Bringing Fit-for-Purpose Applications into Fresh Produce Operations and Managing Control

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Hannover, Germany

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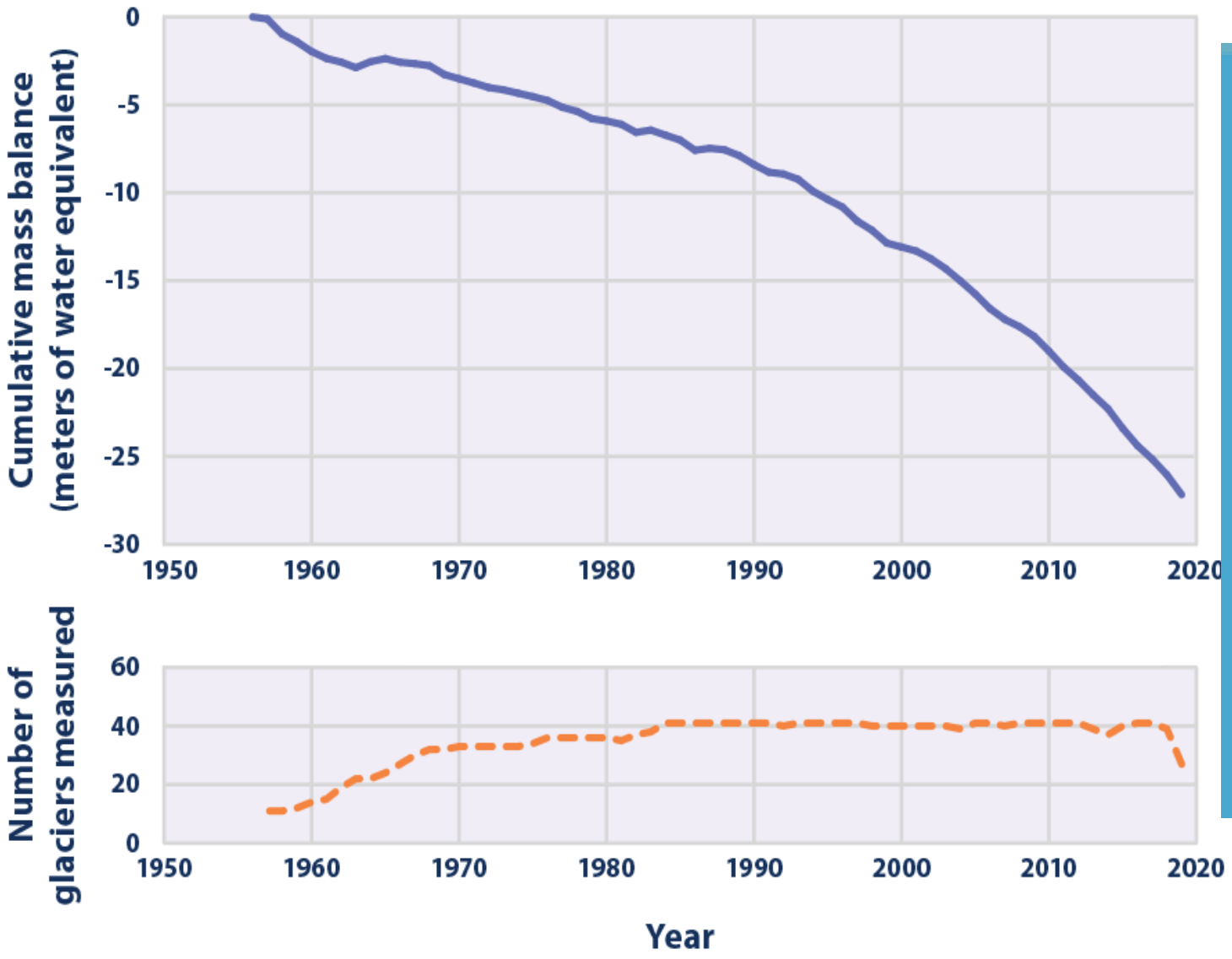
WATER AND CLIMATE COALITION
SECRETARIAT
Water is a top adaptation priority to combat climate change.
Water-related hazards have increased
Integrated water-climate management
3.6 billion with limited access to water
2021 STATE OF CLIMATE SERVICES REPORT

Average Cumulative Mass Balance of "Reference" Glaciers Worldwide, 1956–2019



Data source: WGMS (World Glacier Monitoring Service). 2020. Global glacier change bulletin no. 3 (2016–2017). Zemp, M., I. Gärtner-Roer, S.U. Nussbaumer, F. Hüsler, H. Machguth, N. Mölg, F. Paul, and M. Hoelzle (eds.). ICSU (WDS)/IUGG

Retrieved from https://www.epa.gov/climate-indicators/climate-change-indicators-glaciers

Food production

60%

increase in food production will be needed by 2050 to keep up with growing population.

