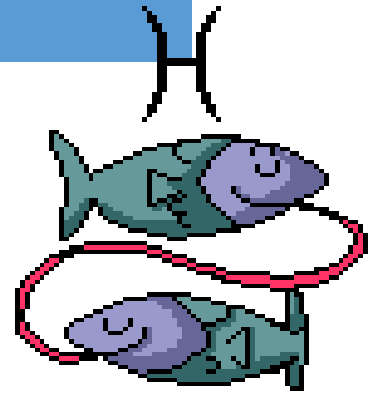
UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

AMR in Aquaculture in the SADC region

Hafizah Y. Chenia
Discipline: Microbiology
University of KwaZulu-Natal, South Africa

cheniah@ukzn.ac.za



AQUACULTURE IN SADC REGION

- **Southern African Development Community (SADC)** - 15 Member States: Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Madagascar, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, United Republic of Tanzania, Zambia and Zimbabwe

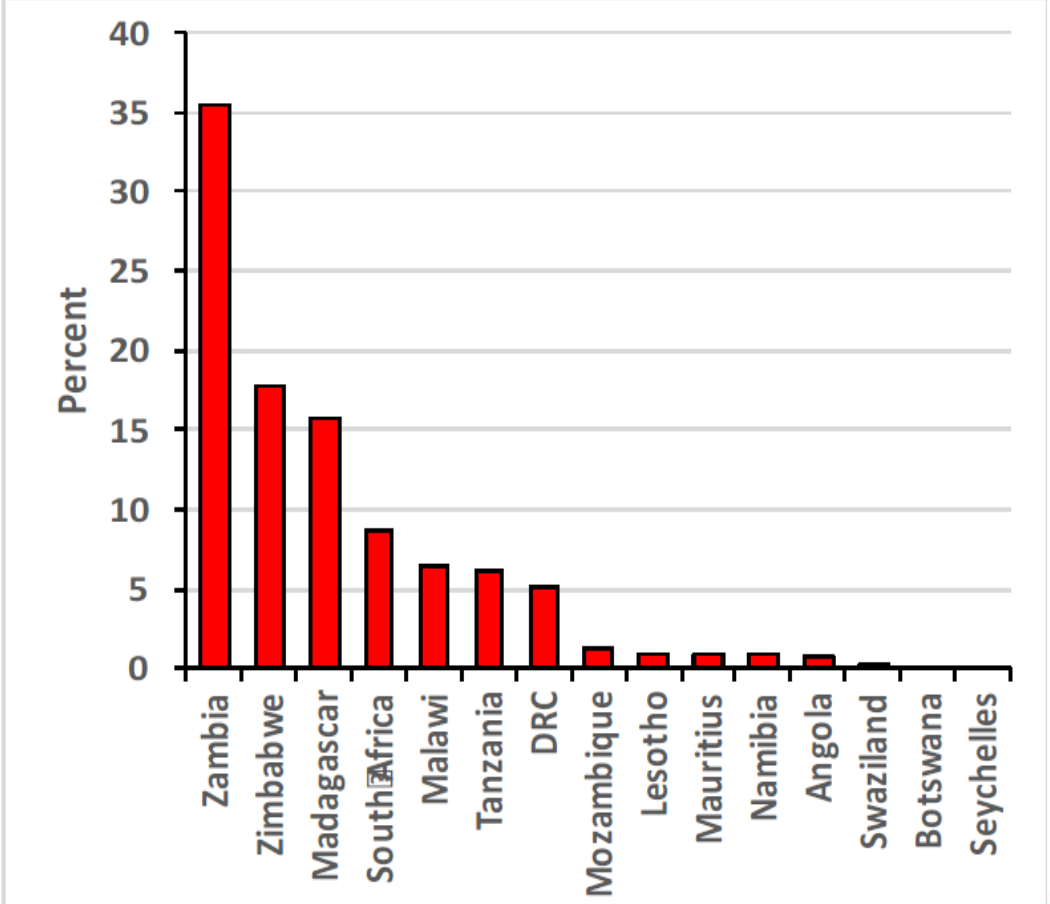
- Marine and inland capture fisheries and aquaculture – benefits: nutrition and food security, livelihoods, employment, exports and foreign currency and conservation and biodiversity values

- Commercial aquaculture undertakings, at various scales - operational in Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe

- Principle species farmed on a commercial scale: tilapia, rainbow trout, abalone, prawns, mussels, oysters, and ornamental fish species

SADC contributes 0.08% to world aquaculture output (excluding seaweeds)

Percent contribution by country to total SADC aquaculture production of 69,851 tonnes in 2015



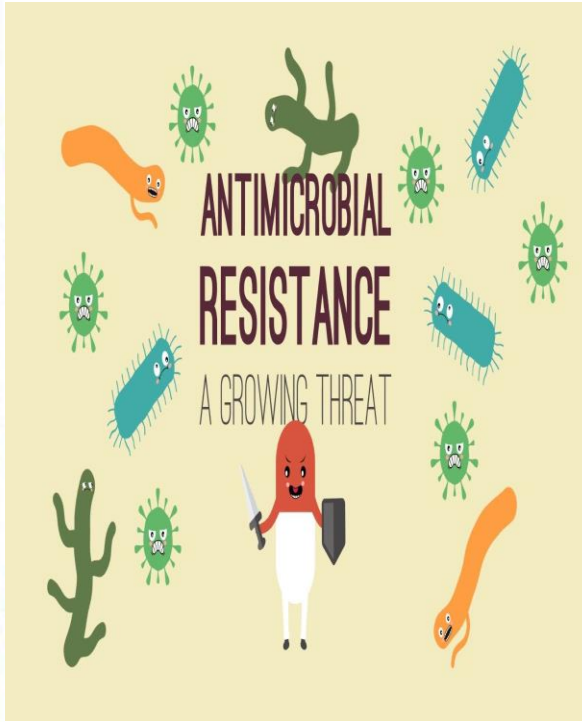
Abalone farming in South Africa

Seaweed farming in Tanzania (Zanzibar)

