ORDINE DEGLI INGEGNERI
DELLA PROVINCIA DI PALERMO

Università degli Studi di Palermo

dipartimento di ingegneria unipa

SEMINARIO TECNICO

"IL RIUSO IRRIGUO DELLE ACQUE REFLUE DEPURATE: APPLICAZIONE IN SICILIA DEL REGOLAMENTO EU N.741/2020"

PALERMO, 23 SETTEMBRE 2022

ASPETTI IGIENICO SANITARI CONNESSI AL RIUSO IRRIGUO DELLE ACQUE REFLUE

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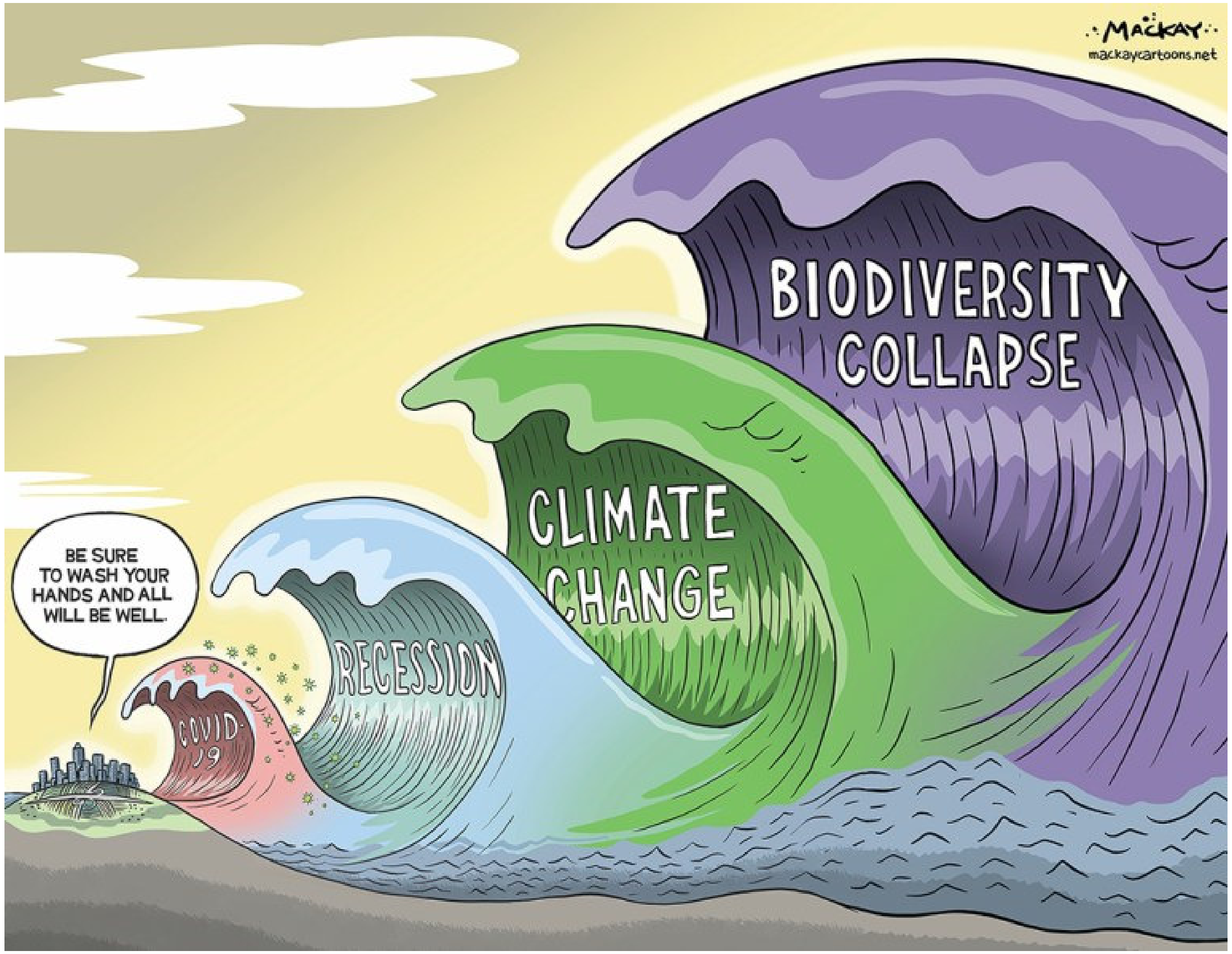
Dipartimento PROMISE – Università di Palermo





Gli ultimi anni trascorsi sono stati caratterizzati da crisi sanitarie, economiche e ambientali che stanno modificando e modificheranno sempre di più il nostro stile di vita.

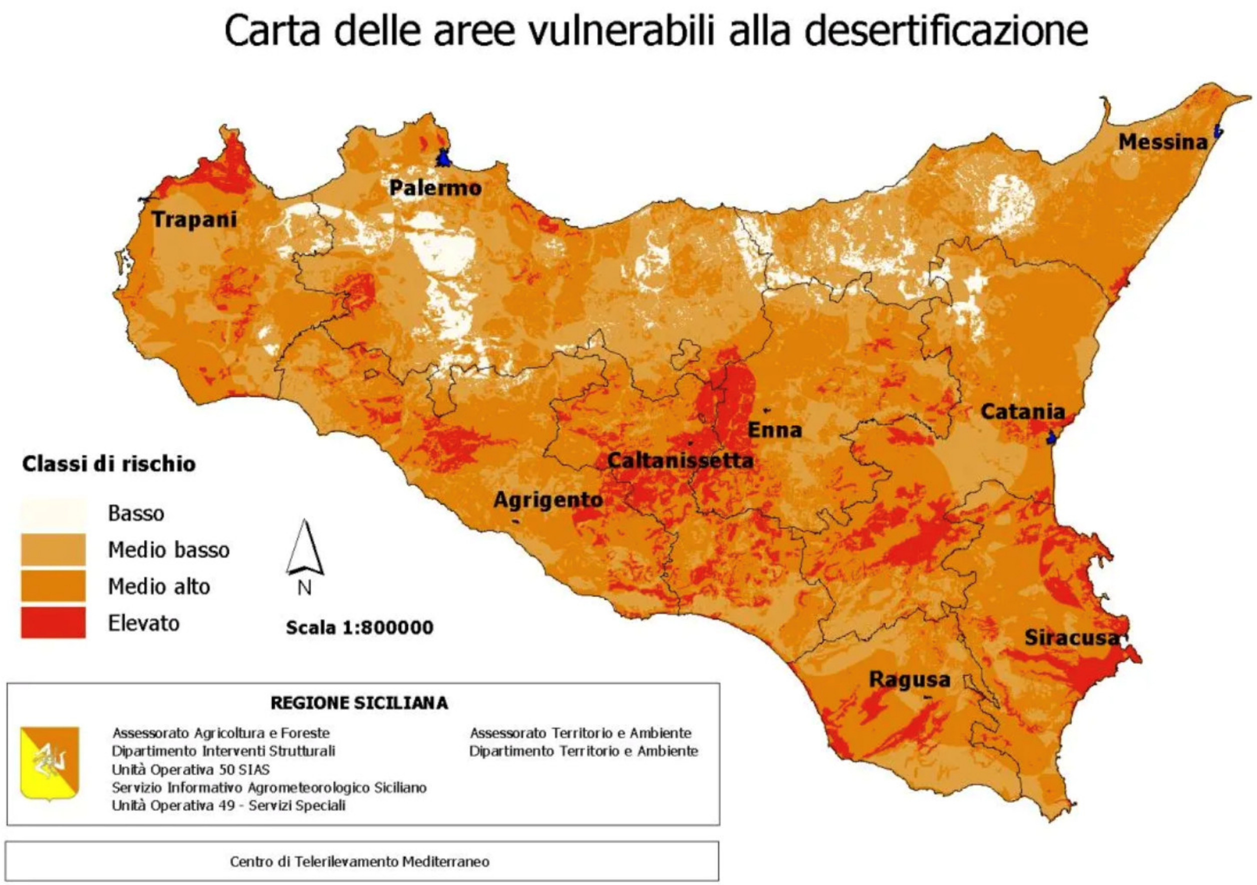


la Repubblica

25 AGOSTO 2021 ALLE 12:50

Desertificazione, la Sicilia zona rossa

"In Italia il 10% del territorio è molto vulnerabile - riporta il dossier -. La **Sicilia** è la regione più colpita (42,9% della superficie regionale), seguita da **Molise**, **Basilicata** (24,4%) e dalla **Sardegna** (19,1%). Secondo il C.N.R. (Consiglio Nazionale delle Ricerche), le aree a rischio sono il 70% in Sicilia, il 58% in Molise, il 57% in Puglia, il 55% in Basilicata, mentre in Sardegna, Marche, Emilia-Romagna, Umbria, Abruzzo e Campania sono comprese tra il 30 e il 50%», dati che indicano che «il 20% del territorio italiano in pericolo di desertificazione». In Sicilia il dato allarmante sulla desertificazione è confermato dall’analisi dei dati diffusi dall’Osservatorio ANBI sulle Risorse Idriche e ad accentuare il pericolo non sono solo i quantitativi pluviometrici, ma l’andamento delle piogge con forti differenziazioni territoriali.



DESERTIFICAZIONE

Trasformazione di un terreno produttivo in deserto, risultato dell'erosione del suolo ad opera dell'uomo, principalmente a causa di[1]:

- disboscamento,
- uso indiscriminato del fuoco,
- coltivazioni di tipo estensivo,
- cattiva gestione delle coltivazioni,
- utilizzo irrazionale delle risorse idriche

[1] *Auberville G., (1949), Climate, Forests, et Desertification de l'Afrique Tropicle Societe des Editions Geographique, Maritimes et Coloni.*

1950

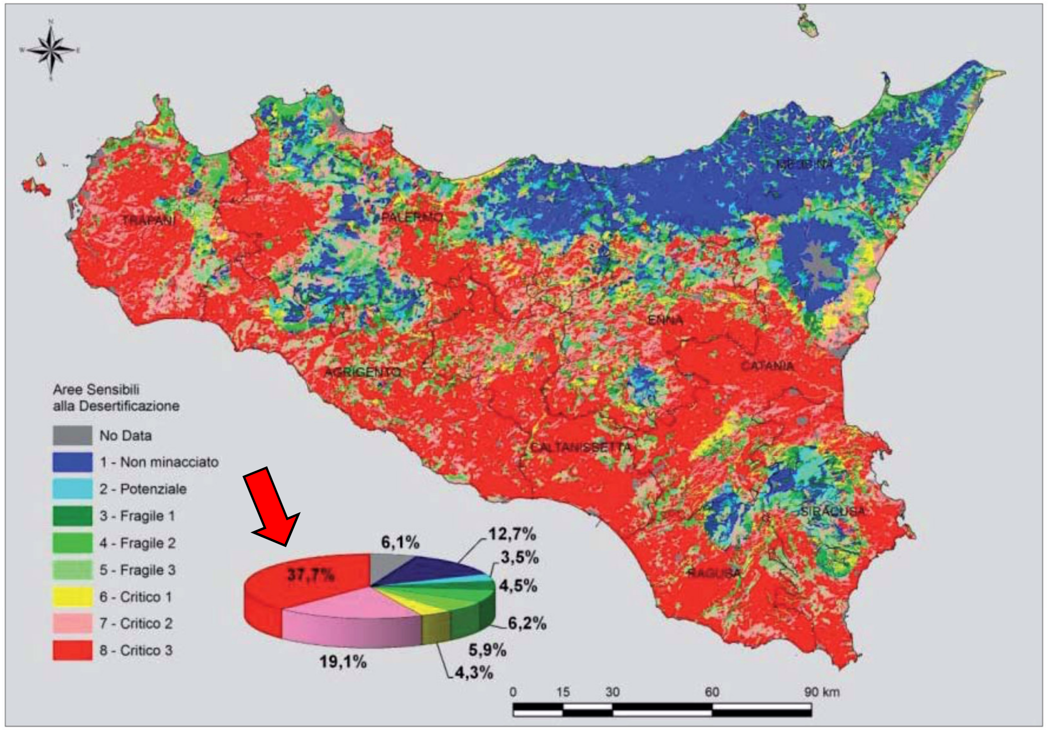


Tavola 3 – Carta delle Aree Sensibili alla Desertificazione in Sicilia (seconda metà XX Secolo)