(source: UN, IWA)

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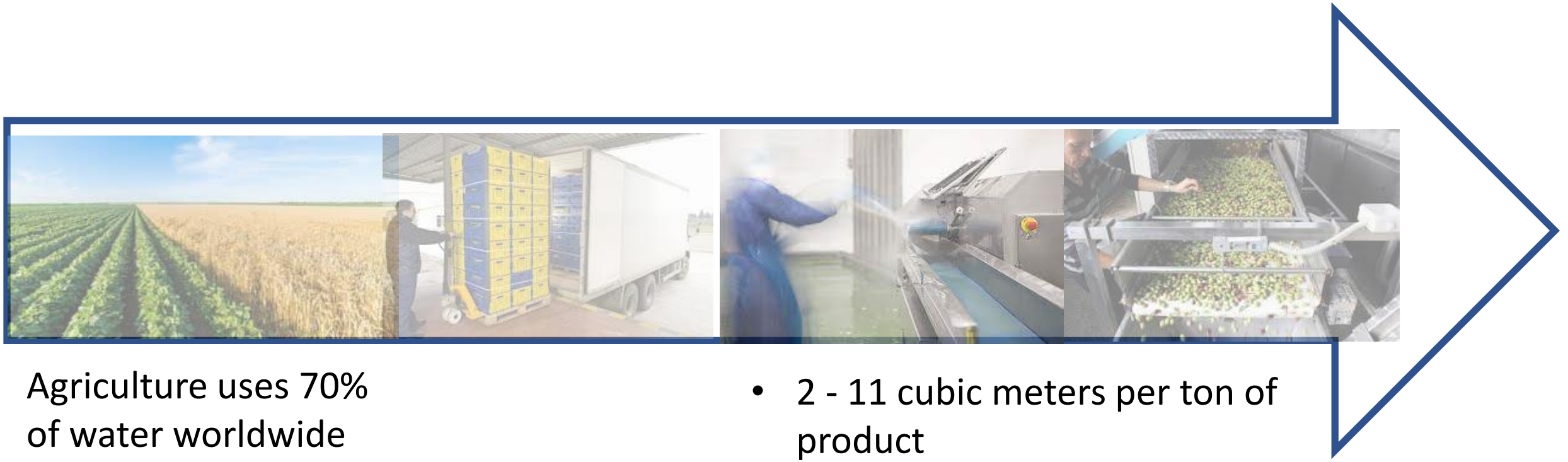
WATER USE IN FFV PRODUCTION



Agriculture uses 70% of water worldwide

- 2 - 11 cubic meters per ton of product
- Ca. 90% of this water consumption for leafy vegetable is estimated to be due to the washing step

(Ölmez, 2017)

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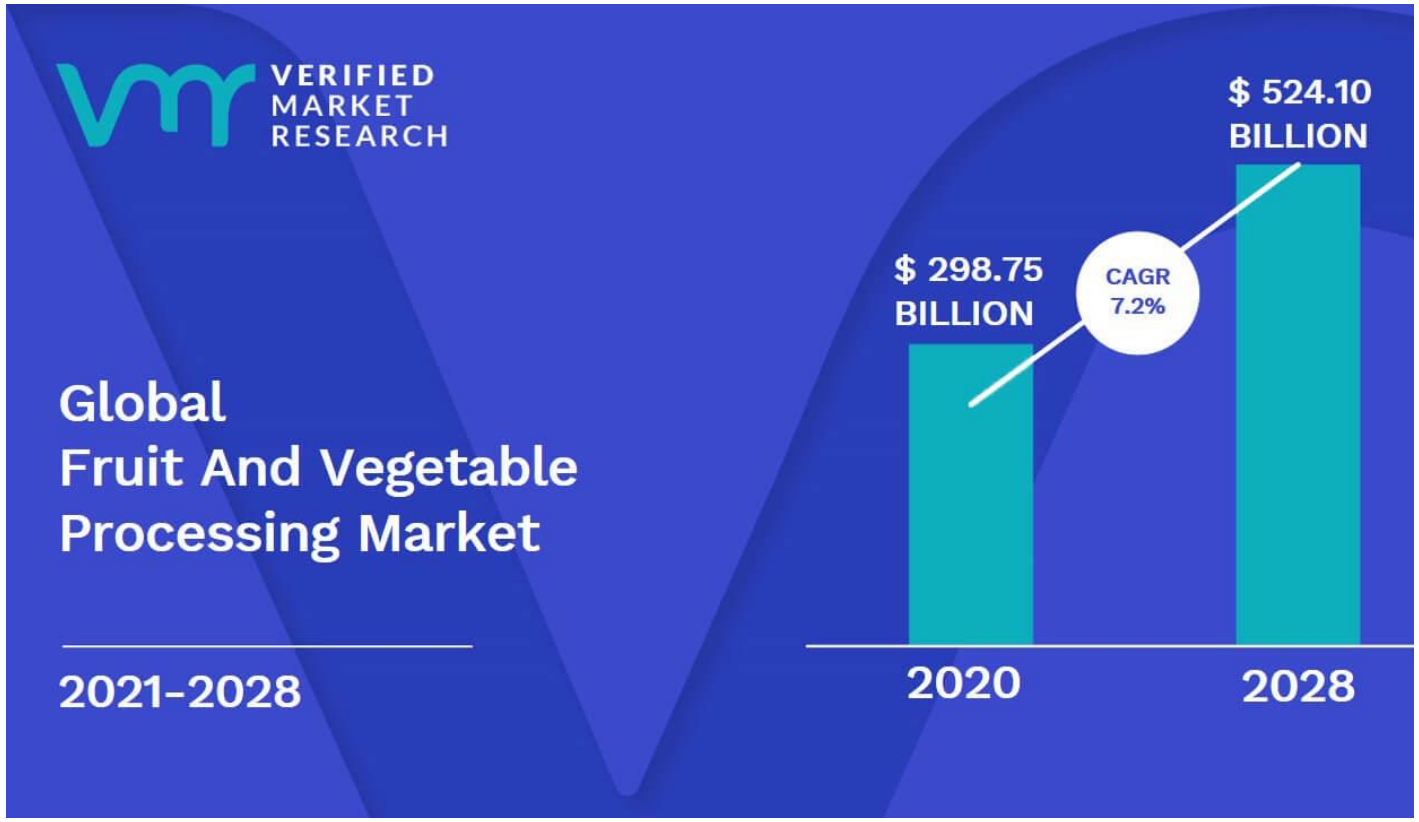


