

Benedito Rodrigues da Silva Neto  
(Organizador)

# Pesquisa Científica e Tecnológica em Microbiologia



Benedito Rodrigues da Silva Neto  
(Organizador)

# Pesquisa Científica e Tecnológica em Microbiologia



2019 by Atena Editora  
Copyright © Atena Editora  
Copyright do Texto © 2019 Os Autores  
Copyright da Edição © 2019 Atena Editora  
Editora Chefe: Profª Drª Antonella Carvalho de Oliveira  
Diagramação: Lorena Prestes  
Edição de Arte: Lorena Prestes  
Revisão: Os Autores



Todo o conteúdo deste livro está licenciado sob uma Licença de Atribuição Creative Commons. Atribuição 4.0 Internacional (CC BY 4.0).

O conteúdo dos artigos e seus dados em sua forma, correção e confiabilidade são de responsabilidade exclusiva dos autores. Permitido o download da obra e o compartilhamento desde que sejam atribuídos créditos aos autores, mas sem a possibilidade de alterá-la de nenhuma forma ou utilizá-la para fins comerciais.

### **Conselho Editorial**

#### **Ciências Humanas e Sociais Aplicadas**

Profª Drª Adriana Demite Stephani – Universidade Federal do Tocantins  
Prof. Dr. Álvaro Augusto de Borba Barreto – Universidade Federal de Pelotas  
Prof. Dr. Alexandre Jose Schumacher – Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso  
Prof. Dr. Antonio Carlos Frasson – Universidade Tecnológica Federal do Paraná  
Prof. Dr. Antonio Gasparetto Júnior – Instituto Federal do Sudeste de Minas Gerais  
Prof. Dr. Antonio Isidro-Filho – Universidade de Brasília  
Prof. Dr. Constantino Ribeiro de Oliveira Junior – Universidade Estadual de Ponta Grossa  
Profª Drª Cristina Gaio – Universidade de Lisboa  
Prof. Dr. Deyvison de Lima Oliveira – Universidade Federal de Rondônia  
Prof. Dr. Edvaldo Antunes de Faria – Universidade Estácio de Sá  
Prof. Dr. Eloi Martins Senhora – Universidade Federal de Roraima  
Prof. Dr. Fabiano Tadeu Grazioli – Universidade Regional Integrada do Alto Uruguai e das Missões  
Prof. Dr. Gilmei Fleck – Universidade Estadual do Oeste do Paraná  
Profª Drª Ivone Goulart Lopes – Istituto Internazionele delle Figlie de Maria Ausiliatrice  
Prof. Dr. Julio Candido de Meirelles Junior – Universidade Federal Fluminense  
Profª Drª Keyla Christina Almeida Portela – Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso  
Profª Drª Lina Maria Gonçalves – Universidade Federal do Tocantins  
Profª Drª Natiéli Piovesan – Instituto Federal do Rio Grande do Norte  
Prof. Dr. Marcelo Pereira da Silva – Universidade Federal do Maranhão  
Profª Drª Miranilde Oliveira Neves – Instituto de Educação, Ciência e Tecnologia do Pará  
Profª Drª Paola Andressa Scortegagna – Universidade Estadual de Ponta Grossa  
Profª Drª Rita de Cássia da Silva Oliveira – Universidade Estadual de Ponta Grossa  
Profª Drª Sandra Regina Gardacho Pietrobom – Universidade Estadual do Centro-Oeste  
Profª Drª Sheila Marta Carregosa Rocha – Universidade do Estado da Bahia  
Prof. Dr. Rui Maia Diamantino – Universidade Salvador  
Prof. Dr. Urandi João Rodrigues Junior – Universidade Federal do Oeste do Pará  
Profª Drª Vanessa Bordin Viera – Universidade Federal de Campina Grande  
Prof. Dr. Willian Douglas Guilherme – Universidade Federal do Tocantins

#### **Ciências Agrárias e Multidisciplinar**

Prof. Dr. Alexandre Igor Azevedo Pereira – Instituto Federal Goiano  
Prof. Dr. Antonio Pasqualetto – Pontifícia Universidade Católica de Goiás  
Profª Drª Daiane Garabeli Trojan – Universidade Norte do Paraná  
Profª Drª Diocléa Almeida Seabra Silva – Universidade Federal Rural da Amazônia  
Prof. Dr. Écio Souza Diniz – Universidade Federal de Viçosa  
Prof. Dr. Fábio Steiner – Universidade Estadual de Mato Grosso do Sul  
Profª Drª Girlene Santos de Souza – Universidade Federal do Recôncavo da Bahia  
Prof. Dr. Jorge González Aguilera – Universidade Federal de Mato Grosso do Sul  
Prof. Dr. Júlio César Ribeiro – Universidade Federal Rural do Rio de Janeiro  
Profª Drª Raissa Rachel Salustriano da Silva Matos – Universidade Federal do Maranhão  
Prof. Dr. Ronilson Freitas de Souza – Universidade do Estado do Pará  
Prof. Dr. Valdemar Antonio Paffaro Junior – Universidade Federal de Alfenas