Shrimp farming in Madagascar & Mozambique

Trout farming in Lesotho & South Africa

Tilapia farming in Zambia & Zimbabwe


ANTIMICROBIAL
RESISTANCE
A GROWING THREAT

IMPORTANT BACTERIAL DISEASES IN AQUACULTURE

Gram-negative bacteria (6)	Gram-positive bacteria (4)
Vibriosis (*V. anguillarum*, *V. harveyi* clade, *V. parahaemolyticus*, *Aliivibrio salmonicida* (*V. salmonicida*), *V. vulnificus* , *Photobacterium damselae*)	**Mycobacteriosis** (*Mycobacterium fortuitum*, *M. marinum*, *Nocardia asteroides*, *N. crassostreae (ostreae)*, *N. seriolae*)
Aeromonasis (Motile *Aeromonas* spp.:*Aeromonas caviae*, *A. hydropila*, *A. sobria*, *A. veronii*, *A. jandaei*; *A. salmonicida*)	**Streptococcosis** (*Streptococcus agalactiae*, *S. iniae*, *Lactococcus garvieae*, *Aerococcus viridans*)
Edwardsiellosis (*Edwardsiella anguillarum*, *E. ictaluri*, *E. piscicida*, *E. tarda*, *Yersinia ruckeri*)	**Renibacteriosis** (*Renibacterium salmoninarum*)
Pseudomonasis (*Pseudomonas anguilliseptica*, *P. fluorescens*)	**Infection with Anaerobic Bacteria** (*Clostridium botulinum*, *Enterobacterium catenabacterium*)
Flavobacteriosis (*Flavobacterium branchiophilum*, *F. columnare*, *F. psychrophilum*, *Tenacibaculum maritinum*)	
Infection with Intracellular Bacteria (*Piscirickettsia salmonis*, *Hepatobacter penaei*, *Francisella noatunensis*, *Chlamydia* spp.)	

TREATING BACTERIAL INFECTIONS

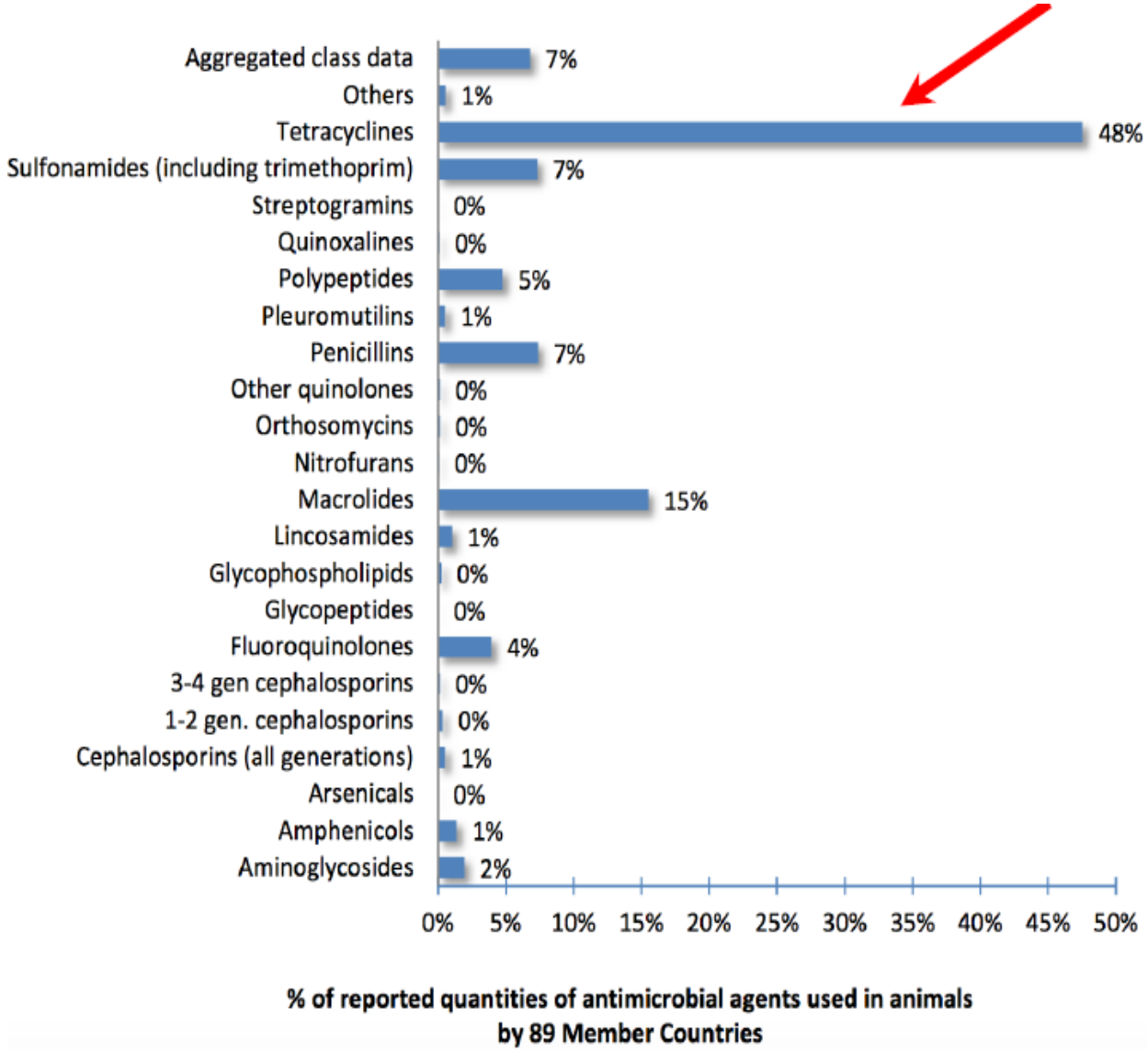
- Cultured fish swim in the equivalent of a bacterial suspension - have adequate natural defence mechanisms against bacterial infections
  - succumb to bacterial infections when stressed

- Identification and removal of the stressor is far more beneficial than antibiotics

- Antibiotics are provided:
  - In feed –but sick animals stop feeding
  - In water –feasible in fish tanks, but on large farms the flow rate washes antibiotic away
  - Bath – but catching the fish and immersing it in a bath of diluted antibiotic is stressful
  - Valuable specimens may be injected

COMMONLY USED ANTIMICROBIALS

- **Erythromycin** (macrolide) – shrimp hatcheries in Asia
- **Florfenicol** (Phenicols)
- **Rifampicin** - shrimp hatcheries in Southeast Asia
- **Sulphonamides** – Romet-30, Tribrissen, cotrimoxazole
- **Tetracyclines** – most widely used broad-spectrum antibiotic in aquaculture – treatment and prevention



% of reported quantities of antimicrobial agents used in animals by 89 Member Countries

SA AQUACULTURE ANTIMICROBIAL USE

- Some antibiotics that are available to public – sold over the counter – purchased and administered by farmers predominantly (Act 36)
- Others available via prescription from a veterinarian (Act 101)
- Abalone aquaculture – minimal antibiotic use – fed on kelp with innate antimicrobial compounds
- Trout farms – strict quarantine measures for imported trout eggs and farmer cooperation
- Ornamentals – imported from Far East predominantly – carry resistant bacteria and arrive stressed and susceptible to infection
  - Small amounts of antibiotics used

WHY ANTIMICROBIAL USE IN AQUACULTURE???