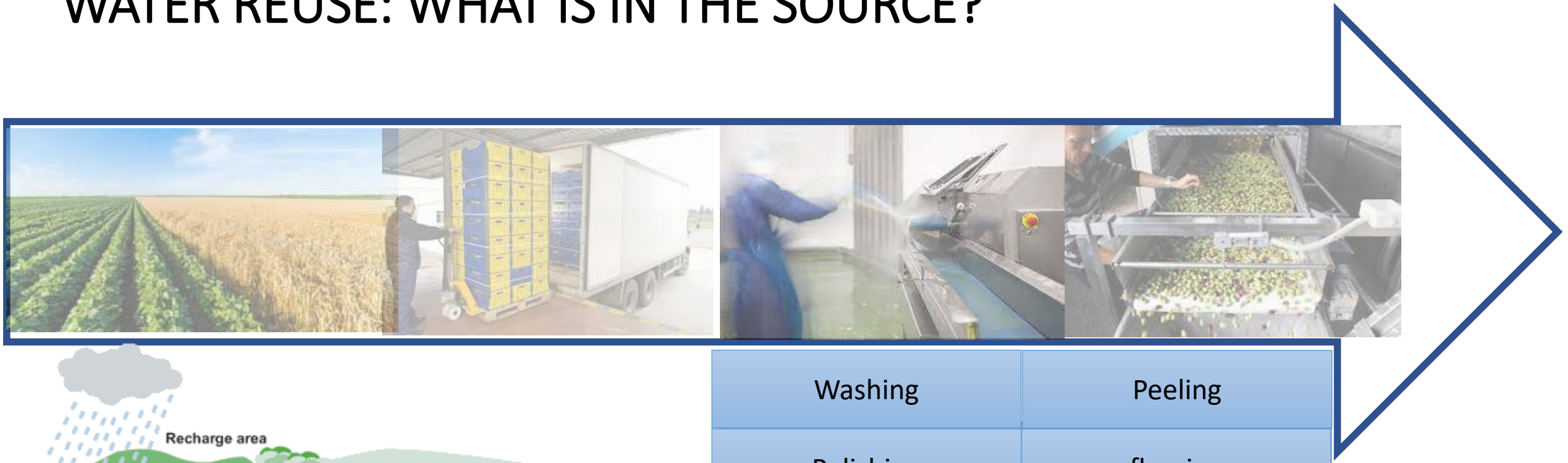
Reducing water use

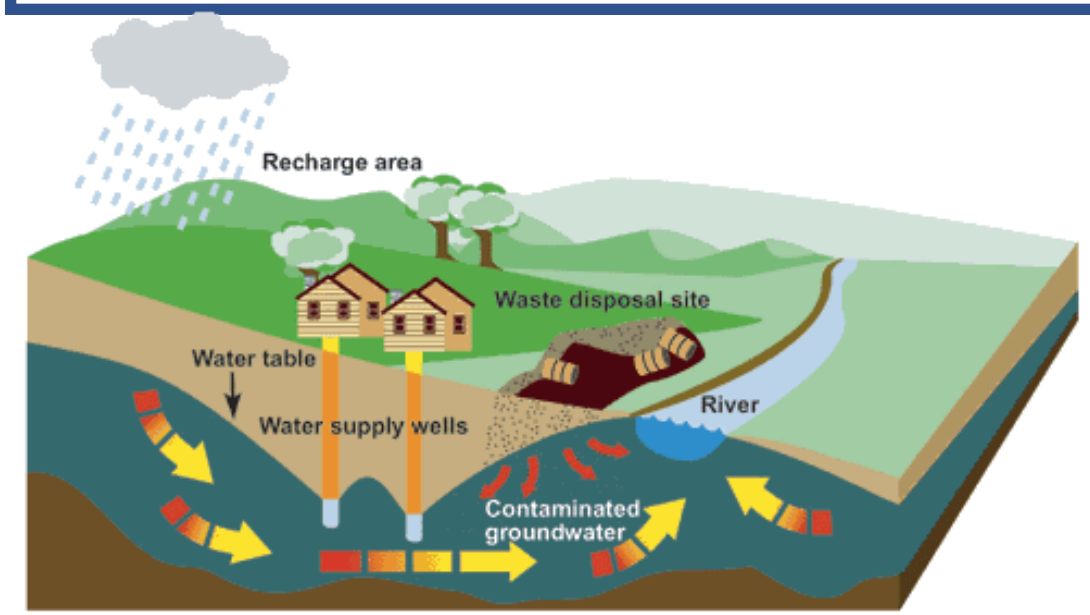
reusing waste water

Using alternative water sources

Save Water With the Three Rs: Reduce, Reuse, Recycle

WATER REUSE: WHAT IS IN THE SOURCE?