previsione al 2030

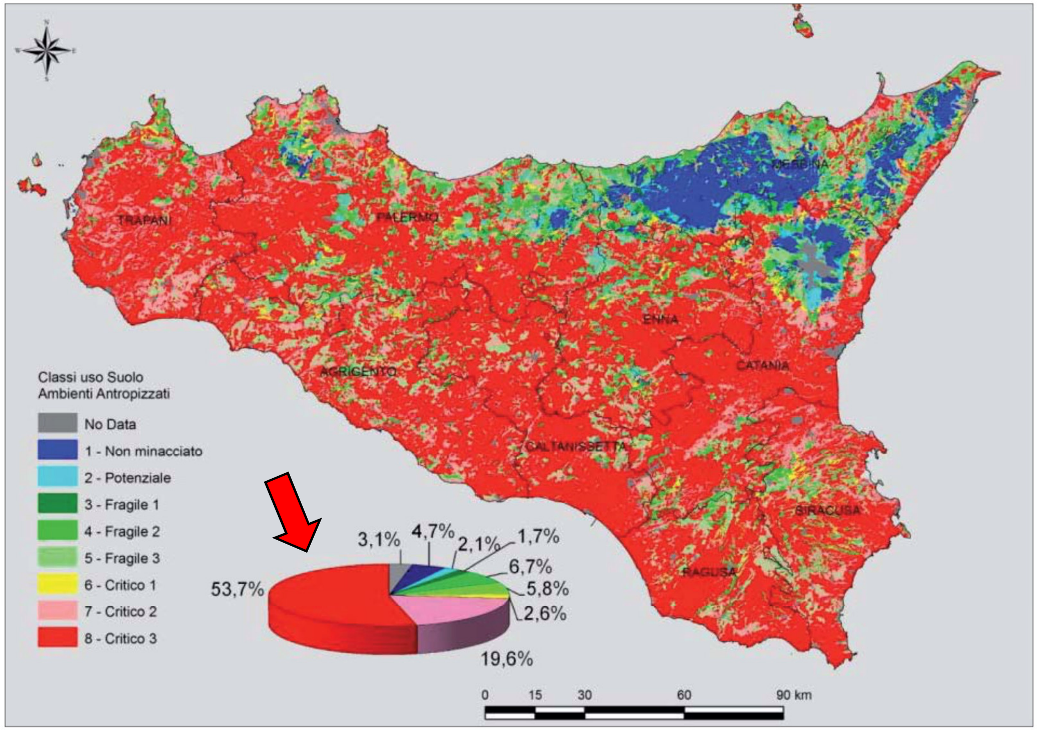


Tavola 6 – Carta delle Aree Sensibili alla Desertificazione in Sicilia (previsione al 2030)

Geologia dell'ambiente 01/2017; available at: https://www.settimanaterra.org/sites/default/files/geoeventi2017/2017-1%20GdA%20desertificazione_0.pdf gestione territoriale e al contesto socioeconomico. Per quanto riguarda i fattori ambientali, il principale fattore limitante è la disponibilità idrica, che dipende dalle condizioni climatiche e dalla capacità di immagazzinamento idrico del suolo e che quindi limita la crescita delle piante. Diversi possono essere le motivazioni socioeconomiche che portano

REPUBBLICA ITALIANA

REGIONE SICILIANA

Presidenza

Autorità di Bacino del Distretto Idrografico della Sicilia

Strategia regionale di azione per la lotta alla desertificazione

available at:
https://pti.regione.sicilia.it/portal/page/portal/PIR_PORTALE/PIR_LaStrutturaRegionale/PIR_PresidenzadellaRegione/PIR_AutoritaBacino/PIR_Areetematiche/PIR_sitiTematici/PIR_Desertificazione/Strategia%2Bregionale%2Blotta%2Bdesertificazione_def_0.pdf

La necessità di attuare una politica complessiva per il contrasto e la mitigazione dei fenomeni di desertificazione è stata ulteriormente ribadita dalla strategia nazionale di adattamento ai cambiamenti climatici.

La carenza d'acqua per i vari usi (civile, industriale, agricolo, ricreativo) che ne consegue, rende indispensabile il ricorso all'uso delle risorse idriche non convenzionali: ACQUE REFLUE E ACQUE SALINE.

INCENTIVAZIONE DEL RIUSO DELLE ACQUE REFLUE

In molte parti del mondo l'uso delle acque reflue è una pratica consolidata nell'ambito della gestione integrata delle risorse idriche per:

- AUMENTARE LA DISPONIBILITÀ DI ACQUA PER USI QUALITATIVAMENTE MENO ESIGENTI
- RIDURRE L'INQUINAMENTO DEI CORPI RICETTORI

UTILIZZI

URBANO NON POTABILE

- Alimentazione scariche WC
- Riserva antincendio
- Lavaggio strade
- Lavaggio autoveicoli
- Campi sportivi, aree cittadine a verde
- Fontane e laghetti

AGRICOLO

- Tutte le colture in relazione al trattamento e al metodo irriguo

INDUSTRIALE

- Siderurgia
- Tessile
- Petrolchimica

AMBIENTALE

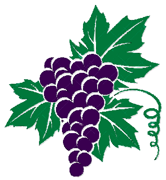
- Ricarica acquiferi
- Deflusso minimo vitale
- Creazione e recupero aree umide

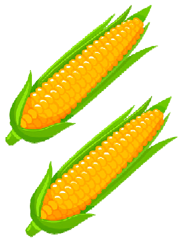
IRRIGUO

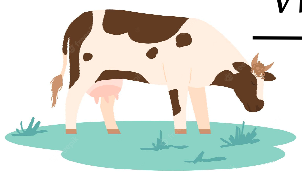
K. K. Kesari, et al. Wastewater Treatment and Reuse: a Review of its Applications and Health Implications. Water Air Soil Pollut (2021) 232: 208

USO IRRIGUO

COLTURE ALIMENTARI TRASFORMATE E NON
PASCOLI PER LA MUNGITURA DI ANIMALI
FORAGGIO
FIBRA
COLTURA IDROPONICA
COLTURA DA SEME
ACQUACOLTURA
SERRE
VITICOLTURA



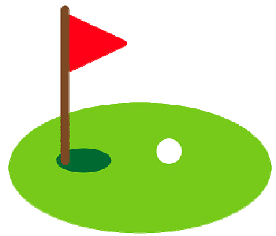


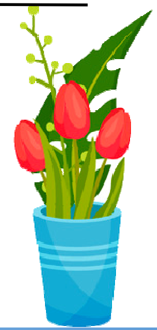


DA DESTINARE AL CONSUMO UMANO

IMPIANTI SPORTIVI (CAMPI GOLF, CALCIO...)
AIUOLE E VERDE PUBBLICO
GIARDINI SCOLASTICI
CIMITERI
CONDOMINI
PIANTE E FIORI

RICREATIVO/PRODUTTIVO





STATO DELL'ARTE

TYPSA CONSULTING ENGINEERS & ARCHITECTS

UPDATED REPORT ON WASTEWATER REUSE IN THE EUROPEAN UNION

April 2013

2.4.14.1. Water reuse current state of art

A survey of Italian treatment plants estimated the total treated effluent flow at 2400Mm3/yr of usable water. This gives an estimate of the potential resource available for reuse. In view of the regulatory obligation to achieve a high level of treatment, the medium to large-sized plants (>100,000 inh. served), accounting for approximately 60% of urban wastewater flow can provide re-usable effluents for a favourable cost/benefit ratio.

Nowadays, treated wastewater is used mainly for agricultural irrigation covering over 4,000 ha. However, the controlled reuse of municipal wastewater in agriculture is not yet developed in most Italian regions and has decreased due to the low quality of water. Water reuse for industry is practiced in the metropolitan area of Turin. Municipal WWTP operator companies have already planned to build a separate supply network for wastewater reuse for industry (Azienda Po Sangone and CIDIU) in the Turin metropolitan area.

Available at: https://ec.europa.eu/environment/water/blueprint/pdf/Final%20Report_Water%20Reuse_April%202013.pdf

Egyptian Journal of Petroleum (2017) 26, 95–102

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Egyptian Petroleum Research Institute

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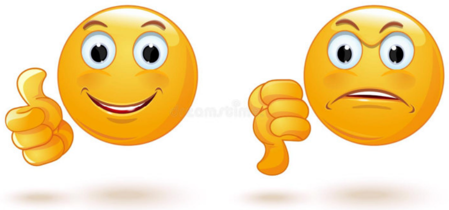
www.sciencedirect.com

ELSEVIER

Environmental and health risks associated with reuse of wastewater for irrigation

Eman Shakir *, Zahraa Zahraw, Abdul Hameed M.J. Al-Obaidy



The health effects of irrigating with wastewater can be both positive and negative. The positive effects are related to food security in poor areas. Wastewater is possible (and commonly the only way) to produce food and increase income in poor areas, thus also increasing nutrition and the quality of life. Negative effects are due to the presence of pathogens and toxic chemical compounds in wastewater [24]. Irrigation with treated wastewater poses a number of potential risks to human health via consumption or exposure to pathogenic microorganisms, heavy metals, harmful organic chemicals.

Available at:
https://reader.elsevier.com/reader/sd/pii/S111006211530115X?token=D30D2A8F25A7437096B4C5391C48154B735A7E877DCB7568F027E618F4B9D68B8576CC7F30F877ADF33626A7FBEA9BB5&originRegion=eu-west-1&originCreation=20220901164518

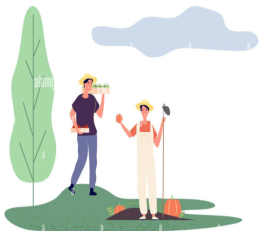
Rischi per la salute

Il riuso delle acque reflue è una pratica che può presentare potenziali RISCHI PER LA SALUTE dell'uomo, degli animali e dell'ambiente in genere.

Per l'attuazione del riuso, questi rischi devono essere gestiti e il pubblico deve essere informato in modo chiaro e trasparente. → ACCETTAZIONE PUBBLICA

Popolazioni suscettibili

Four groups are at risk: (1) agricultural workers and their families; (2) crop handlers; (3) consumers of crops, meat, and milk; and (4) those living near the areas irrigated with wastewater, particularly children, and the elderly. Wastewater contains a variety of excreted organisms, and the types and concentrations vary depending upon the background levels of disease in the population. Many pathogens can survive for long enough periods of time in soil or on crop surfaces and thus be transmitted to humans or animals [25].




Quali sono i rischi per la salute?

RISCHIO CHIMICO

RISCHIO MICROBIOLOGICO

Convenzionali
Non convenzionali
Emergenti

Area geografica
Tipologia di refluo
Impianto di trattamento

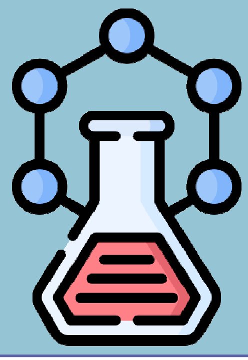
While water quality investigations have traditionally focused on nutrients, bacteria, heavy metals and priority pollutants (compounds with known health effects such as pesticides, industrial chemicals, petroleum hydrocarbons) recent research has revealed the occurrence of hundreds of organic contaminants in wastewater and impacted urban surface waters. These novel contaminants belong to diverse compound classes and are typically detected at concentrations in the range 1 ng/L–1 μg/L although concentrations range up to 100 μg/L in some cases. Their toxicological significance is difficult to assess and generally accepted concentration limits for drinking water and discharge limits for wastewater effluent have not yet been established.