- Improved on-farm biosecurity (disinfectants, heavy metal compounds, vaccines)
- Treatment of chronic diseases resulting in reduced growth, low food conversion rates and poor survival which lead to reduced production
- Treatment of epizootic diseases causing mass mortalities
- Cultured fish often stressed – develop depressed immune systems and compromised non-specific barriers which enhance susceptibility to disease – only resolved by antimicrobial use
- Restricts geographical spread of emerging and re-emerging transboundary aquatic pathogens
- Aquaculture technologies (e.g., recirculating), high stocking densities, elevated growing temperatures, disinfectant and antimicrobial usage – affect interactions between fish host, its commensals and pathogens – diseases require rapid treatment with antimicrobials

ANTIMICROBIAL RESISTANCE IN AQUACULTURE

- AMR – global studies in aquaculture from early 1990s
  - Diversity of fish pathogens, fish commensal bacteria, food-associated pathogens – reported and assessed for antimicrobial susceptibility

- *Aeromonas* and *Vibrio* among the most studied

- Diverse resistance profiles and carry plasmids, transposons, integrons, resistance gene cassettes
  - Potential for spread – horizontal gene transfer

- Presence of resistant bacteria and resistance genes - does not imply misuse of AMR in aquaculture since AR genes predate introduction of antibiotics
  - Source of the resistance genes????

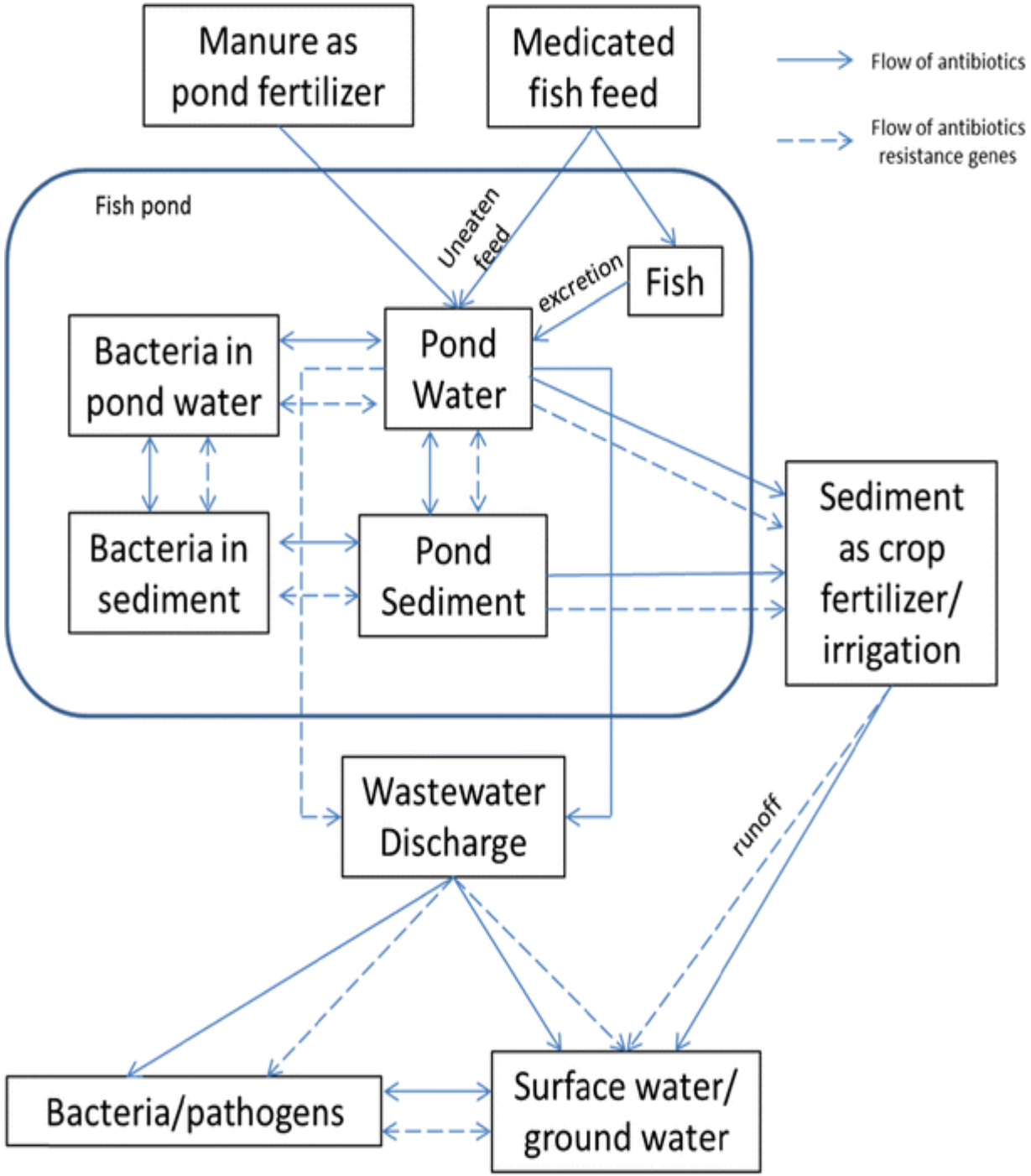
- Access to antimicrobials – overuse and misuse – only for use in confirmed bacterial infections based on diagnoss
  - Self-medication
  - Sub-standard medication

- Use of unapproved drugs in feed without compliance to good veterinary or food hygiene practices