Washing	Peeling
Polishing	fluming
Cutting	Blanching
Personnel hygiene	Cleaning processing equipment /utensils
Laundering	

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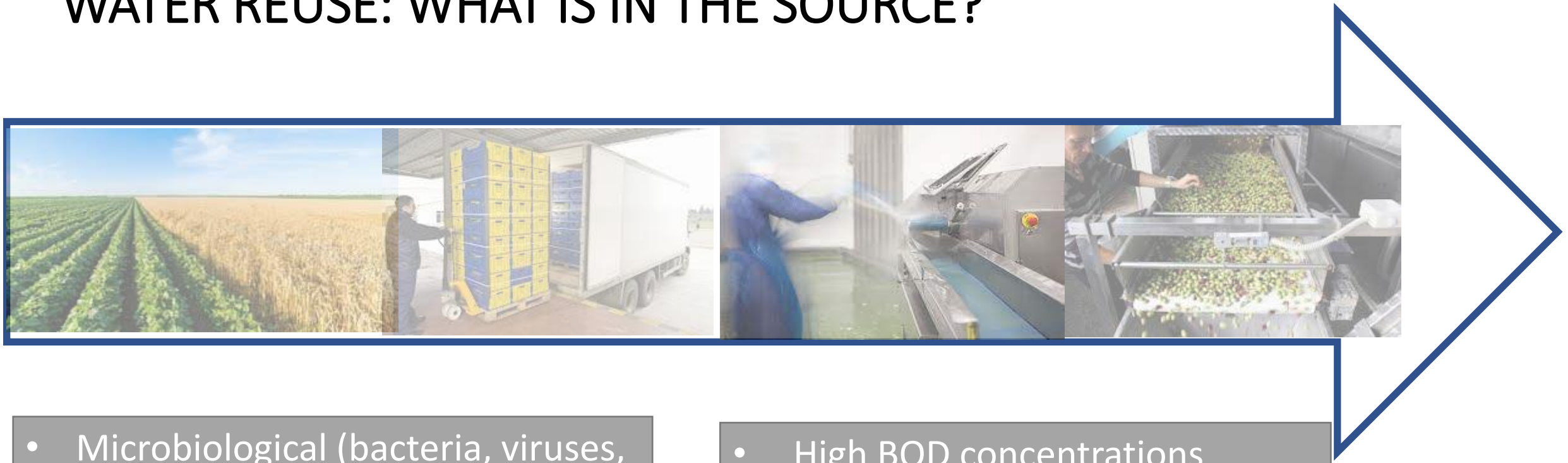
WATER REUSE: WHAT IS IN THE SOURCE?



- Microbiological (bacteria, viruses, protozoa, and helminths)
- Chemicals (ECs/pharmaceuticals, heavy metals, Dioxins, etc.)
- Physical (metal microparticles, metals, glass, etc.)

- High BOD concentrations
- High levels of suspended / dissolved solids
- Minerals

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Location	Health risks	Route of exposure	Type of wastewater	Authors
Mezquital Valley, Mexico	Diarrhea	Occupational exposure, aerosols exposure to resident, underground water contamination	Untreated wastewater	(4)
Uppsala, Sweden	Gastroenteritis (rotavirus-based)	Direct ingestion of greywater during maintenance	Treated greywater	(62)
Vietnam	Parasitic infection (*Ascaris lumbricoides* and *Trichuris trichiura*	Occupational exposure and consumption of vegetable	Partially treated and untreated wastewater	(63)
Brazil	Gastrointestinal infection (*E. coli* and rotavirus)	Consumption of salad crops	Partially treated wastewater	(64)
Bangkok, Thailand	Diarrhea (*Giardia lamblia* and *Entamoeba histolytica*)	Direct exposure	Untreated wastewater	(2)
Thailand and Canada	Gastroenteritis	Swimming, fishing, consuming canal water-irrigated vegetables, and ingesting/inhaling water or aerosols while working in canal water-irrigated fields	Wastewater contaminated Surface water	(65, 66)
Malamulele, South Africa	Parasitic infections (hookworm and *G. lamblia*)	Exposure via occupational consumption	Partially treated wastewater	(67)
Phnom Penh, Cambodia	Skin infection	Occupational exposure	Partially treated wastewater	(7)
Musi River, India	Skin infection/irritation	Exposure to infected source	Partially treated wastewater	(20)
Hyderabad, India	Intestinal parasitic infection	Occupational exposure	Partially treated and untreated wastewater	(68)
Vietnam	*Escherichia coli* infection (risk)	Occupational exposure	Untreated wastewater	(69)
Hanoi, Vietnam	Skin infection	Occupational exposure	Partially treated wastewater	(22)
Hanoi, Vietnam	Diarrhea	Children of occupationally exposed farmers	Partially treated wastewater	(70)
Faisalabad, Pakistan	Giardiasis	Occupational exposure	Untreated wastewater	(71)
Vietnam	Helminthic infection	Occupational exposure	Untreated wastewater	(72)
Nghe An Province, Vietnam	Helminthic infection	Occupational exposure	Partially treated wastewater	(73)
Marrakech, Morocco	Infection of *Ascaris*, *Trichuris*	Children resident in wastewater irrigated farmhouse	Untreated wastewater	(74)
Vietnam	Intestinal parasitic infection	Occupational exposure	Unknown	(75)

Occupational exposure refers essentially to farmers.

Adegoke et al., 2018

FIT-FOR-PURPOSE WATER

Figure 1-3
Treatment technologies are available to achieve any desired level of water quality

- While the increased use of reclaimed water typically poses greater financial, technical, and institutional challenges than traditional sources, a range of treatment options are available such that any level of water quality can be achieved depending upon the use of the reclaimed water (US EPA 2014)
- FAO/WHO (2021). Safety and quality of water used with fresh fruits and vegetables. Microbiological Risk Assessment Series No. 37.