Nuove classi di contaminanti

Concentrazioni moto basse

Effetti sulla salute sconosciuti

Limiti normativa assenti



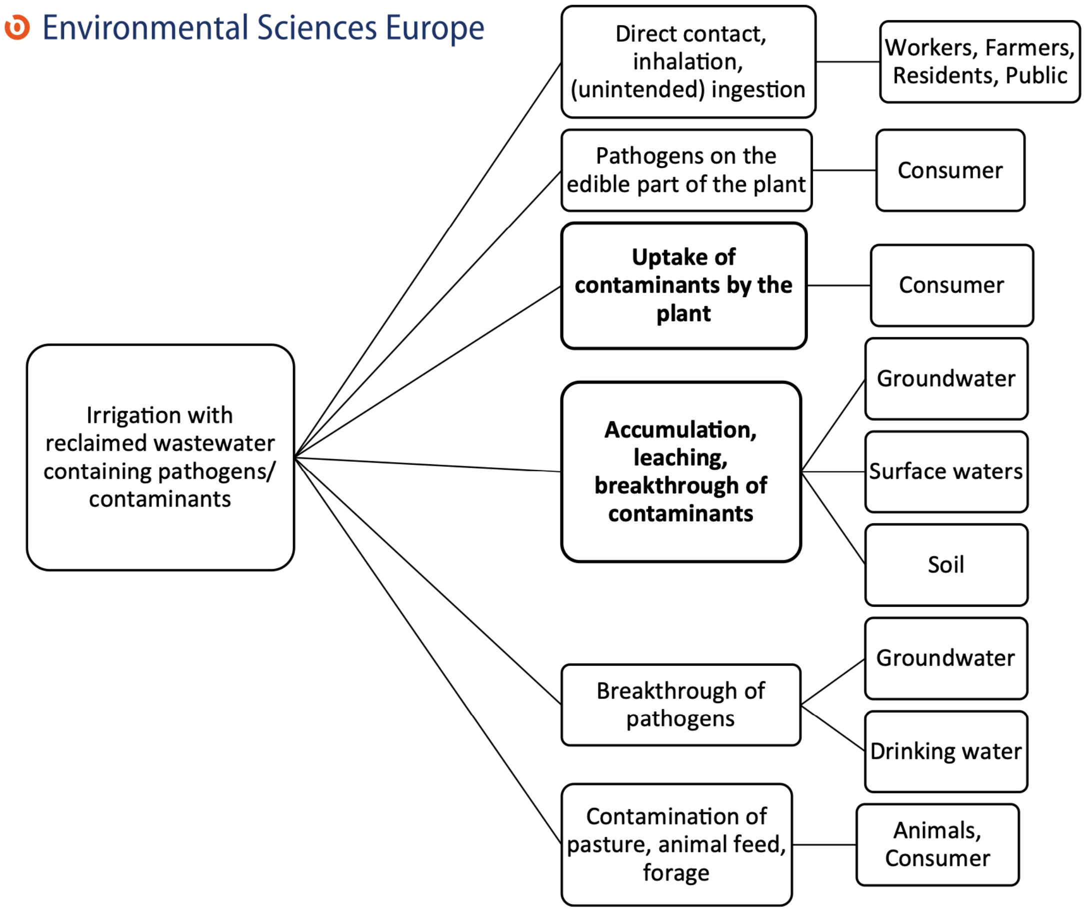
Helmecke *et al. Environ Sci Eur* (2020) 32:4
https://doi.org/10.1186/s12302-019-0283-0

Environmental Sciences Europe

DISCUSSION Open Access

Regulating water reuse for agricultural irrigation: risks related to organic micro-contaminants

Manuela Helmecke[1], Elke Fries[2] and Christoph Schulte[1*]



Available at: https://enveurope.springeropen.com/track/pdf/10.1186/s12302-019-0283-0.pdf

Rischio microbiologico

DECRETO MINISTERIALE 12 giugno 2003, n. 185
«Regolamento recante norme tecniche per il riutilizzo delle acque reflue in attuazione dell'articolo 26, comma 2, del D.Lgs. 11 maggio 1999, n. 152».
(G.U. 23 luglio 2003, n. 169)

Parametri microbiologici	Escherichia coli Nota 3 Salmonella	UFC/100mL	100 valore puntuale max Assente

Convenzionali — Coliformi, Escherichia coli

Non Convenzionali — Protozoi, Elminti

Emergenti — Virus enterici, altri virus di interesse umano

→ Assenza di colimetria

APPLIED AND ENVIRONMENTAL MICROBIOLOGY, June 2003, p. 3393–3398
0099-2240/03/$08.00+0 DOI: 10.1128/AEM.69.6.3393–3398.2003

AMERICAN SOCIETY FOR MICROBIOLOGY Applied and Environmental Microbiology

Giardia Cysts in Wastewater Treatment Plants in Italy

Simone M. Cacciò,[1] Marzia De Giacomo,[1] Francesca A. Aulicino,[2] and Edoardo Pozio[1]*
Laboratory of Parasitology[1] and Laboratory of Environmental Hygiene,[2] Istituto Superiore di Sanità, 00161 Rome, Italy

APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Aug. 2006, p. 5297–5303
0099-2240/06/$08.00+0 doi:10.1128/AEM.00464-06

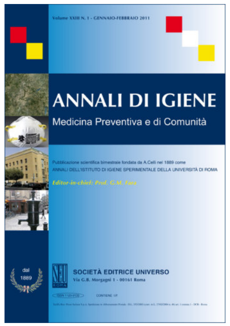
AMERICAN SOCIETY FOR MICROBIOLOGY Applied and Environmental Microbiology

Occurrence of *Cryptosporidium* Oocysts and *Giardia* Cysts in Sewage in Norway†

L. J. Robertson,* L. Hermansen,‡ and B. K. Gjerde
Parasitology Laboratory, Department of Food Safety and Infection Biology, Norwegian School of Veterinary Science, 0033 Oslo, Norway

WWTP (Acqua dei Corsari) = 2,7E7/l

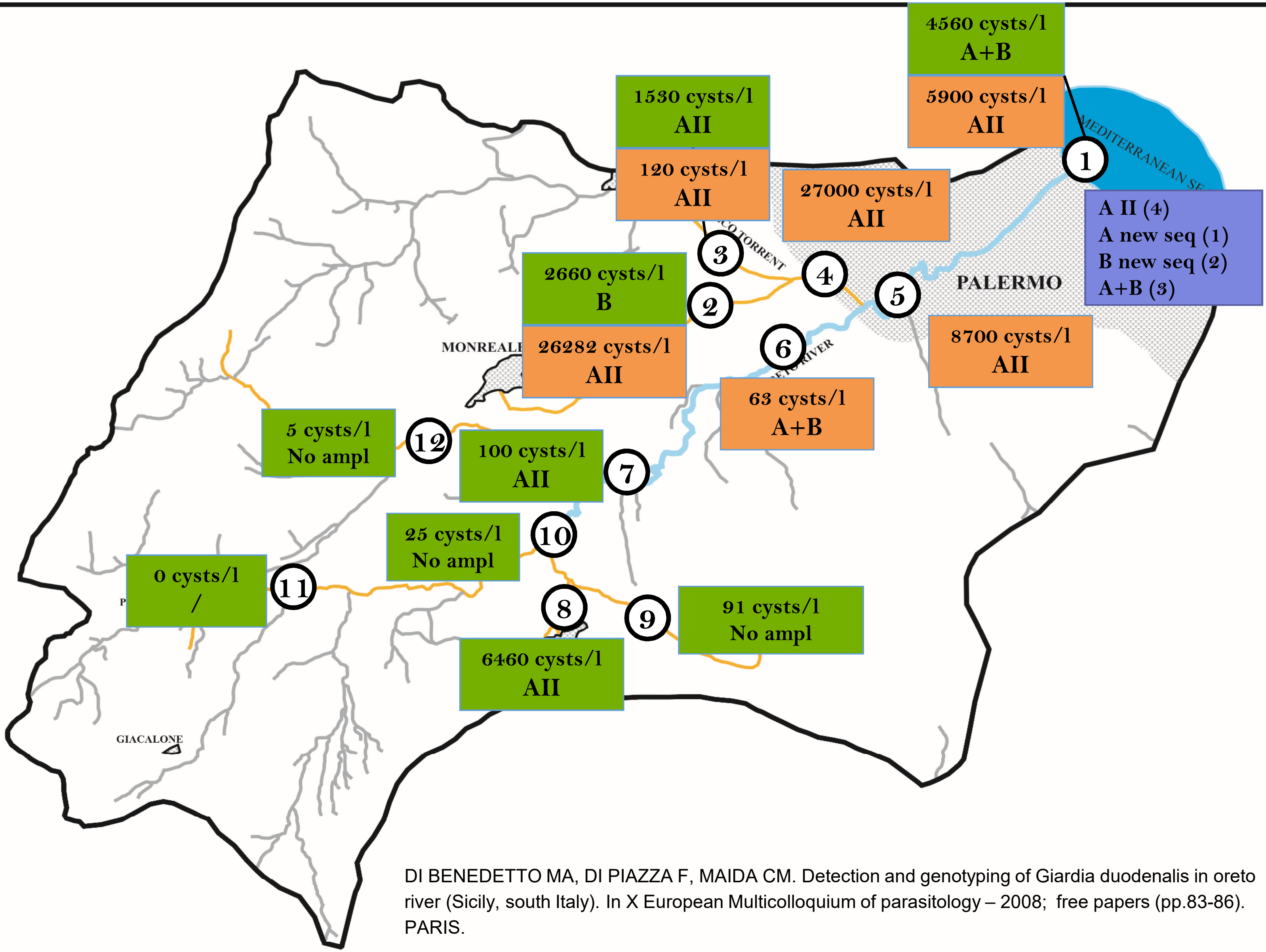
Surface water (Fiume Oreto) = 1,3E4/l



Occurrence of Giardia and Cryptosporidium in wastewater, surface water and ground water samples in Palermo (Sicily).

Di Benedetto MA, Di Piazza F, Maida CM, Firenze A, Oliveri R

Ann Ig 2005;17(5):367-367



DI BENEDETTO MA, DI PIAZZA F, MAIDA CM. Detection and genotyping of Giardia duodenalis in oreto river (Sicily, south Italy). In X European Multicolloquium of parasitology – 2008; free papers (pp.83-86). PARIS.

Nuovo Sistema Informativo Sanitario

Malattie Trasmissibili

Glossario HelpDesk Logout

Sorveglianza Malattie | Monitoraggio | Funzioni Utilità

Funzioni Utilità

- **Report Statistici**
  - -Bollettino
- **Gestione Distretti**
- **Gestione Casi Multipli**
- **Esportazioni Dati**
- **Visualizza Tabelle**

Home > **Funzioni Utilità** > **Report Statistici** > Bollettino ?

Lista Segnalazioni convalidate per Province **SICILIA**

Elaborazione del: 09/10/2019

Malattia: GIARDIASI
Regione: SICILIA
Periodo dal: 01/01/2018
al: 09/10/2019

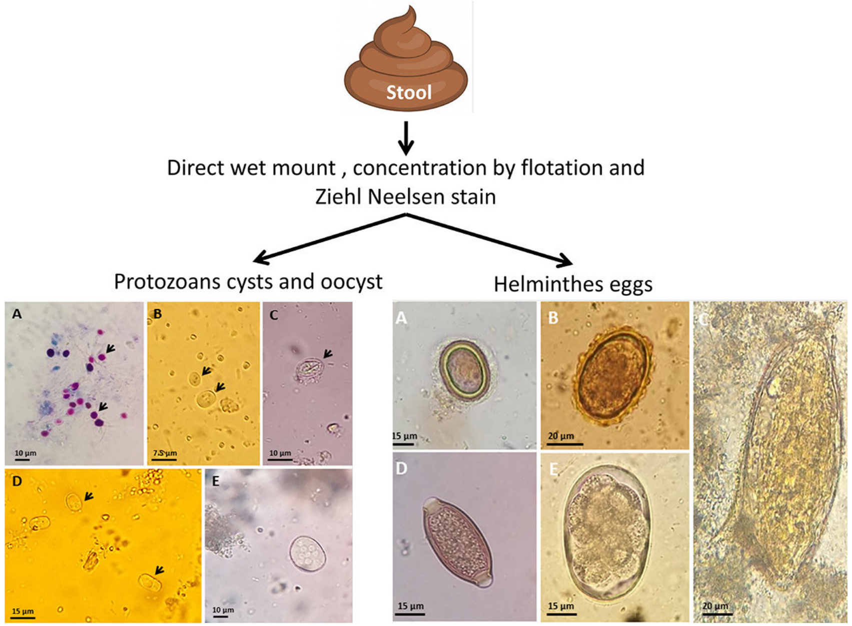
Valutazione dell'impatto sulla salute

Studi ad hoc

Classi di età	0 - 11 MESI		12 - 24 MESI		3 - 4		5 - 9		10 - 14		15 - 24		25 - 34		35 - 44		45 - 54		55 - 64		> 65		Totale
Province	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
AGRIGENTO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CALTANISSETTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CATANIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
ENNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MESSINA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PALERMO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RAGUSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SIRACUSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAPANI	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

Indietro

Wastewater Reuse and Intestinal Parasitic Infections



Intestinal parasitic infections, especially soil-transmitted helminths, are reported as the major health concern associated with wastewater reuse (34). This is partly due to their high persistence in the environment. In line with this concern, epidemiological studies have shown an increase in parasitic infections from the use of wastewater (**Figure 3**). The main exposure route accounted for in these studies has been direct contact for farmers and other farm workers, where increased risks with ORs 0.58–3 have been reported (3, 19, 137, 138). In a study conducted in urban and peri-urban transition zones in Hanoi, Vietnam, Fuhrimann et al. (139) reported that peri-urban farmers had the highest adjusted odds of acquiring intestinal parasitic infection among various groups considered (OR 5.3, 95% CI: 2.1–13.7).

Il contatto diretto tra lavoratori aumenta il rischio di infezioni da parassiti OR = 3

Adegoke A. et al.

