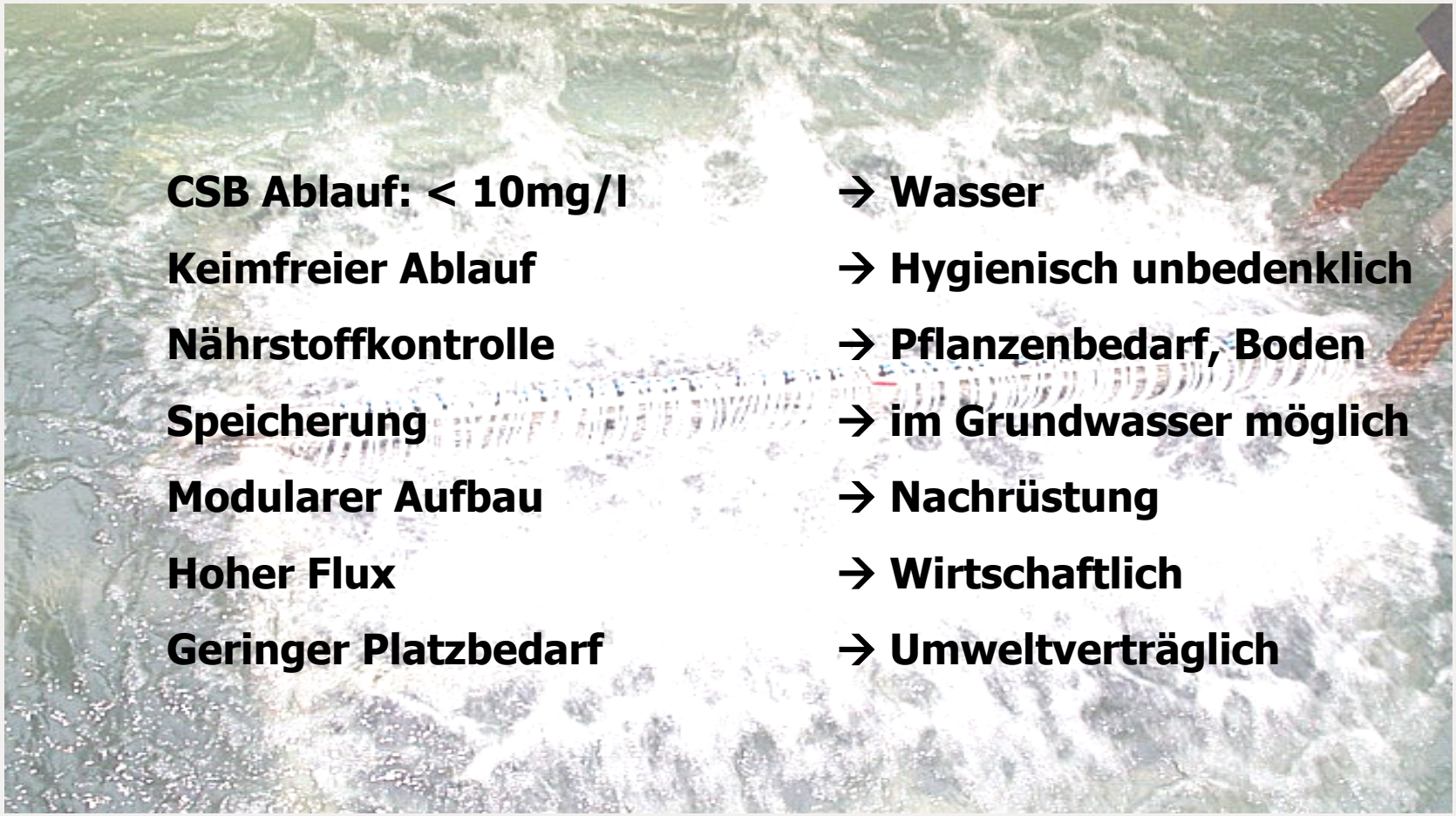
Bild: HAW Amberg-Weiden



Bilder: Hans Huber AG

Hochschule Amberg-Weiden

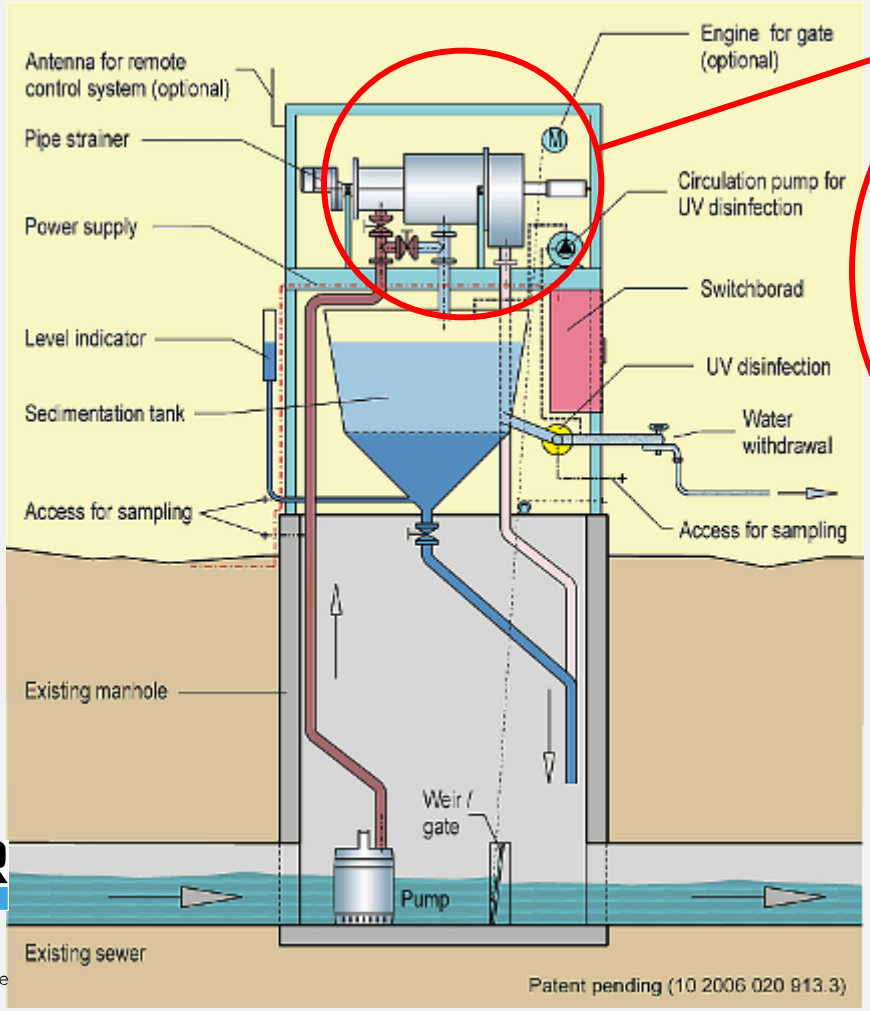
Ohne Chlornebenprodukte

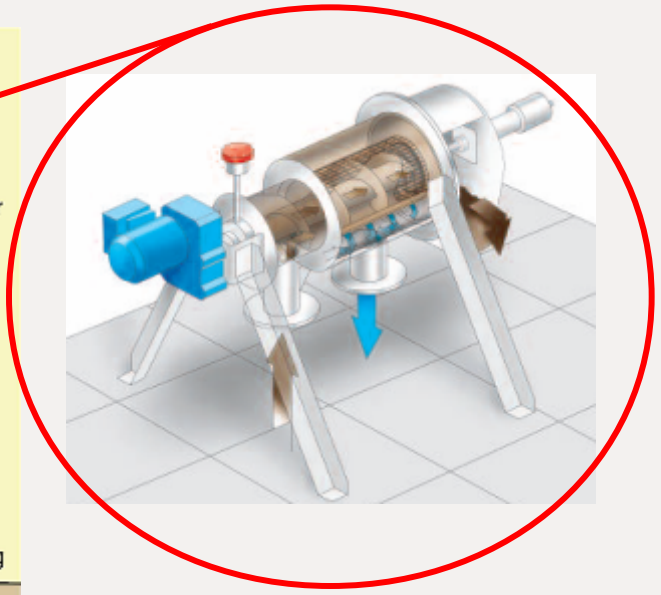


CSB Ablauf: < 10mg/l	**→ Wasser**
Keimfreier Ablauf	**→ Hygienisch unbedenklich**
Nährstoffkontrolle	**→ Pflanzenbedarf, Boden**
Speicherung	**→ im Grundwasser möglich**
Modularer Aufbau	**→ Nachrüstung**
Hoher Flux	**→ Wirtschaftlich**
Geringer Platzbedarf	**→ Umweltverträglich**

Innovative Aufbereitung

Einfach, effizient und kostengünstig





1. Siebung: CSB-Reduktion
2. Sedimentation: Wurm-eier
3. Desinfektion: UV

Sponsored by German BMBF (project no. 02WD0417, 02WD0757)

Zusammenfassung

Frischwasser ist knapp

Ressource Wasser nicht beliebig vermehrbar – nicht ersetzbar

Hoher Wasserbedarf

In der Zukunft steigend – Nahrungsmittelerzeugung prioritär

Verwendung von Abwasser unverzichtbar

Wertstoff und Gefahrenpotential zugleich - Sekundärrohstoff

Nachhaltige Wasserwiederverwendung

Verschiedene Kriterien zur Balance zwischen Mensch – Technik - Natur

Innovative Produkte und Verfahren

Können eine Vielzahl notwendiger Kriterien erfüllen

ENDE

Ich freue mich

auf Ihre Diskussionsbeiträge !

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