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APPROPRIATE MITIGATIONS – PRIMARY PRODUCTION

WHO's 2006 guidelines for the safe use of wastewater, excreta and graywater

- Approach of risk assessment and risk management linked to health-based targets that can be established at a level that is realistic under local conditions.
  - It defines a globally acceptable level of health protection : $\leq 10^{-6}$ disability-adjusted life years (DALYs) per person per year (pppy)

- The scope covers:
  - intentional use specifically but they may also be relevant to some unintentional uses e.g., irrigation or aquaculture with sewage contaminated surface waters
  - Municipal or domestic wastes without substantial industrial inputs

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QMRA MODEL IN DETERMINING SATE WW REUSE

Hazard identification → Exposure assessment → Dose-response modeling → Risk characteri-zation → Annual probability of illness

irrigation scheme meet health standards?

Maximum acceptable risk

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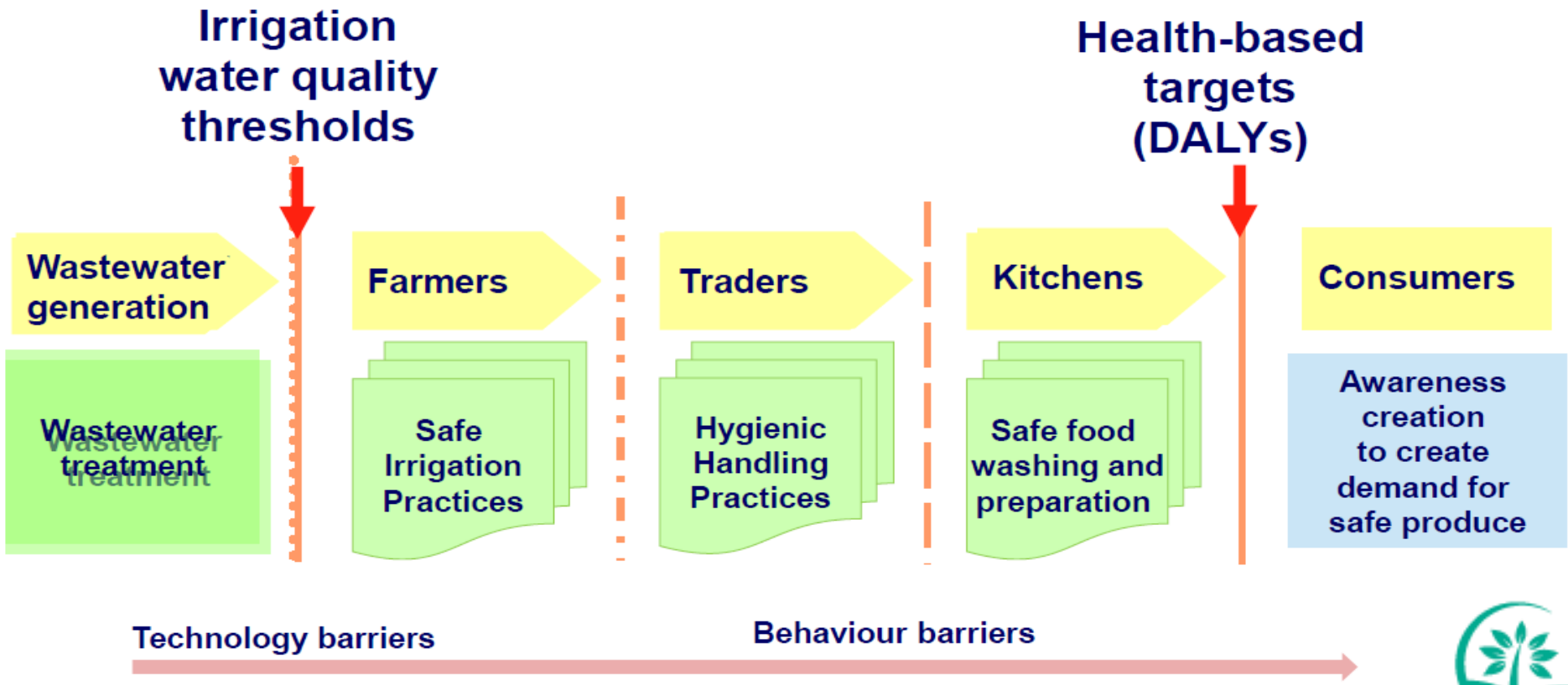
COMBINED PROTECTIVE MEASURES