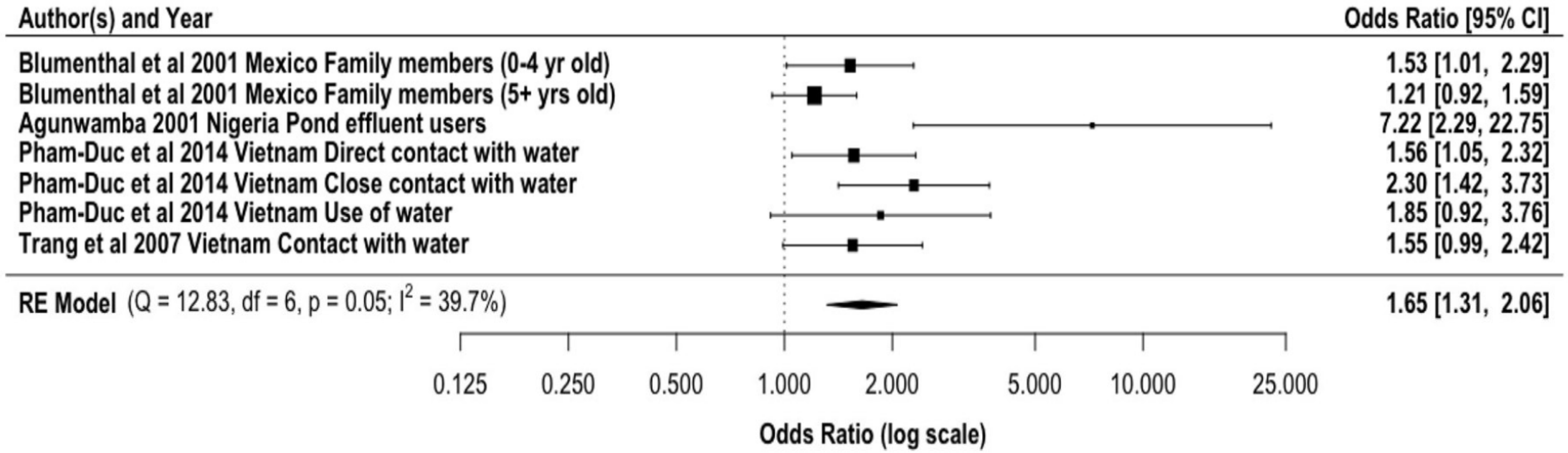
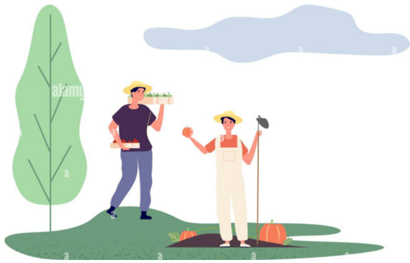


FIGURE 2 | Odds ratio for exposure to partially treated and untreated wastewater and diarrheal disease incidence from selected literature.



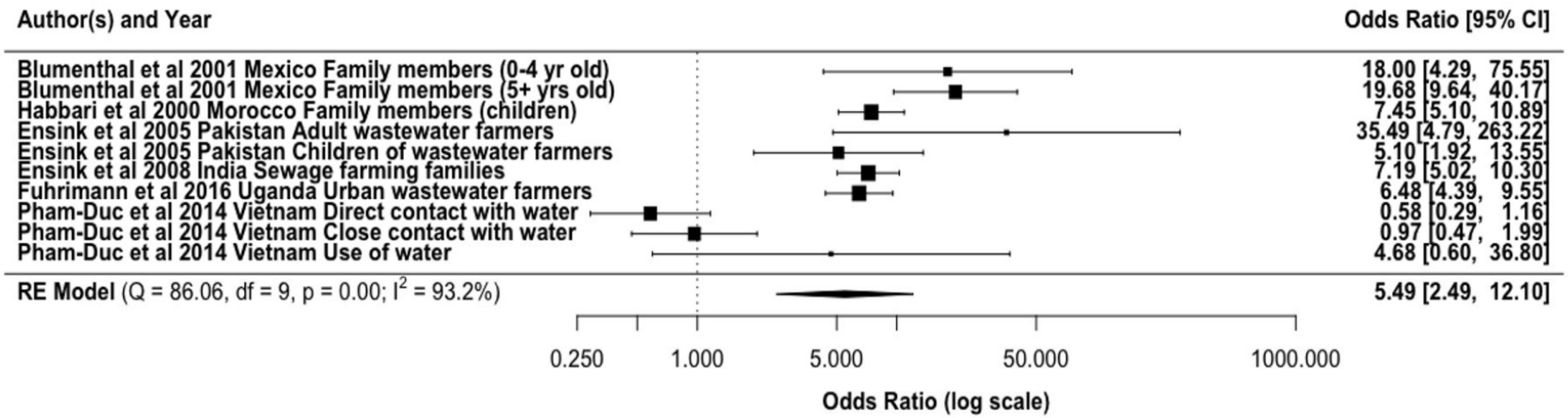


FIGURE 3 | Odds ratio for exposure to partially treated/untreated wastewater and helminth infections from selected literature.

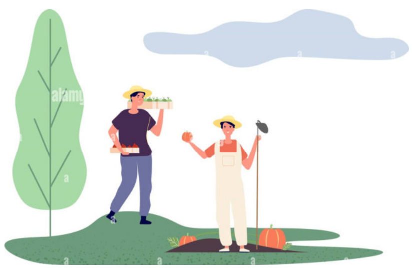


TABLE 3 | Examples of food-borne outbreaks (human) associated with the consumption of fresh produce irrigated with wastewater from selected literature (Only the reports with year of outbreak, food implicated and number of cases were considered).

References	Country	Pathogens	Outbreak year	Food implicated*	No of cases
(115)	China	*Salmonella paratyphi* A	2010–2011	Consumption of raw vegetables	600
(106)	Unspecified	*Salmonella saintpaul*	2008	Jalapeño peppers, serrano peppers, tomatoes	1,442
(116)	Sweden	Enterohemorrhagic *E. coli*	2013	Fresh salad	19
(104)	Denmark	Noroviruses and enterotoxigenic *Escherichia coli*	2010	Lettuce of the lollo bionda type	260
(117)	Norway	*Salmonella* species	2004; 2006; 2007	Rucola Lettuce	21
(112)	Sweden	*E. coli* 0157	2005	Iceberg lettuce	135
(114)	Denmark	Norovirus	2005	Raspberries	>1,000
(118)	Canada	*Cyclospora cayetanensis*	2011	Basil	17
(119)	Germany	*Cyclospora cayetanensis*	2000	Green vegetables	34
(120)	Saudi Arabia	Hepatitis A virus	1996	Food (unspecified); specified not linked	94

**Grown with contaminated (fecal) water.*

PLOS | NEGLECTED TROPICAL DISEASES

RESEARCH ARTICLE

Contribution of Wastewater Irrigation to Soil Transmitted Helminths Infection among Vegetable Farmers in Kumasi, Ghana

Isaac Dennis Amoah[1,3]*, Amina Abubakari[3], Thor Axel Stenström[1], Robert Clement Abaidoo[3], Razak Seidu[2]

1 Institute for Water and Wastewater Technology, Durban University of Technology, Durban, South Africa,
2 Department of Civil Engineering, Norwegian University of Science and Technology, Ålesund, Norway,
3 Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

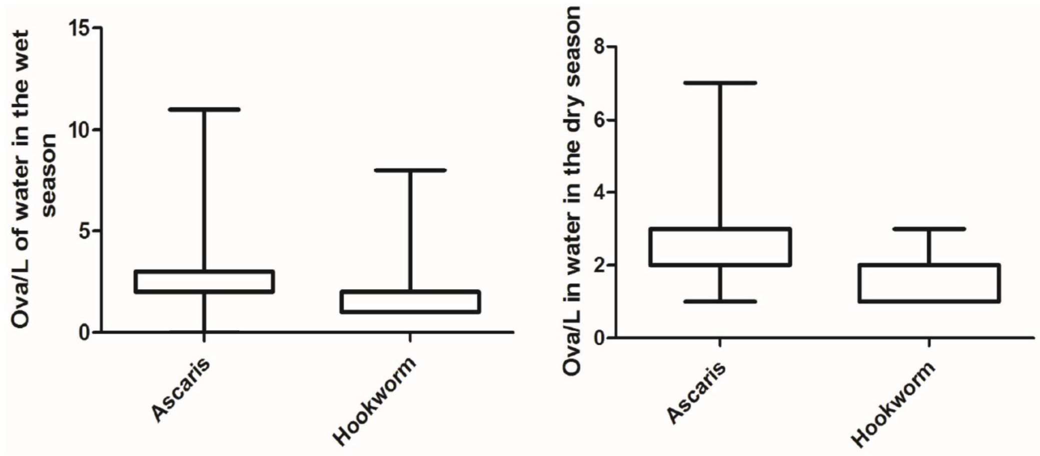


Fig 2. Distribution of *Ascaris* spp and hookworm ova in irrigation water in the dry (n = 71) and wet (n = 107) seasons.

doi:10.1371/journal.pntd.0005161.g002

Table 1. Mean concentration (±S.D) of *Ascaris* spp and hookworm ova in irrigation water and soil for the dry and wet season in Kumasi, Ghana.

	Water			Soil		
	Wet season (n = 107)	**Dry season (n = 78)**	**P value**	**Wet season (n = 107)**	**Dry season (n = 78)**	**P value**
Ascaris spp (ova/L)	2.82 (±0.25)	2.62 (±0.13)	0.41	3.70 (±0.23)	2.90 (±0.21)	0.01
Hookworm (ova/L)	2.05 (±0.23)	1.38 (±0.10)	0.01	2.01(±0.16)	1.67 (±0.14)	0.16

doi:10.1371/journal.pntd.0005161.t001

Table 3. Odds of infection with *Ascaris* spp and hookworm for farmers involved in wastewater irrigation compared with a control group in Kumasi, Ghana.

	DRY SEASON*	WET SEASON$
Ascaris spp	0.92 (95% CI; 0.33–2.56)	3.99 (95% CI; 1.15–13.86)
Hookworm	1.21 (95% CI; 0.24–6.20)	3.07 (95% CI; 0.87–10.82)

*In the dry season the study population was 127 for farmers and 52 for the control group $In the wet season the study population was 165 for farmers and 100 for the control group

Il rischio per la salute potenziale è basato sul numero di uova di parassiti nelle acque.

Il rischio per la salute reale tiene conto anche di:

- Sopravvivenza dei patogeni nelle acque e nei suoli;
- Dose infettante;
- Fattori climatici;
- Difese dell'ospite;
- Abitudini igieniche degli esposti.

The elevated concentrations of STHs ova, above the WHO guideline levels, in the irrigation water and soil pose a risk of infection for farmers involved in the practice of wastewater irrigation. However, there is always a difference between the estimated risk and actual infections. The potential health risk is based on the number of pathogens in the wastewater or soil, while the actual health risk depends on an expansion of this concept, including: i) the period pathogens survive in water or soil; ii) the dose in which pathogens are infective to a human host and iii) host immunity for pathogens circulating in the environment [32]. The seasonal variation in STHs ova concentration in the irrigation water and soil was also apparent in the STHs infection intensity of the farmers, reflected in higher infection frequency in the wet season. There are other factors such as, climate, types of soils and hygiene behavior, which might have also contributed to this variation in infection rate [33].

NO INDICATORI

The majority of the epidemiological studies on reuse and diarrheal diseases have focused on the direct exposure to the wastewater especially by the farmers and farm workers. However, Shuval et al. (60) demonstrated that aerosols could lead to a diarrheal incidence rate ratio of 1.08 for people living close to irrigation fields in Israel. Living in a household with someone engaged in untreated wastewater reuse could also result in higher risk of diarrhea (OR =2.69) (21). This relate to the possibility of additional human to human transmission within the home. This is important because domestic hygiene has been implicated in the increase in diarrheal diseases within the home setting for children (129, 130). Within the domestic domain several other sources of contamination, like from food, contaminated drinking water in the home (131) or direct exposure to feces from humans and animals will superimpose on the effects that is due to the irrigation with wastewater with linked exposure.