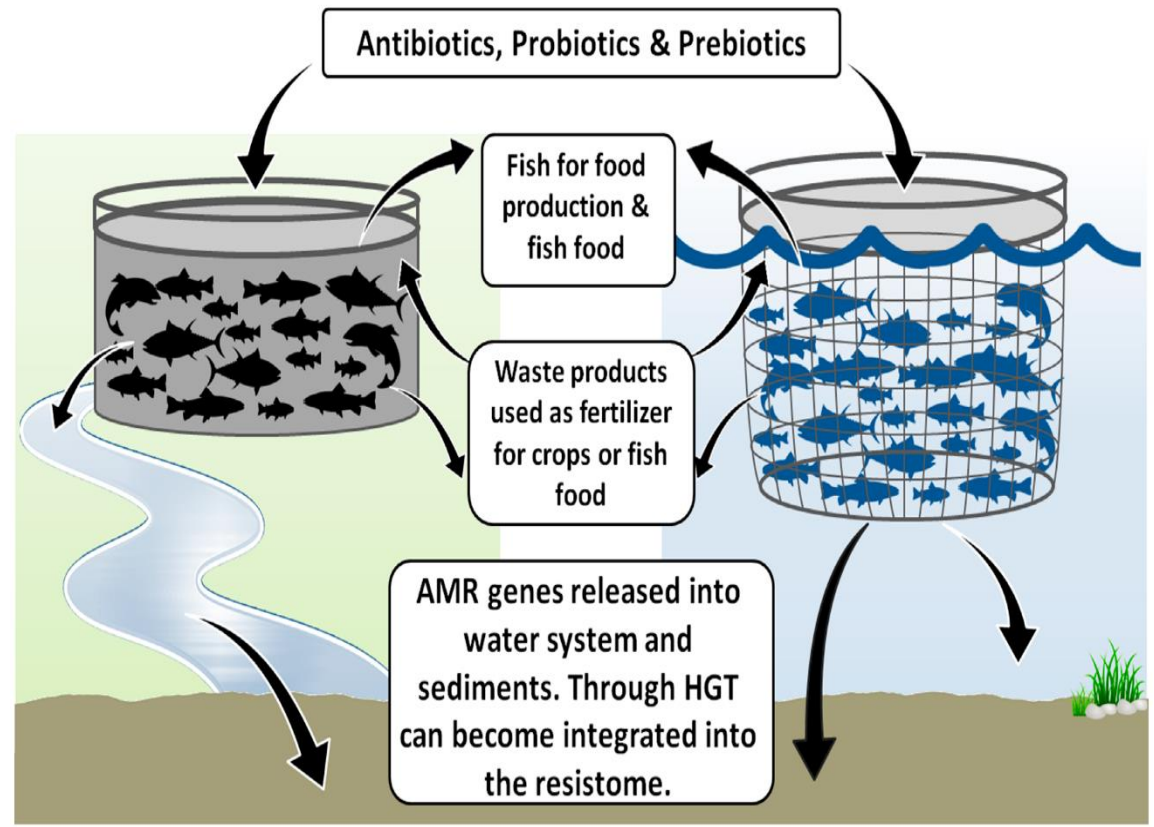
- Use of antibiotics as growth promoters

- Release of antimicrobials into aquatic environment through leaching from unconsumed feeds, release of effluent water from aquaculture facilities and presence of residues in faecal material
  - Accumulation in sediment, effects on natural biota and development of AR in aquatic bacteria
  - Fate?
  - Persistence?

- Residues in fish – food safety


Manure as pond fertilizer
Medicated fish feed
Flow of antibiotics
Flow of antibiotics resistance genes
Fish pond
Uneaten feed
excretion
Fish
Bacteria in pond water
Pond Water
Bacteria in sediment
Pond Sediment
Sediment as crop fertilizer/ irrigation
Wastewater Discharge
runoff
Bacteria/pathogens
Surface water/ ground water


31/05/2018 14:28


Antibiotics, Probiotics & Prebiotics
Fish for food production & fish food
Waste products used as fertilizer for crops or fish food
AMR genes released into water system and sediments. Through HGT can become integrated into the resistome.

Hounmanou *et al. BMC Res Notes (2016) 9:466*
DOI 10.1186/s13104-016-2283-0

BMC Research Notes

RESEARCH ARTICLE Open Access

Toxigenic *Vibrio cholerae* O1 in vegetables and fish raised in wastewater irrigated fields and stabilization ponds during a non-cholera outbreak period in Morogoro, Tanzania: an environmental health study

Yaovi M. G. Hounmanou[1,2*], Robinson H. Mdegela[1], Tamègnon V. Dougnon[2], Ofred J. Mhongole[1], Edward S. Mayila[3], Joseph Malakalinga[1], George Makingi[1] and Anders Dalsgaard[4]

Hindawi
International Journal of Microbiology
Volume 2019, Article ID 8759636, 7 pages
https://doi.org/10.1155/2019/8759636

Received: 20 April 2018 | Revised: 15 July 2018 | Accepted: 1 August 2018
DOI: 10.1002/mbo3.716

ORIGINAL ARTICLE

WILEY MicrobiologyOpen Open Access

Microbial effects of livestock manure fertilization on freshwater aquaculture ponds rearing tilapia (*Oreochromis shiranus*) and North African catfish (*Clarias gariepinus*)

Jeremiah J. Minich[1] | Qiyun Zhu[2] | Zhenjiang Zech Xu[2] | Amnon Amir[2] | Maxon Ngochera[3] | Moses Simwaka[5] | Eric E. Allen[1,4] | Hastings Zidana[5] | Rob Knight[2,4,6]

Onderstepoort Journal of Veterinary Research
ISSN: (Online) 2219-0635, (Print) 0030-2465

AOSIS

Research Article

Antimicrobial Profiling of Bacteria Isolated from Fish Sold at Informal Market in Mufakose, Zimbabwe

Journal of Fish Diseases 2011, 34, 483–487 doi:10.1111/j.1365-2761.2011.01259.x

Short Communication

Pathogenic Gram-positive cocci in South African rainbow trout, *Oncorhynchus mykiss* (Walbaum)

A Bekker, C Hugo, J Albertyn, C E Boucher and R R Bragg

Department of Microbial, Biochemical and Food Biotechnology, University of the Free State, Bloemfontein, South Africa

Detection of virulence factors of South African *Lactococcus garvieae* isolated from rainbow trout, *Oncorhynchus mykiss* (Walbaum)

Onderstepoort J. vet. Res., 57, 101–102 (1990)