### **Ciências Biológicas e da Saúde**

Prof. Dr. Benedito Rodrigues da Silva Neto – Universidade Federal de Goiás  
Prof. Dr. Edson da Silva – Universidade Federal dos Vales do Jequitinhonha e Mucuri  
Profª Drª Elane Schwinden Prudêncio – Universidade Federal de Santa Catarina  
Prof. Dr. Gianfábio Pimentel Franco – Universidade Federal de Santa Maria  
Prof. Dr. José Max Barbosa de Oliveira Junior – Universidade Federal do Oeste do Pará  
Profª Drª Magnólia de Araújo Campos – Universidade Federal de Campina Grande  
Profª Drª Natiéli Piovesan – Instituto Federal do Rio Grande do Norte  
Profª Drª Vanessa Lima Gonçalves – Universidade Estadual de Ponta Grossa  
Profª Drª Vanessa Bordin Viera – Universidade Federal de Campina Grande

### **Ciências Exatas e da Terra e Engenharias**

Prof. Dr. Adélio Alcino Sampaio Castro Machado – Universidade do Porto  
Prof. Dr. Alexandre Leite dos Santos Silva – Universidade Federal do Piauí  
Profª Drª Carmen Lúcia Voigt – Universidade Norte do Paraná  
Prof. Dr. Eloi Rufato Junior – Universidade Tecnológica Federal do Paraná  
Prof. Dr. Fabrício Menezes Ramos – Instituto Federal do Pará  
Prof. Dr. Juliano Carlo Rufino de Freitas – Universidade Federal de Campina Grande  
Profª Drª Neiva Maria de Almeida – Universidade Federal da Paraíba  
Profª Drª Natiéli Piovesan – Instituto Federal do Rio Grande do Norte  
Prof. Dr. Takeshy Tachizawa – Faculdade de Campo Limpo Paulista

<b>Dados Internacionais de Catalogação na Publicação (CIP) (eDOC BRASIL, Belo Horizonte/MG)</b>	
P474	<p>Pesquisa científica e tecnológica em microbiologia [recurso eletrônico] / Organizador Benedito Rodrigues da Silva Neto. – Ponta Grossa, PR: Atena Editora, 2019.</p> <p>Formato: PDF Requisitos de sistema: Adobe Acrobat Reader Modo de acesso: World Wide Web Inclui bibliografia ISBN 978-85-7247-772-7 DOI 10.22533/at.ed.727191111</p> <p>1. Microbiologia – Pesquisa – Brasil. I. Silva Neto, Benedito Rodrigues da.</p> <p style="text-align: right;">CDD 579</p>
<b>Elaborado por Maurício Amormino Júnior – CRB6/2422</b>	

Atena Editora  
Ponta Grossa – Paraná - Brasil  
[www.atenaeditora.com.br](http://www.atenaeditora.com.br)  
contato@atenaeditora.com.br

## APRESENTAÇÃO

A microbiologia é um vasto campo que inclui o estudo dos seres vivos microscópicos nos seus mais variados aspectos como morfologia, estrutura, fisiologia, reprodução, genética, taxonomia, interação com outros organismos e com o ambiente além de aplicações biotecnológicas. Como uma ciência básica a microbiologia utiliza células microbianas para analisar os processos fundamentais da vida, e como ciência aplicada ela é praticamente a linha de frente de avanços importantes na medicina, agricultura e na indústria.

De forma integrada e colaborativa a nossa proposta apoiada e certificada pela editora Atena é apresentar aqui a obra “Pesquisa científica e tecnológica em microbiologia” contendo trabalhos e pesquisas desenvolvidas em diversos institutos do território nacional contendo análises de processos biológicos embasados em células microbianas ou estudos científicos na fundamentação de atividades microbianas com capacidade de interferir nos processos de saúde/doença.