Il riuso, soprattutto con acque non trattate, determina una diffusa contaminazione ambientale che ha effetti sulle comunità

EPA United States Environmental Protection Agency
2012 Guidelines for Water Reuse

Reuse Category and Description	Treatment	Reclaimed Water Quality [2]	Reclaimed Water Monitoring
Urban Reuse			
Unrestricted The use of reclaimed water in nonpotable applications in municipal settings where public access is not restricted.	▪ Secondary[(4)] ▪ Filtration[(5)] ▪ Disinfection[(6)]	▪ pH = 6.0-9.0 ▪ ≤ 10 mg/l BOD [(7)] ▪ ≤ 2 NTU [(8)] ▪ No detectable fecal coliform /100 ml [(9,10)] ▪ 1 mg/l Cl2 residual (min.) [(11)]	▪ pH – weekly ▪ BOD - weekly ▪ Turbidity - continuous ▪ Fecal coliform - daily ▪ Cl2 residual – continuous
Restricted The use of reclaimed water in nonpotable applications in municipal settings where public access is controlled or restricted by physical or institutional barriers, such as fencing, advisory signage, or temporal access restriction	▪ Secondary [(4)] ▪ Disinfection [(6)]	▪ pH = 6.0-9.0 ▪ ≤ 30 mg/l BOD [(7)] ▪ ≤ 30 mg/l TSS ▪ ≤ 200 fecal coliform /100 ml [(9, 13, 14)] ▪ 1 mg/l Cl2 residual (min.) [(11)]	▪ pH – weekly ▪ BOD – weekly ▪ TSS – daily ▪ Fecal coliform - daily ▪ Cl2 residual – continuous

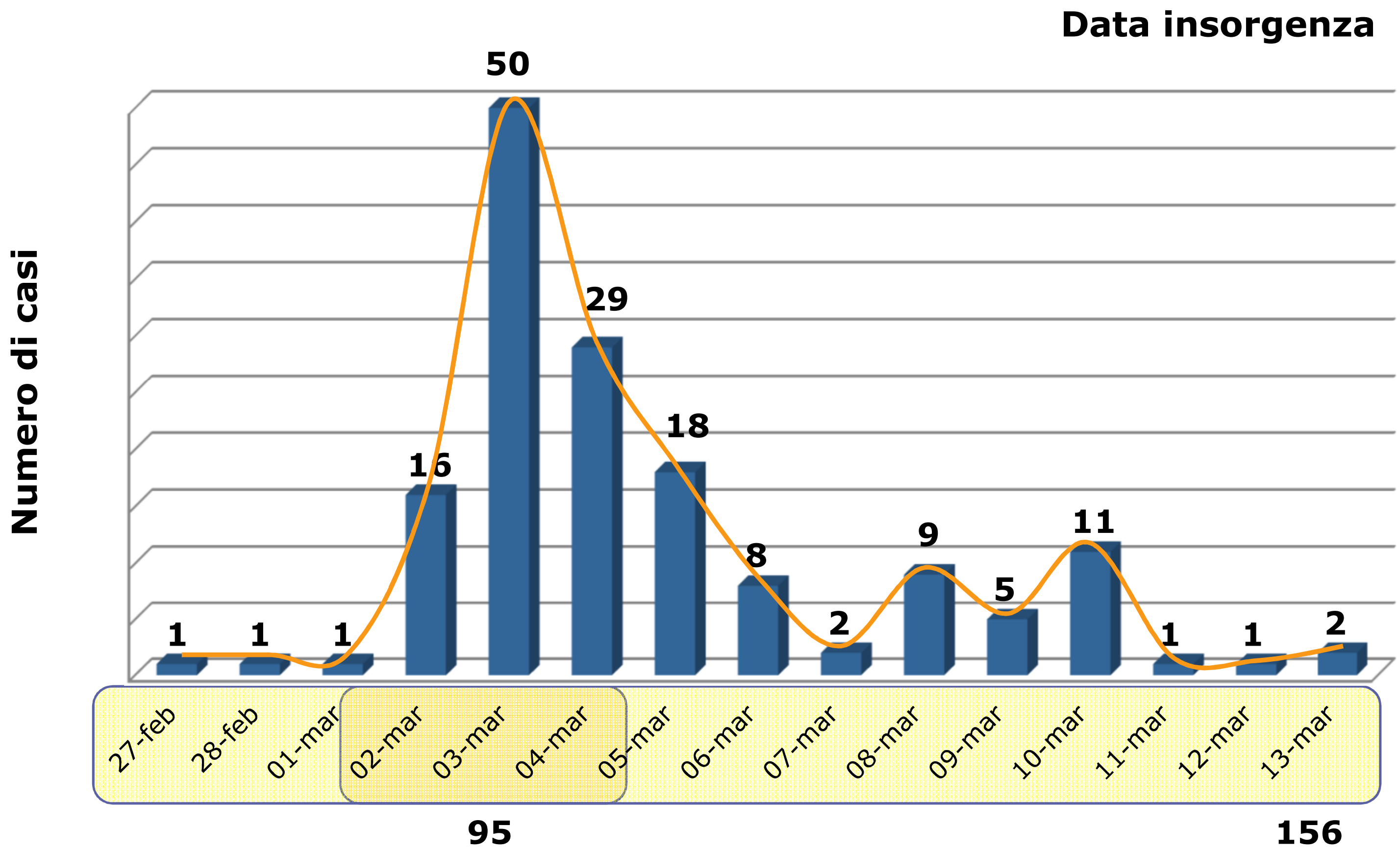
Reuse Category and Description	Treatment	Reclaimed Water Quality [2]	Reclaimed Water Monitoring
Agricultural Reuse			
Food Crops [15] The use of reclaimed water for surface or spray irrigation of food crops which are intended for human consumption, consumed raw.	▪ Secondary (4) ▪ Filtration (5) ▪ Disinfection (6)	▪ pH = 6.0-9.0 ▪ ≤ 10 mg/l BOD (7) ▪ ≤ 2 NTU (8) ▪ No detectable fecal coliform/100 ml (9,10) ▪ 1 mg/l Cl_2 residual (min.) (11)	▪ pH – weekly ▪ BOD - weekly ▪ Turbidity - continuous ▪ Fecal coliform - daily ▪ Cl_2 residual – continuous
Processed Food Crops [15] The use of reclaimed water for surface irrigation of food crops which are intended for human consumption, commercially processed. ***Non-Food Crops*** The use of reclaimed water for irrigation of crops which are not consumed by humans, including fodder, fiber, and seed crops, or to irrigate pasture land, commercial nurseries, and sod farms.	▪ Secondary (4) ▪ Disinfection (6)	▪ pH = 6.0-9.0 ▪ ≤ 30 mg/l BOD (7) ▪ ≤ 30 mg/l TSS ▪ ≤ 200 fecal coli/100 ml (9,13, 14) ▪ 1 mg/l Cl2 residual (min.) (11)	▪ pH – weekly ▪ BOD - weekly ▪ TSS - daily ▪ Fecal coliform - daily ▪ Cl_2 residual – continuous

1 © IWA Publishing 2014 Journal of Water and Health | in press | 2014

Investigation and control of a Norovirus outbreak of probable waterborne transmission through a municipal groundwater system

Giovanni M. Giammanco, Ilaria Di Bartolo, Giuseppa Purpari, Claudio Costantino, Valentina Rotolo, Vittorio Spoto, Gaetano Geraci, Girolama Bosco, Agata Petralia, Annalisa Guercio, Giusi Macaluso, Giuseppe Calamusa, Simona De Grazia, Franco M. Ruggeri, Francesco Vitale, Carmelo M. Maida and Caterina Mammina

Focolaio epidemico di GEV – 156 casi


Data insorgenza
Numero di casi
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29
18
16
8
9
5
11
1
1
1
2
1
1
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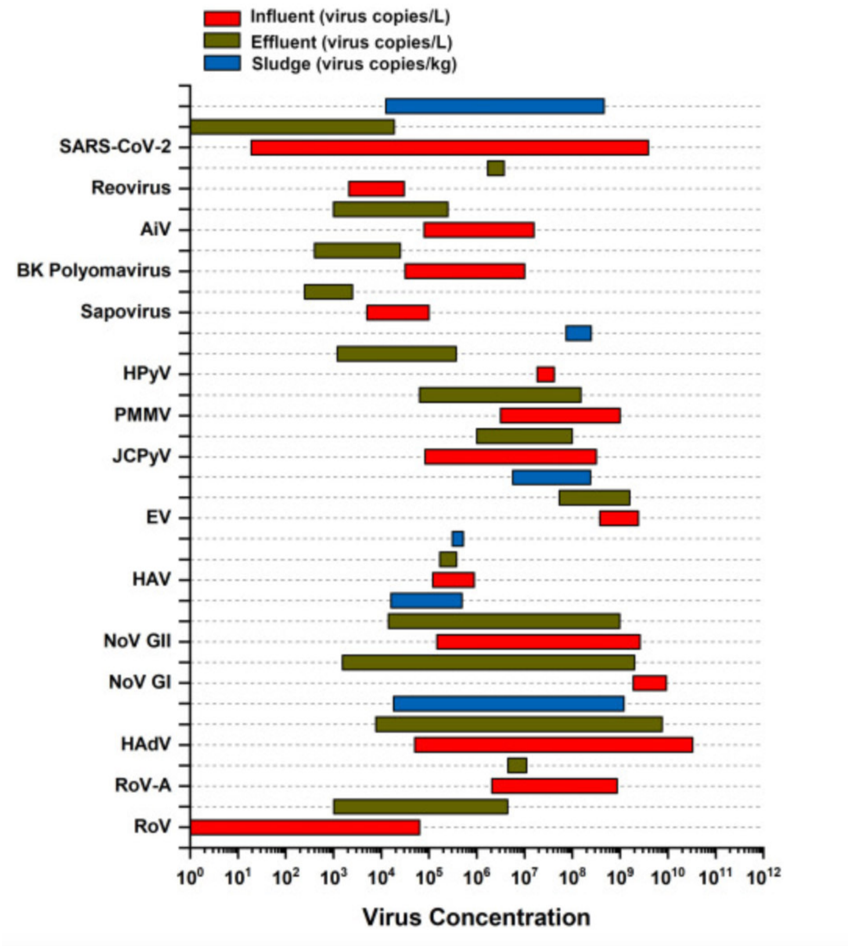
27-feb
28-feb
01-mar
02-mar
03-mar
04-mar
05-mar
06-mar
07-mar
08-mar
09-mar
10-mar
11-mar
12-mar
13-mar
95
156

ELSEVIER
Science of The Total Environment
Volume 745, 25 November 2020, 140910

Viruses in wastewater: occurrence, abundance and detection methods

Mary Vermi Aizza Corpuz [a], Antonio Buonerba [b, c], Giovanni Vigliotta [d], Tiziano Zarra [b, c], Florencio Ballesteros Jr [a, e], Pietro Campiglia [f], Vincenzo Belgiorno [b, c], Gregory Korshin [g], Vincenzo Naddeo [b, c]

VIRUS	Influent gc/L
HEV	7.80E3 - 5.80E8
RoV	1.00E1– 6.31E4
NoV GI	1.70E5 - 1.90E9
NoVGII	1.48E5 – 2.60E9
HAV	0.00 – 1,80E6
SARS-CoV-2	1.90E1 – 3.00E6



EPA United States Environmental Protection Agency
2012
Guidelines for Water Reuse

Table 6-3 Indicative log removals of indicator microorganisms and enteric pathogens during various stages of wastewater treatment

	Indicator microorganisms			Pathogenic microorganisms				
Type of Microorganism	*Escherichia coli* (indicator bacteria)	*Clostridium perfringens*	Phage (indicator virus)	Enteric bacteria (e.g., *Campylobacter*)	Enteric viruses	*Giardia lamblia*	*Cryptosporidium parvum*	Helminths
Bacteria	X	X		X				
Protozoa and helminths						X	X	X
Viruses			X		X			
Indicative Log Reductions in Various Stages of Wastewater Treatment[1]								
Secondary treatment	1 - 3	0.5 - 1	0.5 - 2.5	1 - 3	0.5 - 2	0.5 - 1.5	0.5 - 1	0 - 2
Dual media filtration[2]	0 - 1	0 - 1	1 - 4	0 - 1	0.5 - 3	1 - 3	1.5 - 2.5	2 - 3
Membrane filtration (UF, NF, and RO)[3]	4 - >6	>6	2 - >6	>6	2 - >6	>6	4 - >6	>6
Reservoir storage	1 - 5	N/A	1 - 4	1 - 5	1 - 4	3 - 4	1 - 3.5	1.5 - >3
Ozonation	2 - 6	0 - 0.5	2 - 6	2 - 6	3 - 6	2 - 4	1 - 2	N/A
UV disinfection	2 - >6	N/A	3 - >6	2 - >6	1 ->6	3 - >6	3 - >6	N/A
Advanced oxidation	>6	N/A	>6	>6	>6	>6	>6	N/A
Chlorination	2 - >6	1 - 2	0 - 2.5	2 - >6	1 - 3	0.5 - 1.5	0 - 0.5	0 – 1

(Sources: Bitton, 1999; EPHC, 2008; Mara and Horan, 2003; NRC, 1998; NRC, 2012; Rose et al., 1996; Rose, et al., 2001; EPA, 1999, 2003, 2004; WHO, 1989)

Quantitative Microbial Risk Assessment:

Application for Water Safety Management

World Health Organization

These findings highlight the importance of ensuring the microbial safety of water and sanitation services. The WHO water quality guidelines therefore emphasize that primary attention should be given to managing microbial hazards in the water cycle. In controlling these, there has traditionally been great emphasis on the examination of faecal indicator bacteria. At the turn of the millennium, it was increasingly recognized that this basis for the risk management of microbial hazards was:

- too little – viruses and parasites are significant microbial hazards in water; their fate and transport in the environment and water treatment processes are very different from those of (faecal indicator) bacteria; and outbreaks of waterborne disease have occurred while the water complied with the guidelines for faecal indicator bacteria; and
- too late – by the time the faecal indicator bacteria examination highlighted a potential health problem, the exposure to the water had already occurred.