MYCOBACTERIUM FORTUITUM ISOLATED FROM THREE SPECIES OF FISH IN SOUTH AFRICA

R. R. BRAGG, HILDEGARD F. A. K. HUCHZERMEYER and MONICA A. M. HANISCH, Veterinary Research Institute, Onderstepoort 0110

International Journal of
Environmental Research and Public Health

MICROBIAL DRUG RESISTANCE
Volume 00, Number 00, 2018

DOI: 10.1089/mdr.2017.0276

Article

Occurrence of Virulence Genes Associated with Human Pathogenic Vibrios Isolated from Two Commercial Dusky Kob (*Argyrosmus japonicus*) Farms and Kareiga Estuary in the Eastern Cape Province, South Africa

Justine Fri [1,*], Roland Ndip Ndip [1,2], Henry Akum Njom [1] and Anna Maria Clarke [1]

Available online at www.sciencedirect.com
ScienceDirect
International Journal of Food Microbiology 114 (2007) 295–306
INTERNATIONAL JOURNAL OF Food Microbiology
www.elsevier.com/locate/ijfoodmicro

Antibiotic Susceptibility of Non-Cholera Vibrios Isolated from Farmed and Wild Marine Fish (*Argyrosomus japonicus*), Implications for Public Health

Justine Fri,[1] Roland Ndip Ndip,[2] Henry Akum Njom,[1] and Anna Maria Clarke[1]

International Journal of Food Microbiology 231 (2016) 26–32
Contents lists available at ScienceDirect
International Journal of Food Microbiology
journal homepage: www.elsevier.com/locate/ijfoodmicro

Characterization of integrons and tetracycline resistance determinants in *Aeromonas* spp. isolated from South African aquaculture systems

Liezl Jacobs, Hafizah Y. Chenia *

Department of Microbiology, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa

African Journal of Microbiology Research Vol. 6(39), pp. 6761-6768, 11 October, 2012
Available online at http://www.academicjournals.org/ajmr
DOI: 10.5897/AJMR10.840
ISSN 1996-0808 ©2012 Academic Journals

Prevalence and characterization of plasmid-mediated quinolone resistance genes in *Aeromonas* spp. isolated from South African freshwater fish

Hafizah Yousuf Chenia

Vol. 126: 199–209, 2017
https://doi.org/10.3354/dao03173
DISEASES OF AQUATIC ORGANISMS
Dis Aquat Org
Published November 21

Full Length Research Paper

Tetracycline resistance determinants of heterotrophic bacteria isolated from a South African tilapia aquaculture system

H. Y. Chenia[1]* and C. Vietze[2]

[1]Department of Microbiology School of Life Sciences, University of KwaZulu-Natal, Westville Campus, Private Bag X54001, KwaZulu-Natal, 4001, South Africa.
[2]Department of Microbiology, University of Stellenbosch, Private Bag X1, Matieland, 7602, South Africa.

Antimicrobial resistance, heavy metal resistance and integron content in bacteria isolated from a South African tilapia aquaculture system

Hafizah Y. Chenia[1,*], Anelet Jacobs[2]

[1]Microbiology, School of Life Sciences, University of KwaZulu-Natal, Private Bag X54001, Durban 4001, South Africa
[2]Department of Microbiology, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa

ELSEVIER

INSTITUT PASTEUR

Research in Microbiology 158 (2007) 18–30

www.elsevier.com/locate/resmic

Phenotypic and molecular characterisation of fish-borne *Flavobacterium johnsoniae*-like isolates from aquaculture systems in South Africa

Leonard Flemming, Douglas Rawlings, Hafizah Chenia*

Department of Microbiology, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa

Vol. 7(20), pp. 2385-2394, 14 May, 2013
DOI: 10.5897/AJMR2013.5424
ISSN 1996-0808 ©2013 Academic Journals
http://www.academicjournals.org/AJMR

African Journal of Microbiology Research

Microbial Ecology

Evaluation of Adherence, Hydrophobicity, Aggregation, and Biofilm Development of *Flavobacterium johnsoniae*-Like Isolates

A. Basson, L. A. Flemming and H. Y. Chenia

Department of Microbiology, University of Stellenbosch, Private Bag X1, Matieland, 7602, South Africa

Journal of Fish Diseases 2017, **40**, 339–350 doi:10.1111/jfd.12516

Full Length Research Paper

Effect of physiochemical factors on autoaggregation and adhesion of *Flavobacterium johnsoniae*-like isolates

Hafizah Yousuf Chenia* and Nicholas Chadwick

Discipline: Microbiology, School of Life Sciences, University of KwaZulu-Natal, Private Bag X54001, Durban, 4001, South Africa.

Jacobs and Chenia *Annals of Clinical Microbiology and Antimicrobials* 2011, **10**:16
http://www.ann-clinmicrob.com/content/10/1/16

ANNALS OF CLINICAL MICROBIOLOGY AND ANTIMICROBIALS

Characterization of virulence, cell surface characteristics and biofilm-forming ability of *Aeromonas* spp. isolates from fish and sea water

H Y Chenia and S Duma

Microbiology (Westville Campus), School of Life Sciences, University of KwaZulu-Natal, Durban, South Africa

Journal of Applied Microbiology

Journal of Applied Microbiology ISSN 1364-5072

RESEARCH **Open Access**

Biofilm formation and adherence characteristics of an *Elizabethkingia meningoseptica* isolate from *Oreochromis mossambicus*