WHO (2013): Safe Use of Wastewater, Greywater and Excreta

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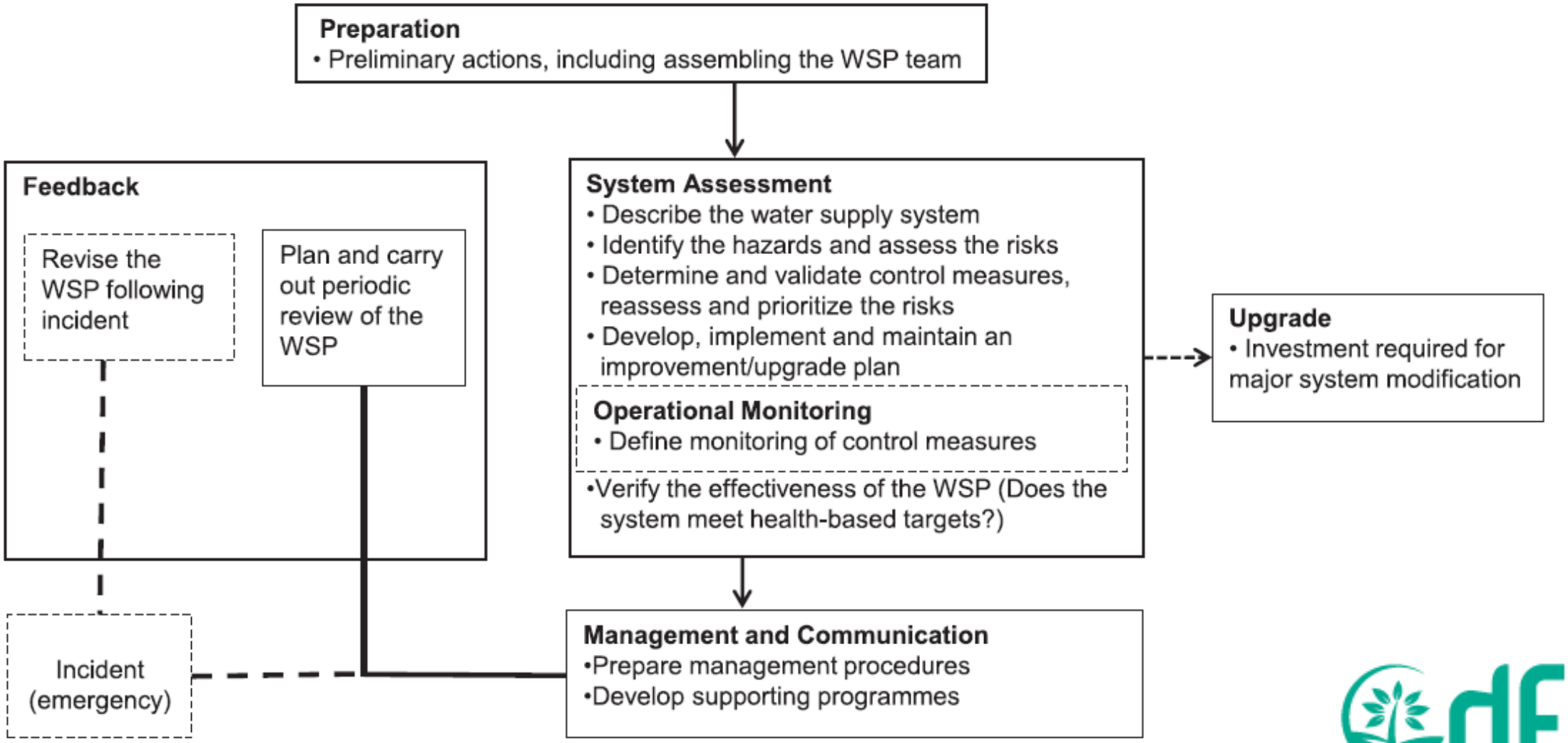
WATER SAFETY PLAN



Y.Y. Omar et al.(2017) from WHO (2004).

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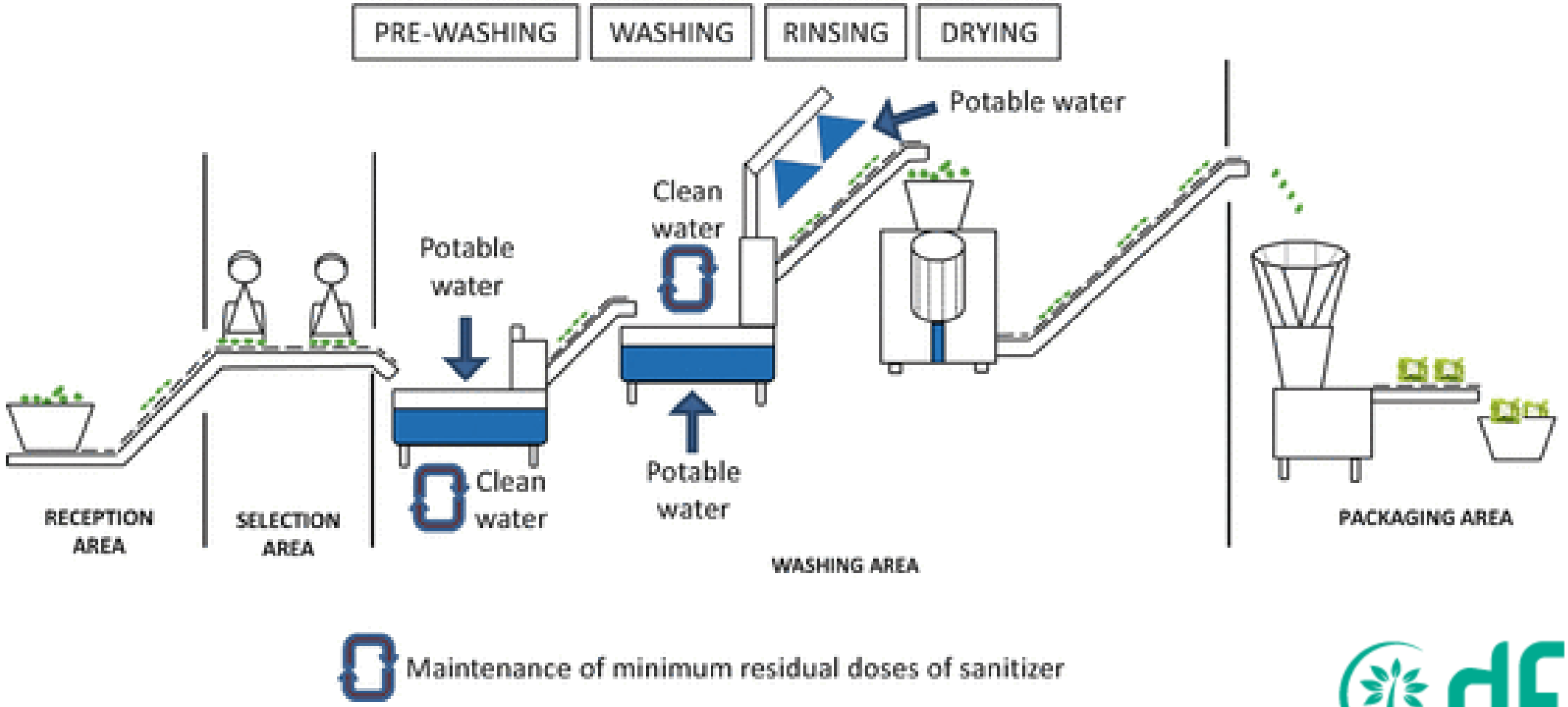
FCFV PROCESSING INDUSTRY