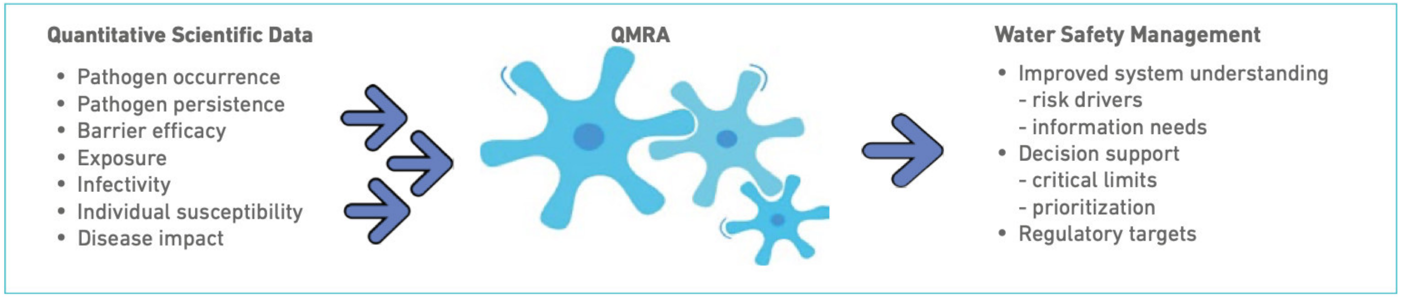


Table 2.4 Summary of the four-step framework for water-related QMRA

Step	Description
Problem formulation	The overall context (reference pathogens, exposure pathways, hazardous events and health outcomes of interest) of the risk assessment is defined and constrained in order to successfully target the specific risk management question that must be addressed.
Exposure assessment	The magnitude and frequency of exposure to each reference pathogen via the identified exposure pathway(s) and hazardous events are quantified.
Health effects assessment	Dose–response relationships (linking exposure dose to probability of infection or illness) and probability of morbidity and mortality (depending on the health end-point of the assessment) are identified for each reference pathogen.
Risk characterization	The information on exposure and the health effects assessment are combined to generate a quantitative measure of risk.

Rischio chimico

Convenzionali	Solidi sospesi totali, BOD, COD, Ammonio, Nitriti, Nitrati, Fosforo
Non convenzionali	Metalli Pesanti, Solidi totali disciolti, Pesticidi
Emergenti	Antibiotici, Farmaci, Prodotti per la cura personale, Droghe, Nanoparticelle

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Occurrence of pharmaceutical residues, personal care products, lifestyle chemicals, illicit drugs and metabolites in wastewater and receiving surface waters of Krakow agglomeration in South Poland

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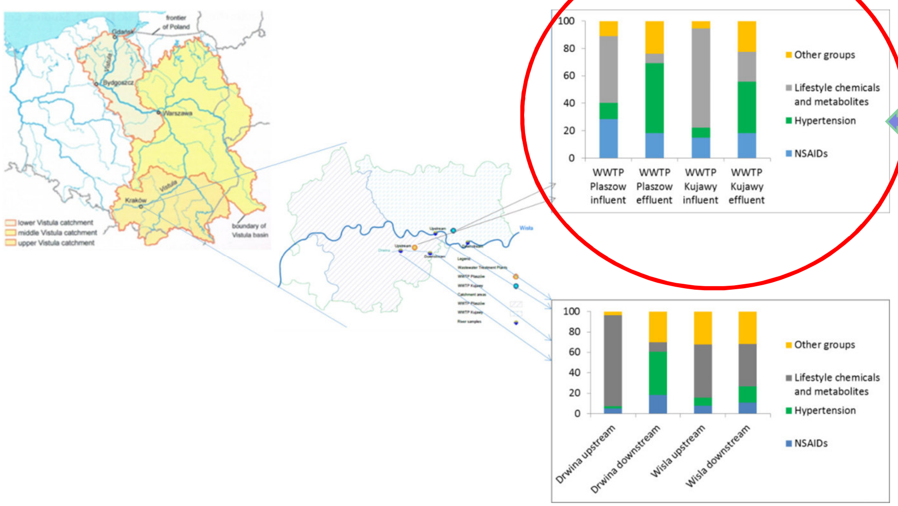


Abstract

This is the first study of broad range of chemical classes CECs conducted in the upper Wisla river catchment including the biggest WWTPs in this region and surface waters. The list of compounds is extensive and the paper provides, for the first time, better understanding of environmental burden from PCPCs in Poland. Cumulative contribution of hypertension pharmaceuticals, nonsteroidal anti-inflammatory drugs (NSAIDs) and lifestyle chemicals was 89% and 95% in wastewater influent, and 75% in wastewater effluent at both WWTPs. Significant removal efficiencies, exceeding 90%, were found for parabens, UV filters, NSAIDs, steroid estrogens, plasticizers, antibacterials/antibiotics, stimulants and metabolites and lifestyle chemicals. The comparison of the average mass loads of CECs between the influent and effluent, has shown that 27% and 29% of all detected CECs were removed by less than 50%. An increase of

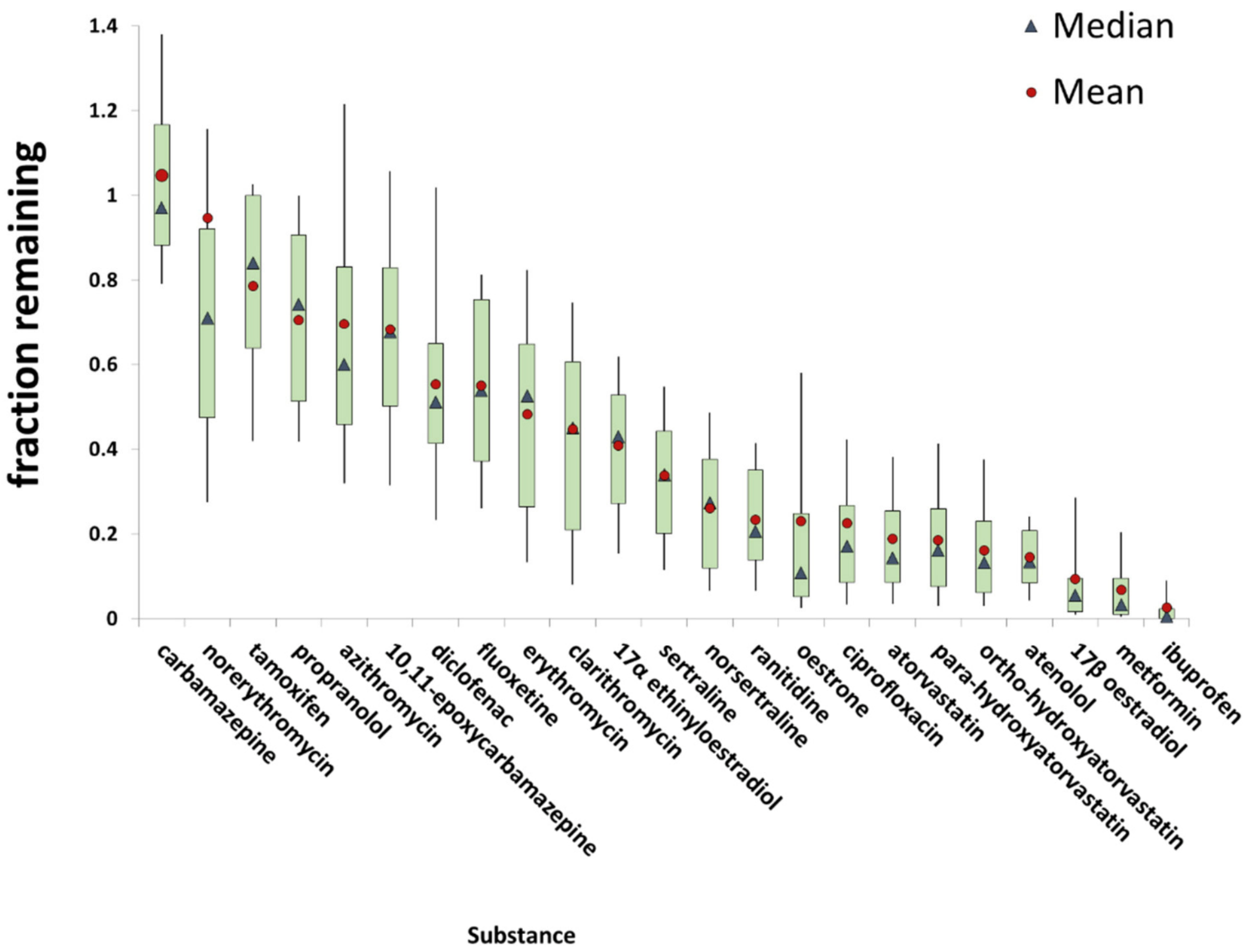
CECs

CHEMICALS OF EMERGING CONCERN

ELSEVIER
Science of The Total Environment
Volume 676, 1 August 2019, Pages 222-230

The removal of pharmaceuticals during wastewater treatment: Can it be predicted accurately?

Sean Comber [a], Mike Gardner [b], Pernilla Sörme [c], Brian Ellor [d]



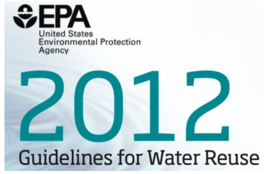


Table 6-5 Indicative percent removals of organic chemicals during various stages of wastewater treatment

Treatment	Percent Removal								
			Pharmaceuticals					Hormones	
	B(a)p	Antibiotics[1]	DZP	CBZ	DCF	IBP	PCT	Steroid[2]	Anabolic[3]
Secondary (activated sludge)	nd	10–50	nd	–	10–50	>90	nd	>90	nd
Soil aquifer treatment	nd	nd	nd	25–50	>90	>90	>90	>90	nd
Aquifer storage	nd	50–90	10–50	–	50–90	50–90	Nd	>90	nd
Microfiltration	nd	<20	<20	<20	<20	<20	<20	<20	nd
Ultrafiltration/ powdered activated carbon (PAC)	nd	>90	>90	>90	>90	>90	nd	>90	nd
Nanofiltration	>80	50–80	50–80	50–80	50–80	50–80	50–80	50–80	50–80
Reverse osmosis	>80	>95	>95	>95	>95	>95	>95	>95	>95
PAC	>80	20–>80	50–80	50–80	20–50	<20	50–80	50–80	50–80
Granular activated carbon		>90	>90	>90	>90	>90		>90	
Ozonation	>80	>95	50–80	50–80	>95	50–80	>95	>95	>80
Advanced oxidation		50–80	50–80	>80	>80	>80	>80	>80	>80
High-level ultraviolet		20–>80	<20	20–50	>80	20–50	>80	>80	20–50
Chlorination	>80	>80	20–50	–<20	>80	<20	>80	>80	<20
Chloramination	50–80	<20	<20	<20	50–80	<20	>80	>80	<20

(Sources: Ternes and Joss, 2006; Snyder et al., 2010)

B(a)p = benz(a)pyrene; CBZ = carbamazepine, DBP = disinfection by-product; DCF = diclofenac; DZP = diazepam; I nitrosodimethylamine; nd = no data; PAC = powdered activated carbon; PCT = paracetamol.

[1] erythromycin, sulfamethoxazole, triclosan, trimethoprim

[2] ethynylestradiol; estrone, estradiol and estriol

[3] progesterone, testosterone

CECs enter water systems from various sources, such as sewage, industry and agriculture. Previous work indicated that the effluent from wastewater treatment plants (WWTPs) was one of the major pathways for CECs' discharge into the aquatic environment. CECs are usually present at low concentrations in the environment (they range from pg L^{-1} to μg L^{-1}), but their levels can potentially cause undesired physiological effects in wildlife and humans (Hernando et al., 2011; Stuart et al., 2012; Pal et al., 2014; Zenker et al., 2014). This is more concerning considering that they do not appear individually, but as a complex mixture (Vasquez et al., 2014).