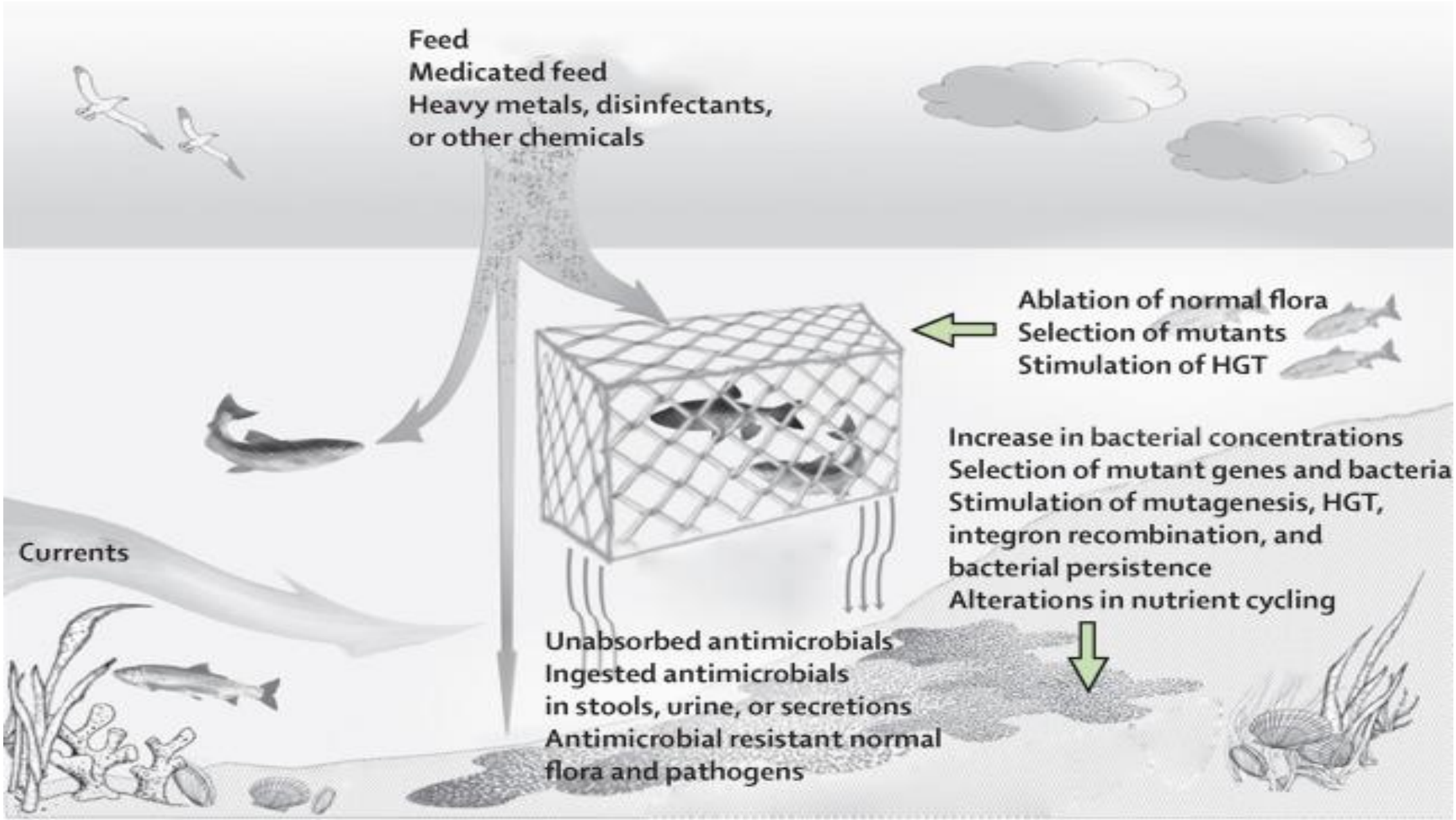
Anelet Jacobs[1] and Hafizah Y Chenia[2*]

ORIGINAL ARTICLE

Biofilm-forming capacity, surface hydrophobicity and aggregation characteristics of *Myroides odoratus* isolated from South African *Oreochromis mossambicus* fish

A. Jacobs[1] and H.Y. Chenia[2]

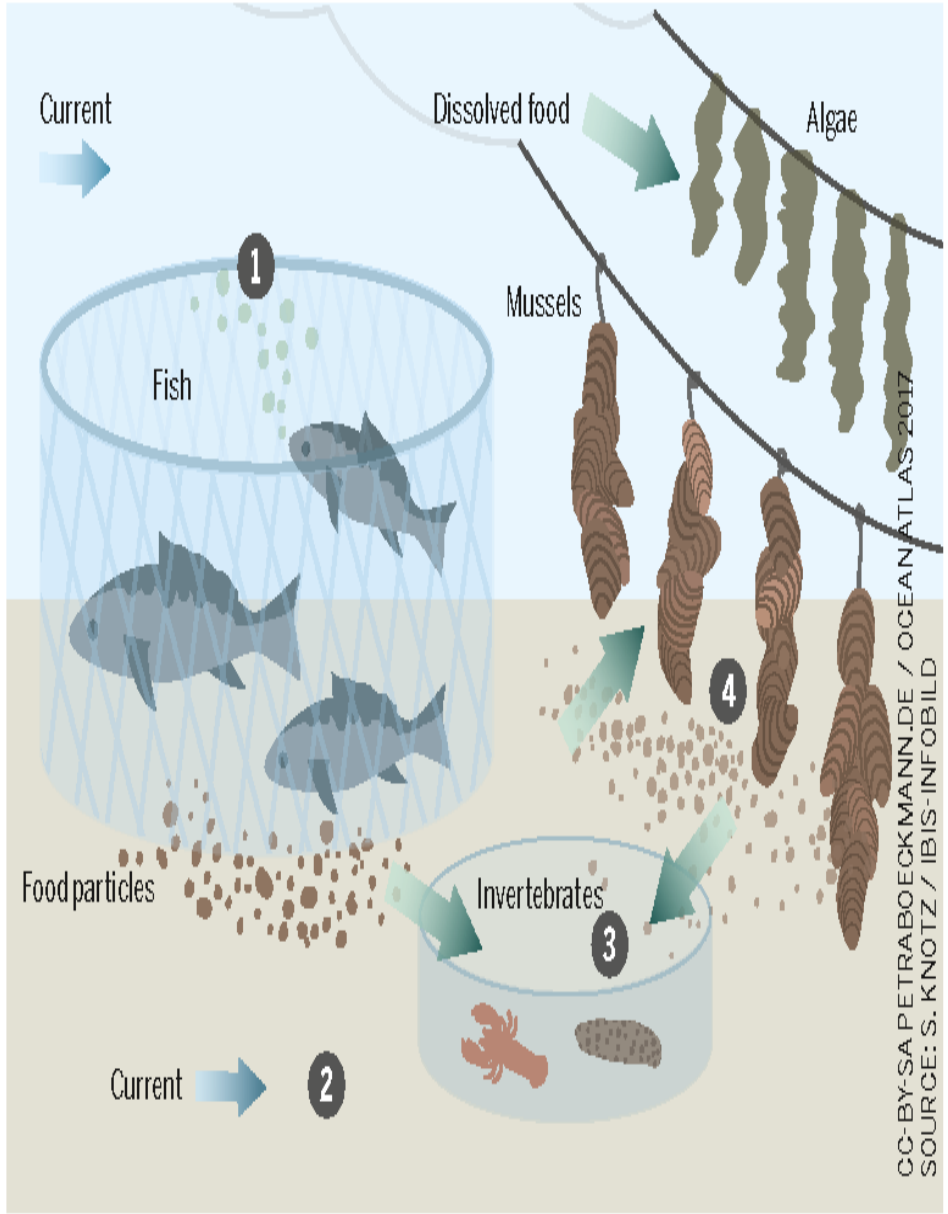
1 Department of Microbiology, University of Stellenbosch, Matieland, South Africa
2 Discipline: Microbiology; School of Biochemistry, Genetics, and Microbiology; University of KwaZulu-Natal, Durban, South Africa


Feed
Medicated feed
Heavy metals, disinfectants,
or other chemicals
Ablation of normal flora
Selection of mutants
Stimulation of HGT
Increase in bacterial concentrations
Selection of mutant genes and bacteria
Stimulation of mutagenesis, HGT,
integron recombination, and
bacterial persistence
Alterations in nutrient cycling
Currents
Unabsorbed antimicrobials
Ingested antimicrobials
in stools, urine, or secretions
Antimicrobial resistant normal
flora and pathogens
Microbial communities: eg, planktonic, biofilms, or bacteriophages

Alternatives to Antimicrobials???