Gil and Allende, 2018

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General principles of food hygiene (FAO)
Only potable water, should be used in food handling and processing, with the following exceptions: for steam production, fire control and other similar purposes not connected with food .

Regulation (EC) 852/2004 on the hygiene of foodstuffs: *recycled water used in processing or as an ingredient (does not) present a risk of contamination. It is to be of the same standard as potable water, unless the competent authority is satisfied that the quality of the water cannot affect the wholesomeness of the product in its finished.*

Regulation (EC) 853/2004, 21CFR Part 117
Water used in food processing must be of a quality that is safe and suitable for human consumption.

Draft Guidelines for the Hygienic Reuse of Processing Water in Food Plants (CAC):
while water should be reconditioned to a level safe and suitable for its intended use, reconditioning to the level of potable water is unnecessary in many cases. Water reuse for incorporation into a food product shall meet at least the microbiological and, chemical specifications for potable water.

Hazard Analysis Critical Control Point (HACCP)

Evidence and Documentation of System Control for Safe Water Reuse

- ✓ Conduct a hazard analysis:
  - Hazard analysis and risk assessment should be carried out for each particular reuse application.
  - Define the exact first use case of the water and its quality to aid in the identification of appropriate hazards and their suitable control points.
- ✓ Determine critical control points (CCPs)
- ✓ Establish critical limits
- ✓ Establish monitoring procedures:
  - the reuse / recycling of reconditioned water requires continuous monitoring of the efficiency of the treatment
  - frequency of monitoring and testing are dictated by the source of water or its prior condition and the intended reuse of water
- ✓ Establish corrective actions
- ✓ Establish verification procedures
- ✓ Establish record-keeping and documentation procedures

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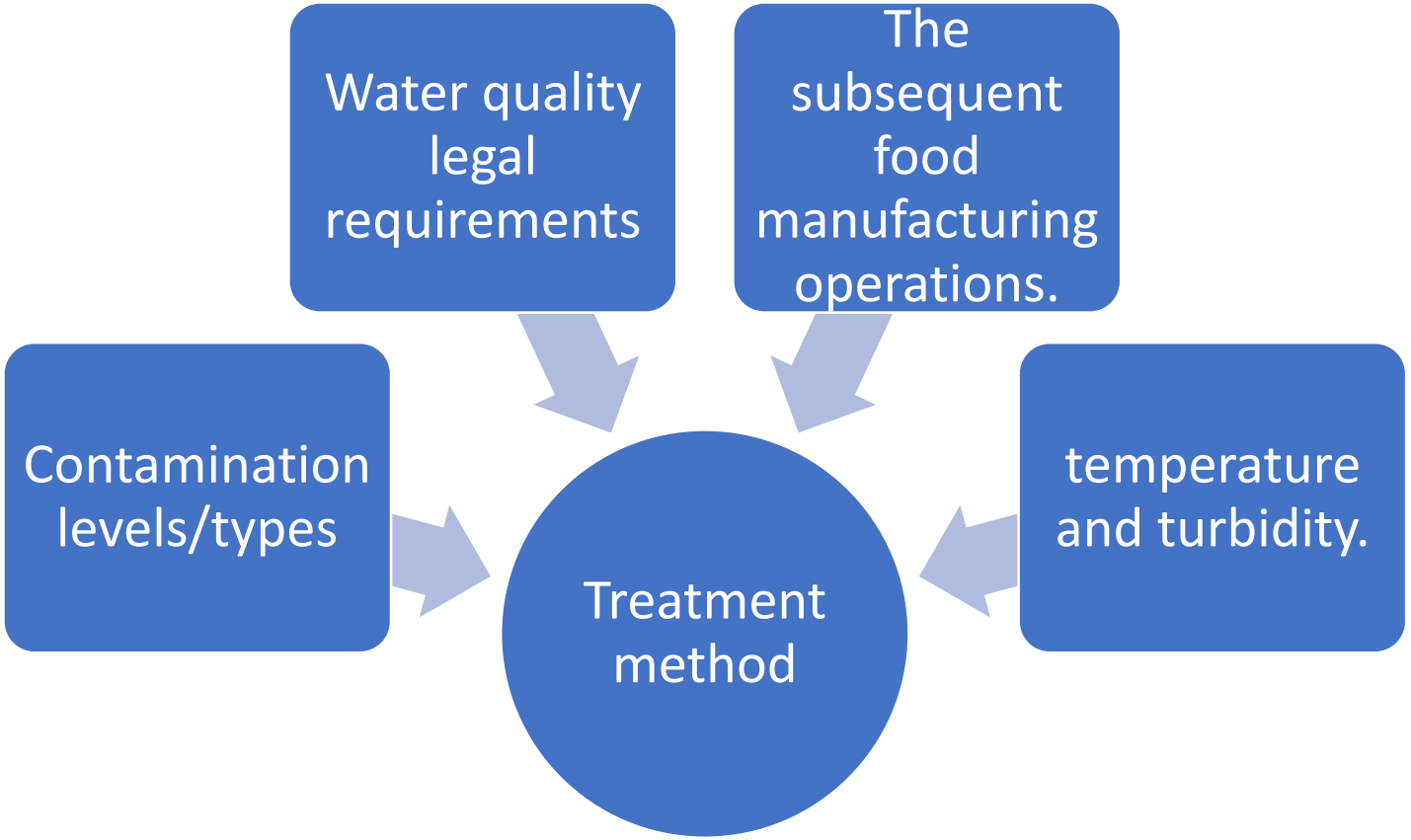
Hazard Analysis Critical Control Point (HACCP)