PHYSIOLOGICAL EFFECT IN HUMANS

Environment International 71 (2014) 46–62

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Review

Emerging contaminants of public health significance as water quality indicator compounds in the urban water cycle

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Da dove vengono questi contaminanti chimici?

Table 2a
Categories, sources, annual production and releases of representative EOCs and activities causing release into the UWC.

Categories	Representative chemicals			
	Chemicals	Annual production capacity, year[*], ref.	Activities causing contaminant release to UWCs	Annual release to water, year[*], ref.
Plasticizers	Bisphenol A	5,216,312.3 t (global), 2008, (Dow, 2012)	Plastic manufacture from plants; combustion of domestic waste; natural breakdown of plastics in environment; landfill leachates; WWTP effluents	2.8 t, (global), 2007, (USEPA, 2010)
Perfluorinated compounds	PFOS	73–162 t (global), 2005, (OECD, 2006)	Manufacturing wastes; via volatilization, oxidation & precipitation from pesticides, PCPs, flame retardants, upholstery, coatings, food-packaging etc.; landfill leachates; WWTP effluents	<1.25 t (global), 2008, (OECD, 2011)
Pesticides	Fipronil	480 t (France), 1997, (Tingle et al., 2000)	Spray drift after various applications: pest control & crop protection, irrigation runoff	-
Surfactants	4-nonylphenol monoethoxylate (NP1EO)	118,000 t nonylphenolethoxylates (Europe), 1997, (Wenzel et al., 2004)	Application of raw sludge to soils followed by landfill leachates; WWTP effluents	~37% released to water undegraded, (Linley-Adams, 1999)
Antibiotics	Sulfamethoxazole	53.6 t[#] (Germany), 2001, (Huschek et al., 2004); 10.9 t[a](Spain), 2009, (Ortiz de García et al., 2013)	Manufacturing wastes; domestic and farm disposal of unused, expired antibiotics; land use of animal manure and sewage sludge; WWTP effluents	2.1 t[b] (Spain), 2009, (Ortiz de García et al., 2013)
Pharmaceuticals	Acetaminophen	621.6 t[#] (Germany), 2001, (Huschek et al., 2004); 1,460.2 t[a] (Spain), 2009, (Ortiz de García et al., 2013)	Manufacturing wastes; unused and expired drugs disposed from households; landfill leachates; WWTP effluents	23.3 t[b] (Spain), 2009, (Ortiz de García et al., 2013)
Hormones	Estrone (E1)	-	Hormones injected to livestock and fishes, released from animal farms and aquacultures respectively; human and animal excreta via WWTP effluents	28.2. kg[b] E1 metabolite, (Spain), 2009, (Ortiz de García et al., 2013)
Iodinated X-ray contrast media (ICM)	Iopromide	64.1 t[#] (Germany), 2001, (Huschek et al., 2004); 23.7 t[a] (Spain), 2009, (Ortiz de García et al., 2013)	Manufacturing waste; excreted from human bodies after intravascular administration at hospitals and released via WWTP effluents	14.8 t[b] (Spain), 2009, (Ortiz de García et al., 2013)
Artificial sweeteners	Sucralose (SCL)	15,000 t (global), expected by 2018 (Searby, 2011)	Direct release from food industries, households, animal farming; WWTP effluents as excretion after consumption without undergoing change within the human bodies	98% of SCL consumed by humans excreted unchanged, (Loos et al., 2009)
Musks& fragrances	Galaxolide	1000–5000 t (Europe), 2004, (Fernandes et al., 2013)	Applied as perfumes, cosmetics, soaps, lotions and washed by water; WWTP effluents	~77% used musks drains into sewage, (Fernandes et al., 2013)
UV-filters	4-methylbenzylidene camphor (4-MBC)	10,000 t UV-filters (global), (Gago-Ferrero et al., 2012)	Use of sunscreens, shampoos, whitening lotions, cosmetics, lipsticks, hairsprays & dyes: released through swimming and showers	-
Antimicrobial preservatives	Benzylparaben	<7.7 t total parabens, (USA), (Dobbins et al., 2009)	Manufacturing wastes; runoffs through use in cosmetics, toiletries, pharmaceuticals, food; WWTP effluents	2.1 t[b] methylparaben (Spain), 2009, (Ortiz de García et al., 2013)
Other personal care products	N,N-diethyl-m-toluamide (DEET)	1,814.4 t[c], (USA), 1990, (USEPA, 1998)	Mosquito repellants: released through showers, swimming as <20% absorbed dermally; WWTP effluents	>80% released to water, (Aronson et al., 2012)
Fluorescent whitening agents (FWAs)	4,4′-bis(2-sulfostyryl) biphenyl (DSBP)	3,000 t estimated (global), 1992, (Kramer et al., 1996)	Used in laundry detergents: 5–80% remain in washing liquor and are disposed to sewers	5–80% discharged with wash liquor, (Kramer et al., 1996)
Algal toxins	Microcystin	-	Many species of cyanobacteria produce toxins in water impacted by algal blooms	-
Off flavors	Geosmin	-	produced by: algal blooms, & natural bacterial populations such as actinobacteria	-

Quali sono gli effetti sulla salute dell'uomo?

Table 2b
Release of EOCs in the UWC and their potential ecotoxicological effect.

Categories	Representative chemicals	Potential health concerns of representative chemicals				Ref.
		Humans	Animals	Aquatic species	Others	
Plasticizers	Bisphenol A	Possible carcinogenic effect, EDC	Meiotic aneuploidy, synaptic abnormalities, EDC	Estrogenic& reproductive effect	Possible EDC in birds	(Flint et al., 2012; Sharma et al., 2009; Wu et al., 2012)
Perfluorinated compounds	PFOS	Possibility of thyroid disease and low sperm count;	Reduced body weight and cholesterol, increased liver weight, neonatal mortality; carcinogenic to rodents	Mussel mortality observed	-	(Giesy et al., 2010; Lau et al., 2007; Lindstrom et al., 2011; Post et al., 2012)
Pesticides	Fipronil	May pose mild temporary health effect; possible carcinogen but no data so far	Increases thyroid tumors in rats by increasing plasma concentrations of thyroid stimulating hormones	Potential adverse effect on endocrine and neuromuscular systems of larval fish	Highly toxic to lizard, bees (LD50: 0.004 μg/bee), gallinaceous birds	(Beggel et al., 2012; Herin et al., 2011; Lee et al., 2010; Tingle et al., 2003)
Surfactants	NP1EO	Possible endocrine disruptive effect	Possible cardiotoxicity in dogs; possible endocrine disruptive effect	Weakly estrogenic to rainbow trout; weakly toxic to fathead minnow	NPEO mixture weakly toxic to earthworms, plants	(Ademollo et al., 2008; Chen et al., 2009b; Domene et al., 2009; Dussault et al., 2005; Montgomery-Brown & Reinhard, 2003; TenEyck & Markee, 2007)
Antibiotics	Sulfamethoxazole	Mixture with 12 other pharmaceuticals could potentially inhibit the growth of human embryonic kidney cells at ng/l	-	Mutagenic; acute, chronic toxicity at low mg/l; chronic effect on freshwater microalgae *P. subcapitata;* acute effect on cyanobacterium *S. leopoliensis*	Antimicrobial resistance	(Bound et al., 2006; Pomati et al., 2006; Zhang et al., 2010; Zheng et al., 2012)
Pharmaceuticals	Acetaminophen	Alters steroidogenic pathway, increases estrogenicity in adrenal cell H295R high above aquatic concentrations	Chronic hepatoxicity (cirrhosis and hepatocyte necrosis) in mice at high ppm levels	Affects embryonic development of zebrafish; survival of *Daphnia* and fish (Oryziaslatipes) affected at ppm levels	-	(Blanset et al., 2007; Galus et al., 2013; Kim et al., 2012)
Hormones	Estrone	-	-	Fathead minnows: abnormal testicular growth in male at low ng/l; chronic exposure causes feminization	Potato plant, sunflower seedlings: affect flowering, root, shoot growth with E2	(Hamid & Eskicioglu, 2012; Hanselman et al., 2003)
ICM	Iopromide	Possibility of low human toxicity	ICM iopamidol forms iodo-DBPs in chlorinated, chloraminated drinking water that are cytotoxic, genotoxic to mammalian cells	No chronic toxicity of the degradation product on zebrafish even at 100 ppm	Notmicrocidal to bacteria	(Duirk et al., 2011; Steger-Hartmann et al., 1999; Steger-Hartmann et al., 2002)
Artificial sweeteners	Sucralose	Not mutagenic, carcinogenic; no developmental or reproductive toxicity	No adverse effects on reproduction system of rats; not acutely toxic to mice	Low bioaccumulation in mussels, species of *Daphnia*, fish, algae; may be toxic to aquatic species at ≥1123 ppm; may affect locomotion in crustaceans	Not toxic to plant growth; food intake increases in one species of marine copepod	(Shwide-Slavin et al., 2012; Soh et al., 2011; Tollefsen et al., 2012; Wiklund et al., 2012)
Musks & fragrances	Galaxolide	Weak estrogenic effect at concentrations much higher than environmentally relevant levels	Risk ratios for predators on aquatic and soil organisms ≤ 0.01	In marine mussel gills, inhibits activity of multidrug efflux transporters (that protect cells from damage by pumping out pollutants)	-	(Balk & Ford, 1999; Luckenbach & Epel, 2005; Schreurs et al., 2002; Seinen et al., 1999; Witorsch & Thomas, 2010)
UV-filters	4-MBC	Effect on reproductive and thyroid hormone possible after dermal application of mixture of 3 UV-filters	Changes gonadal weight and steroid hormone production in male rats	Potency for estrogenic activity using fish MCF-7 cell lines; antiestrogenic activity using fish hERα; mixture with other UV-filters may risk aquatic environment	Reproduction increased, mortality decreased in worm *Lumbriculus variegates*	(Brausch & Rand, 2011; Fent et al., 2010b; Krause et al., 2012)
Antimicrobial preservatives	Benzylparaben	-	Potential EDC; but concentrations in surface water is much lower than PNEC	EDC in some fishes; toxic to some fish	Toxic to invertebrates	(Brausch & Rand, 2011)
Other personal care products	DEET	Not carcinogenic, developmentally toxic, or mutagenic; seizures at high dose	Not toxic to small mammals	Chronic and acute toxic effects on *Daphnia* and algae at concentrations much higher than aquatic concentrations	Slightly toxic to birds	(Aronson et al., 2012; Costanzo et al., 2007; USEPA, 1998)
FWAs	DSBP	May cause inhibition to estrogenic response	-	May cause inhibition to estrogenic response in rainbow trout	-	(Simmons et al., 2008)
Algal toxins	Microcystin	Liver cancer, death from liver failure, skin damage, respiratory problem	Disrupts hepatocyte cytoskeleton, damages DNA, promotes tumor in rats	Anemia, kidney dysfunction in carps; accumulation in livers of turtles	Accumulation in spleens and livers of ducks, waterbirds	(Chen et al., 2009c; Sedan et al., 2013)
Off flavors	Geosmin	Not toxic to humans	Study on monkey, dog shows non-toxicity	No acute toxicity to fish (copper fin); not mutagenic	Toxic to *Salmonella typhimurium*	(Mochida, 2009)

A. Pal et al. / Environment International 71 (2014) 46–62

Emerging Contaminants

Antibiotics and Antibiotic Resistance Genes (ARGs) in Wastewater for Reuse

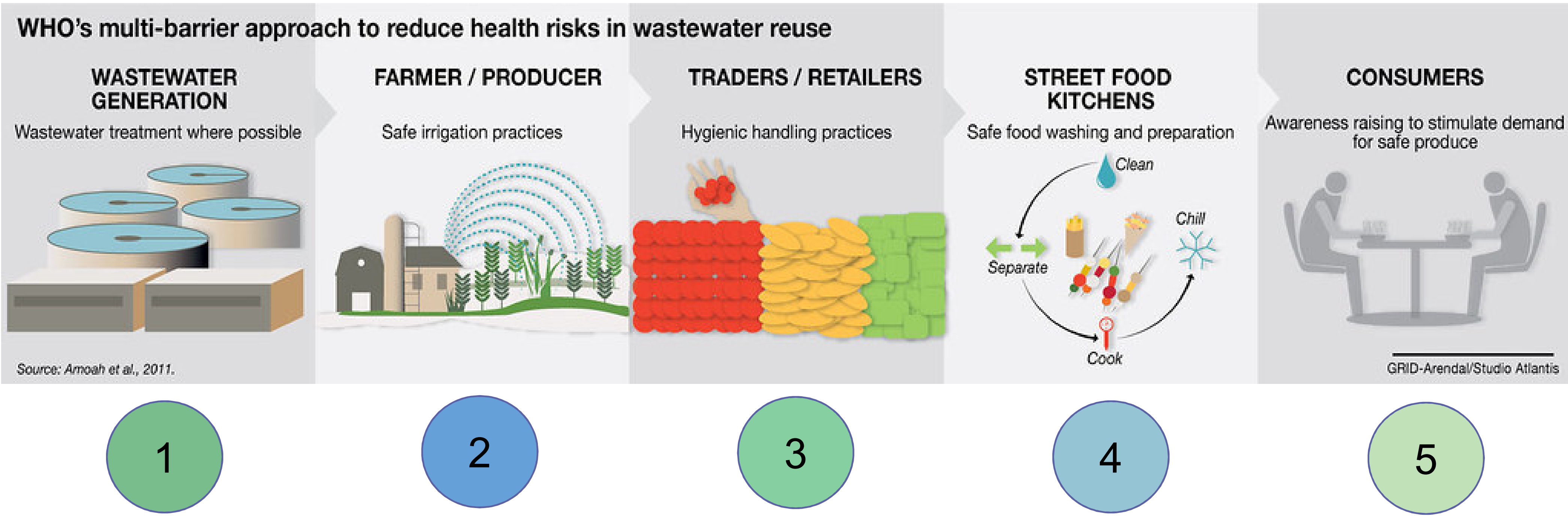
Antibiotic residues and antibiotic resistant genes ARGs have been reported in wastewater released from wastewater treatment plants (157–162). The presence of these in wastewater has been identified as a possible source of antibiotic resistance microorganisms (13, 163). This resistance could be developed through induction, selection or horizontal gene transfer of ARGs (162, 164). Varying antibiotic removal efficiencies from wastewater for reuse has been reported (165–167).