- Prudent antimicrobial use
- Biosecurity on farms
- Increased farm hygiene – feed and pond water management
- Increased hygiene during food processing
- Residue monitoring
- Immunostimulants
- Antimicrobial peptides

Another Way—Aquaculture as a Closed Nutrition Cycle

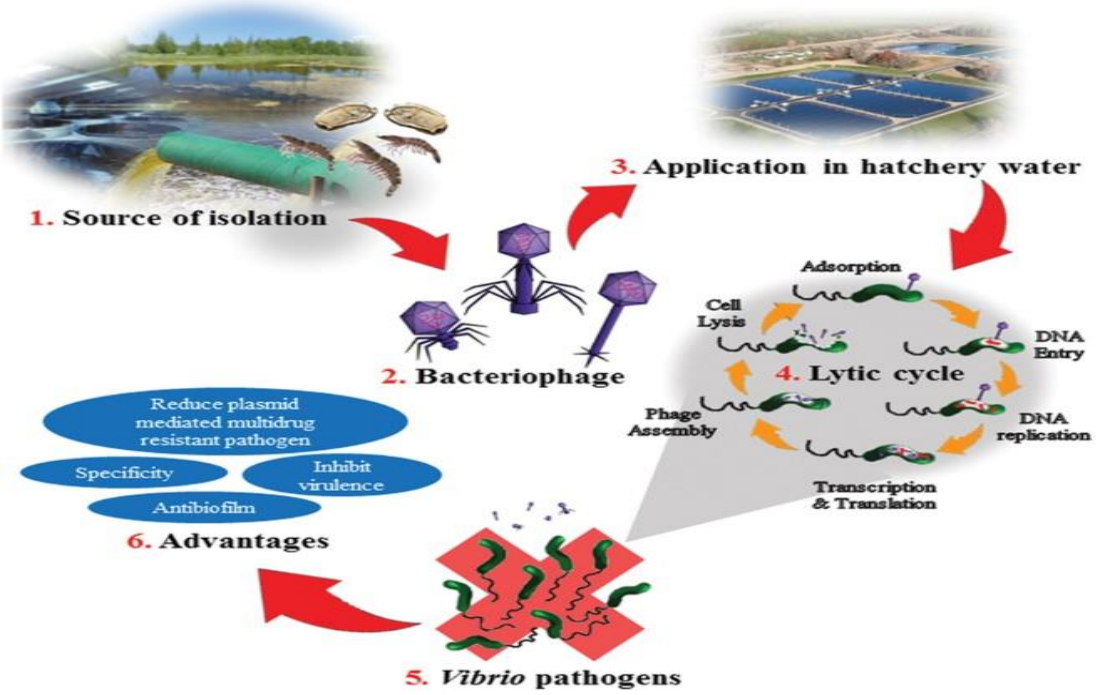


If farmed fish are kept in nets or cages and actively fed ❶*, their excretions normally cause the environment to become overfertilized (eutrophication). The exception: when other organisms on lower levels of the food chain are kept downstream* ❷*. Shrimp, crabs, or sea cucumbers kept in cages* ❸ *eat particles that sink to the bottom. Mussels* ❹ *filter smaller particles out. Their excretions are metabolized by the algae and invertebrates.*

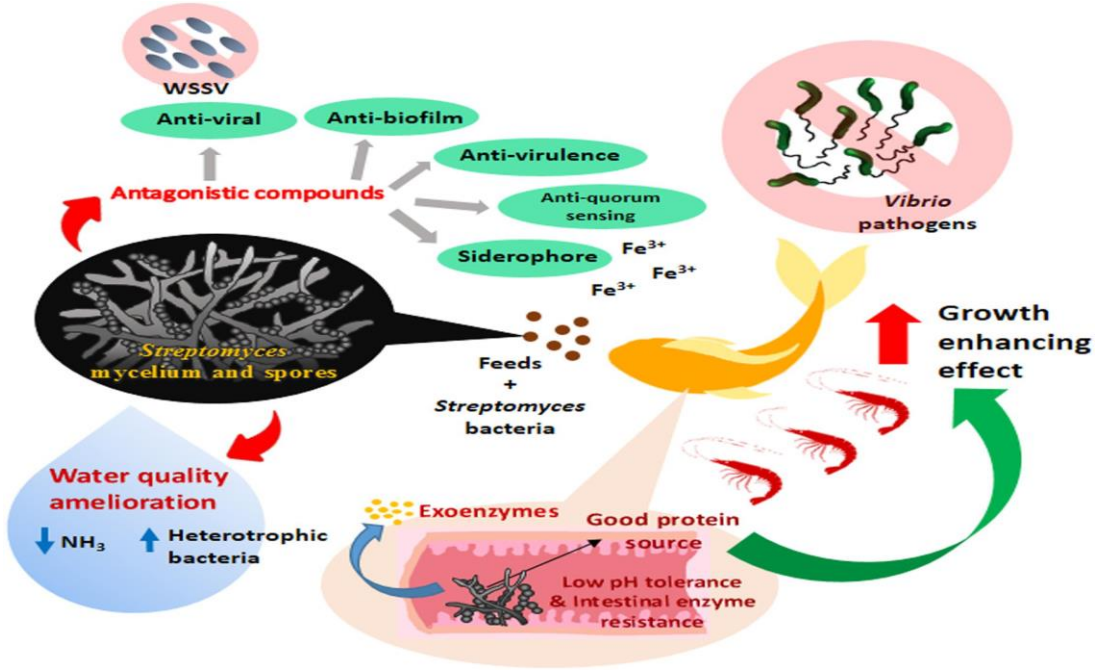
Unlike conventional fish farming, so-called integrated multitrophic aquaculture is an environmentally friendly approach that actually takes the surrounding ecosystem into account.