Evidence and Documentation of System Control for Safe Water Reuse



Knochel et al. 2002

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Table 1 **Physical, chemical, biological and microbial parameters of wash-water from IP1.**

Parameters	Characterization				Physiochemical treatment	
	IP1 primary	IP1 peel	IP1 polish	IP1 F	IP1 F in DAF	IP1 F in centrifuge
T (°C)	10	10	10	10	23	23
pH	7.31 ± 0.27	6.71 ± 0.10	6.87 ± 0.19	7.13 ± 0.21	7	7.10
Turbidity range (NTU)	-	> 1,000	> 1,000	800-1,000	28	25
UV transmittance (%)	-	-	-	< 0.01	6	3
TS (mg/L)	4,703 ± 1,618	17,054 ± 5,564	8,781 ± 1,448	7,137 ± 1,673	-	-
SS (mg/L)	3,136 ± 1,784	9,252 ± 6,050	4,279 ± 1,782	2,375 ± 799	-	-
DS (mg/L)	1,566 ± 578	7,802 ± 2,231	4,502 ± 1,315	4,762 ± 1,155	222 ± 21	184 ± 76
TVS (mg/L)	-	18,216 ± 1,414	8,248 ± 143	4,398 ± 613	-	-
Average particle size (µm)	72	570	447	116	76	508
NO_3-N (mg/L)	-	-	-	< 0.05	0.008	0.057
NO_2-N (mg/L)	-	-	-	0.30	0.031	0.069
TKN (mg/L)	-	-	-	77.20	13.35	22.48
NH_4-N (mg/L)	-	-	-	5.30	1.68	1.16
SAR	-	-	-	1	2.35	1.05
Heavy metals	< MDL	< MDL	< MDL	< MDL	-	-
BOD_5 (mg/L)	-	-	-	3,800	2,300	3,400
E. coli (log)	-	-	-	3.60	0.70	0.70
Coliforms (log)	-	-	-	6.78	6.43	5.60
Filtration (2 µm and then 0.2 µm paper filter)						
Turbidity range (NTU)					2	4
UV transmittance (%)					15	5
UV disinfection dosage (mJ/cm^2)						
After pretreatment					30	10
After 2.0 µm paper filter					10	10

Mundi et al., 2015

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Bringing Fit-for-Purpose Applications into Fresh Produce Operations and Managing Control – ARE WE READY?

Leafy greens and other fresh produce is chopped and washed in huge volumes as part of the salad production process. This allows bacteria on one head of lettuce to be spread to thousands of bags. *Photo illustration*

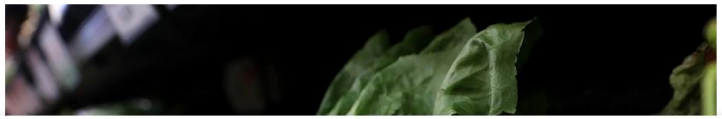
Listeria outbreak traced to Dole salads continues with another patient discovered

By News Desk on February 2, 2022

Another person has been added to the patient toll in a a deadly outbreak of Lister monocytogenes infections traced to Dole packaged salads.

E. Coli Outbreak Turns Deadly With a Fatal Case in California

Give this article



HEALTH | E. Coli Outbreak Turns Deadly With a Fatal Case in California

The outbreak involves both whole-head and chopped, bagged romaine lettuce. Justin Sullivan/Getty Images

By Maggie Astor
May 2, 2018

Deadly outbreak of Listeria illnesses has been linked to Fresh Express salads, including products from Walmart, Hannaford, Safeway, Giant Eagle, and other major grocery stores. Daily Hornet on December 30, 2021

Bringing Fit-for-Purpose Applications into Fresh Produce Operations and Managing Control – Key issues

- Development of effective preventive strategies
- Comprehensive approach for risk management
- Limited data availability
- Health concern of emerging contaminants
- Clear guidelines and criteria under processing conditions
- Significant costs: treatment technologies, infrastructure, skills
- Supportive regulatory framework for water reuse
- Formalizing water reuse

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UNREGULATED WATER REUSE

Direct use of sewage effluent directed from drain to river canals and fields (Faour-Klingbeil et al., 2016)

Dip-Washing Parsley and Radish (Faour-Klingbeil et al., 2016)

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