These studies show that most treatment plants have antibiotics in their effluents which when reused may impact and accumulate in soil and be taken up by the crops.

HOTSPOT
ANTIBIOTICS
RESISTANCE

Fattori limitanti il rischio

Approccio muiltibarriera



1 WASTEWATER GENERATION

RIDURRE LA CONCENTRAZIONE DI PATOGENI/RESIDUI CHIMICI

Table 6-3 Indicative log removals of indicator microorganisms and enteric pathogens during various stages of wastewater treatment

Type of Microorganism	Indicator microorganisms: *Escherichia coli* (indicator bacteria)	Indicator microorganisms: *Clostridium perfringens*	Indicator microorganisms: Phage (indicator virus)	Pathogenic microorganisms: Enteric bacteria (e.g., *Campylobacter*)	Pathogenic microorganisms: Enteric viruses	Pathogenic microorganisms: *Giardia lamblia*	Pathogenic microorganisms: *Cryptosporidium parvum*	Pathogenic microorganisms: Helminths
Bacteria	X	X		X				
Protozoa and helminths						X	X	X
Viruses			X		X			
Indicative Log Reductions in Various Stages of Wastewater Treatment[1]								
Secondary treatment	1 - 3	0.5 - 1	0.5 - 2.5	1 - 3	0.5 - 2	0.5 - 1.5	0.5 - 1	0 - 2
Dual media filtration[2]	0 - 1	0 - 1	1 - 4	0 - 1	0.5 - 3	1 - 3	1.5 - 2.5	2 - 3
Membrane filtration (UF, NF, and RO)[3]	4 - >6	>6	2 - >6	>6	2 - >6	>6	4 - >6	>6
Reservoir storage	1 - 5	N/A	1 - 4	1 - 5	1 - 4	3 - 4	1 - 3.5	1.5 - >3
Ozonation	2 - 6	0 - 0.5	2 - 6	2 - 6	3 - 6	2 - 4	1 - 2	N/A
UV disinfection	2 - >6	N/A	3 - >6	2 - >6	1 ->6	3 - >6	3 - >6	N/A
Advanced oxidation	>6	N/A	>6	>6	>6	>6	>6	N/A
Chlorination	2 - >6	1 - 2	0 - 2.5	2 - >6	1 - 3	0.5 - 1.5	0 - 0.5	0 – 1

(Sources: Bitton, 1999; EPHC, 2008; Mara and Horan, 2003; NRC, 1998; NRC, 2012; Rose et al., 1996; Rose, et al., 2001; EPA, 1999, 2003, 2004; WHO, 1989)

Table 6-5 Indicative percent removals of organic chemicals during various stages of wastewater treatment

Treatment	Percent Removal								
			Pharmaceuticals					Hormones	
	B(a)p	Antibiotics[1]	DZP	CBZ	DCF	IBP	PCT	Steroid[2]	Anabolic[3]
Secondary (activated sludge)	nd	10–50	nd	–	10–50	>90	nd	>90	nd
Soil aquifer treatment	nd	nd	nd	25–50	>90	>90	>90	>90	nd
Aquifer storage	nd	50–90	10–50	–	50–90	50–90	Nd	>90	nd
Microfiltration	nd	<20	<20	<20	<20	<20	<20	<20	nd
Ultrafiltration/ powdered activated carbon (PAC)	nd	>90	>90	>90	>90	>90	nd	>90	nd
Nanofiltration	>80	50–80	50–80	50–80	50–80	50–80	50–80	50–80	50–80
Reverse osmosis	>80	>95	>95	>95	>95	>95	>95	>95	>95
PAC	>80	20–>80	50–80	50–80	20–50	<20	50–80	50–80	50–80
Granular activated carbon		>90	>90	>90	>90	>90		>90	
Ozonation	>80	>95	50–80	50–80	>95	50–80	>95	>95	>80
Advanced oxidation		50–80	50–80	>80	>80	>80	>80	>80	>80
High-level ultraviolet		20–>80	<20	20–50	>80	20–50	>80	>80	20–50
Chlorination	>80	>80	20–50	–<20	>80	<20	>80	>80	<20
Chloramination	50–80	<20	<20	<20	50–80	<20	>80	>80	<20

(Sources: Ternes and Joss, 2006; Snyder et al., 2010)

B(a)p = benz(a)pyrene; CBZ = carbamazepine, DBP = disinfection by-product; DCF = diclofenac; DZP = diazepam; I nitrosodimethylamine; nd = no data; PAC = powdered activated carbon; PCT = paracetamol.

[1] erythromycin, sulfamethoxazole, triclosan, trimethoprim
[2] ethynylestradiol; estrone, estradiol and estriol
[3] progesterone, testosterone

water

MDPI

Article

Are Fresh Water and Reclaimed Water Safe for Vegetable Irrigation? Empirical Evidence from Lebanon

Marie Therese Abi Saab [1,2,*], Ihab Jomaa [3], Rima El Hage [1], Sleiman Skaf [3], Salim Fahed [1], Ziad Rizk [1], Randa Massaad [3], Dany Romanos [1], Yara Khairallah [1], Valerie Azzi [1], Rhend Sleiman [1], Roula Abi Saad [1], Celine Hajjar [1], Mohamed Houssemeddine Sellami [4], Rodolph Aziz [2], Rita Sfeir [2], Marie Helene Nassif [5] and Javier Mateo-Sagasta [6]

DIFFERENZIARE I TRATTAMENTI IN BASE ALLE COLTURE

in the order of Cu < Cd < Ni < Cr < Zn. The target hazard quotient values for all metals were lower than 1.0. Under trial conditions, the adoption of drip irrigation with water with less than 3 log *E. coli* CFU/100 mL proved to be safe, even for vegetables consumed raw, except for root crops such as onions and radishes that should not be irrigated with water having over 2 log *E. coli* CFU/100 mL. Treated wastewater had no adverse effect on vegetable quality compared to vegetables irrigated with other water sources. These results support efforts to update the Lebanese standards for water reuse in agriculture; standards proposed in 2011 by the FAO, and currently being reviewed by the Lebanese Institution of Standards. This research will inform a sustainable water management policy aimed at protecting the Litani River watershed by monitoring water quality.

DIFFERENZIARE I TRATTAMENTI IN BASE ALLE COLTURE

Tabella 1 — Classi di qualità delle acque affinate e tecniche di irrigazione e utilizzi agricoli consentiti

Classe minima di qualità delle acque affinate	Categoria di coltura (*1)	Tecniche di irrigazione
A	Tutte le colture alimentari da consumare crude la cui parte commestibile è a diretto contatto con le acque affinate e le piante da radice da consumare crude	Tutte
B	Colture alimentari da consumare crude la cui parte commestibile è prodotta al di sopra del livello del terreno e non è a diretto contatto con le acque affinate, colture alimentari trasformate e colture non alimentari, comprese le colture utilizzate per l'alimentazione di animali da latte o da carne	Tutte
C	Colture alimentari da consumare crude la cui parte commestibile è prodotta al di sopra del livello del terreno e non è a diretto contatto con le acque affinate, colture alimentari trasformate e colture non alimentari, comprese le colture utilizzate per l'alimentazione di animali da latte o da carne	Irrigazione a goccia (*2) o altra tecnica di irrigazione che eviti il contatto diretto con la parte commestibile della coltura
D	Colture industriali, da energia e da sementi	Tutte le tecniche di irrigazione (*3)

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a) Prescrizioni minime di qualità delle acque

Tabella 2 — Prescrizioni di qualità delle acque affinate a fini irrigui in agricoltura

Classe di qualità delle acque affinate	**Obiettivo tecnologico indicativo**	**Prescrizioni di qualità**				
		E. coli **(numero/100 ml)**	**BOD_5 (mg/l)**	**TSS (mg/l)**	**Torbidità (NTU)**	**Altro**
A	Trattamento secondario, filtrazione e disinfezione	≤ 10	≤ 10	≤ 10	≤ 5	*Legionella* spp.: < 1 000 ufc/l se vi è rischio di diffusione per via aerea Nematodi intestinali (uova di elminti): ≤ 1 uovo/l per irrigazione di pascoli o colture da foraggio
B	Trattamento secondario e disinfezione	≤ 100	In conformità della direttiva 91/271/CEE (allegato I, tabella 1)	In conformità della direttiva 91/271/CEE (allegato I, tabella 1)	–	
C	Trattamento secondario e disinfezione	≤ 1 000			–	
D	Trattamento secondario e disinfezione	≤ 10 000			–	

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VALIDAZIONE DELLA QUALITÀ DELLE ACQUE A MAGGIORE CLASSE DI RISCHIO

Tabella 4 — Monitoraggio a fini di validazione delle acque affinate a fini irrigui in agricoltura

Classe di qualità delle acque affinate	**Microrganismi indicatori** (*4)	**Obiettivi prestazionali per la catena di trattamento (riduzione di $\log_{10}$)**
A	*E. coli*	≥ 5,0
	Colifagi totali/colifagi F-specifici/colifagi somatici/colifagi (*5)	≥ 6,0
	Spore di *Clostridium perfringens*/solfobatteri sporigeni (*6)	≥ 4,0 (in caso di spore di *Clostridium perfringens*) ≥ 5,0 (in caso di solfobatteri sporigeni)

2

FARMERS/PRODUCERS

EVITARE IL CONTATTO DIRETTO DEI REFLUI CON LE COLTURE

CESSATION OF IRRIGATION BEFORE HARVESTING

Keraita et al. studied the reduction of microbial contamination [illegible] eggs [illegible] -1 for *Ascaris suum* on lettuce following cessation of irrigation before harvesting.

3

INTRODURRE SPECIFICHE MISURE DI PREVENZIONE

Classe di qualità delle acque affinate	Misure specifiche di prevenzione
A	— I suini non devono essere esposti a foraggi irrigati con acque affinate, a meno che non vi siano dati sufficienti che indichino la possibilità di gestire i rischi legati a un caso specifico.
B	— Divieto di raccolta di prodotti irrigati umidi o caduti a terra. — Esclusione delle vacche da latte in lattazione dal pascolo finché quest'ultimo non è asciutto. — Il foraggio deve essere essiccato o insilato prima dell'imballaggio. — I suini non devono essere esposti a foraggi irrigati con acque affinate, a meno che non vi siano dati sufficienti che indichino la possibilità di gestire i rischi legati a un caso specifico.
C	— Divieto di raccolta di prodotti irrigati umidi o caduti a terra. — Esclusione degli animali dal pascolo per cinque giorni dopo l'ultima irrigazione. — Il foraggio deve essere essiccato o insilato prima dell'imballaggio. — I suini non devono essere esposti a foraggi irrigati con acque affinate, a meno che non vi siano dati sufficienti che indichino la possibilità di gestire i rischi legati a un caso specifico.
D	— Divieto di raccolta di prodotti irrigati umidi o caduti a terra.

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4 RENDERE SICURI I CIBI VENDUTI

5 AUMENTARE LA DOMANDA ATTRAVERSO LA CONSAPEVOLEZZA


THANK YOU