However, it represents only a marginal share of global aquaculture, and the use of fish oil and fishmeal remains problematic.

- **Bacteriophages** – phage therapy



- **Probiotics** –
  - *Bacillus*
  - lactic acid bacteria
  - *Streptomyces*



Plant extracts - medicinal plants

Vol. 7(29), pp. 2054-2064, 8 August, 2013
DOI 10.5897/AJPP12.1390
ISSN 1996-0816 © 2013 Academic Journals
http://www.academicjournals.org/AJPP

African Journal of Pharmacy and Pharmacology

Full Length Research Paper

Susceptibility of fish-associated *Flavobacterium* spp. isolates to cinnamaldehyde, vanillin and *Kigelia africana* fruit extracts

Hafizah Y. Chenia* and Sarisha Singh

Microbiology (Westville Campus), School of Life Sciences, University of KwaZulu-Natal, Private Bag X54001, KwaZulu-Natal, 4001, South Africa

Chenia et al., Afr J Tradit Complement Altern Med. (2015) 12(3):55-67
http://dx.doi.org/10.4314/ajtcam.v12i3.7

ANTIMICROBIAL ACTIVITY OF CINNAMALDEHYDE, VANILLIN AND *KIGELIA AFRICANA* FRUIT EXTRACTS AGAINST FISH-ASSOCIATED *CHRYSEOBACTERIUM* AND *MYROIDES* SPP. ISOLATES

Hafizah Yousuf Chenia*

Discipline: Microbiology (Westville Campus), School of Life Sciences, University of KwaZulu-Natal, Private Bag X54001, KwaZulu-Natal, 4001, South Africa

Journal of Applied Microbiology

Journal of Applied Microbiology ISSN 1364-5072

ORIGINAL ARTICLE

Antimicrobial activity of *trans*-cinnamic acid and commonly used antibiotics against important fish pathogens and nonpathogenic isolates

S. Yilmaz[1], M. Sova[2] and S. Ergün[1]

1 Department of Aquaculture, Faculty of Marine Sciences and Technology, Çanakkale Onsekiz Mart University, Çanakkale, Turkey
2 Faculty of Pharmacy, University of Ljubljana, Ljubljana, Slovenia

Aquacult Int (2018) 26:289–308
https://doi.org/10.1007/s10499-017-0219-x

CrossMark

Beneficial effects of medicinal plants in fish diseases

Deyan Stratev[1] · Georgi Zhelyazkov[2] · Xavier Siwe Noundou[3] · Rui W. M. Krause[3]

JOURNAL OF THE WORLD AQUACULTURE SOCIETY

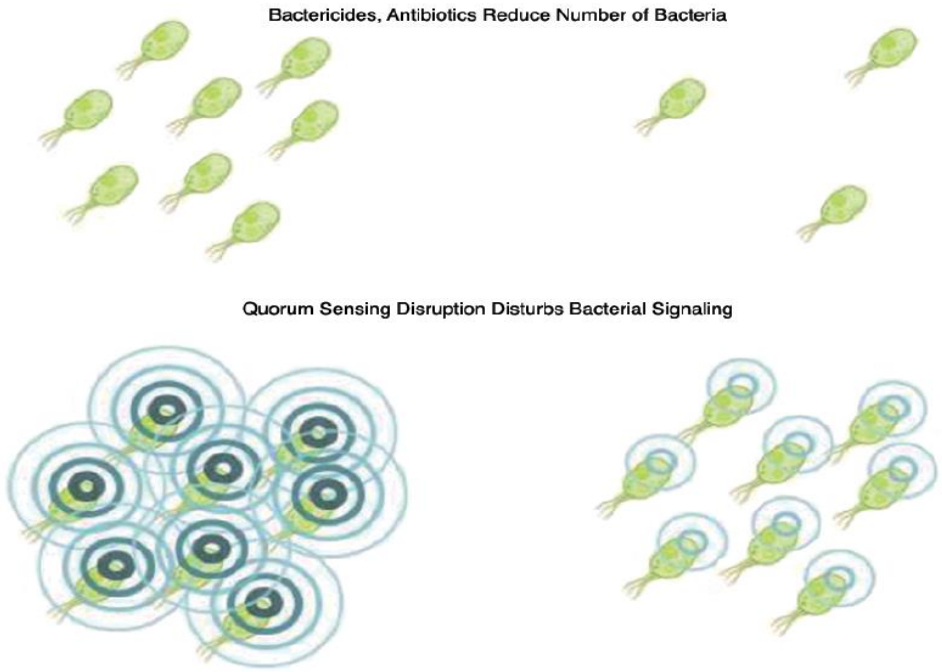
Vol. 44, No. 4
August, 2013

Assessment of Aquatic *Aeromonas* spp. Isolates' Susceptibility to Cinnamaldehyde, Vanillin, and Crude *Kigelia africana* Fruit Extracts

CHINENYE OKOLIE, HAFIZAH Y. CHENIA[1]

Department of Microbiology (Westville Campus), School of Life Sciences, University of KwaZulu-Natal, Private Bag X54001, KwaZulu-Natal, 4001, South Africa

- **Quorum sensing inhibition** – bacteria, plant extracts



Journal of Aquatic Animal Health 27:112–122, 2015

ISSN: 0899-7659 print / 1548-8667 online
DOI: 10.1080/08997659.2014.1001534

ARTICLE

Growth Inhibition of Bacterial Fish Pathogens and Quorum-Sensing Blocking by Bacteria Recovered from Chilean Salmonid Farms

Mery de la Fuente
Laboratorio de Biotecnología e Ingeniería Acuícola, Departamento de Ingeniería Ambiental y Recursos Naturales, Facultad de Ingeniería, Universidad Católica de la Santísima Concepción, Alonso de Ribera 2850, Concepción, Chile; and Departamento de Ciencias Biológicas y Químicas, Facultad de Ciencias, Universidad San Sebastián, Concepción, Chile

Claudio D. Miranda*

Feed additives based on quorum sensing disruption could aid fight against EMS

Wednesday, 1 January 2014

By Peter Coutteau, Ph.D. and Tim Goossens, Ph.D.

Compounds active in QS disruption may be alternatives to antibiotics due to efficacy at low concentrations

THANK YOU