A microbiologia como ciência iniciou a cerca de 200 anos, entretanto os avanços na área molecular como a descoberta do DNA elevou a um novo nível os estudos desses seres microscópicos, além de abrir novas frentes de pesquisa e estudo, algumas das quais pretendemos demonstrar nesse primeiro volume da obra “Pesquisa científica e tecnológica em microbiologia”. Sabemos na atualidade que os microrganismos são encontrados em praticamente todos os lugares, e a falta de conhecimento que havia antes da invenção do microscópio hoje não é mais um problema no estudo, principalmente das enfermidades relacionadas aos agentes como bactérias, vírus, fungos e protozoários.

Acreditamos no potencial dessa obra em primeiro lugar pela qualidade dos trabalhos aqui apresentados, e em segundo pelo campo em potencial para futuras novas discussões, haja vista que enfrentamos a questão da resistência dos microrganismos à drogas, identificação de viroses emergentes, ou reemergentes, desenvolvimento de vacinas e principalmente a potencialização do desenvolvimento tecnológico no estudo e aplicações de microrganismos de interesse.

Temas ligados à pesquisa e tecnologia microbiana são, deste modo, discutidos aqui com a proposta de fundamentar o conhecimento de acadêmicos, mestres e todos aqueles que de alguma forma se interessam pela saúde em seus aspectos microbiológicos. Portanto a obra propõe uma teoria bem fundamentada nos resultados práticos obtidos em alguns campos da microbiologia, abrindo perspectivas futuras para os demais pesquisadores de outras subáreas da microbiologia.

Assim desejo a todos uma ótima leitura!

Benedito Rodrigues da Silva Neto

## SUMÁRIO

<b>CAPÍTULO 1</b> .....	<b>1</b>
ANÁLISE DA CONTAMINAÇÃO MICROBIOLÓGICA DE MÁQUINAS E FERRAMENTAS PRESENTES EM UM LABORATÓRIO DE MECÂNICA	
Francisco Angelo Gurgel da Rocha Priscylla Cinthya Alves Gondim Liane Raquel Alves dos Santos Vitoria Fernandes Cabral Dantas	
<b>DOI 10.22533/at.ed.7271911111</b>	
<b>CAPÍTULO 2</b> .....	<b>14</b>
ANALISE DO EFEITO ANTIMICROBIANO DO EXTRATO AQUOSO DO ALHO ( <i>Allium sativum</i> L.) SOBRE O CRESCIMENTO DAS BACTÉRIAS <i>Staphylococcus aureus</i> E <i>Escherichia coli</i>	
Karine Ferreira Lopes Dayane Nair Rocha de Souza Débora Luiz de Barros Estefânia Isabel Pereira Ana Paula Gonçalves Coelho Glaysen Martins de Oliveira Suzanne Ramos Mota Andrea Amélia Silva Vieira	
<b>DOI 10.22533/at.ed.7271911112</b>	
<b>CAPÍTULO 3</b> .....	<b>22</b>
CAMUNDONGOS BALB/C INFECTADOS COM A CEPA 66985 DO VÍRUS DA DENGUE PELA VIA INTRAVENOSA EXIBE DANO NO SISTEMA NERVOSO CENTRAL	
Natália Gedeão Salomão Kíssila Rabelo Tiago Fajardo Póvoa Ada Maria de Barcelos Alves Simone Morais da Costa Antonio José da Silva Gonçalves Juliana Fernandes Amorim da Silva Adriana de Souza Azevedo Priscilla Conrado Guerra Nunes Carlos Alberto Basílio-de-Oliveira Rodrigo Panno Basílio-de-Oliveira Luiz Henrique Medeiros Geraldo Celina Garcia Fonseca Flávia Regina Souza Lima Ronaldo Mohana-Borges Emiliana Mandarano Silva Flávia Barreto dos Santos Edson Roberto Alves Oliveira Marciano Viana Paes	
<b>DOI 10.22533/at.ed.7271911113</b>	
<b>CAPÍTULO 4</b> .....	<b>44</b>
CARACTERIZAÇÃO DE UM PEPTÍDEO ANTAGONISTA PRODUZIDO POR <i>Bacteroides fragilis</i> ISOLADO DE PÁCIENTE COM INFECÇÃO INTRA-ABDOMINAL	
Marcela Nascimento Pinheiro Braga Natália Rocha Guimarães Jamil Silvano Oliveira Simone Gonçalves dos Santos	

Marcelo Porto Bemquerer  
Paula Prazeres Magalhães  
Luiz de Macêdo Farias

**DOI 10.22533/at.ed.7271911114**

**CAPÍTULO 5 ..... 55**

DESENHO VACINAL PARA O ZIKA VÍRUS COM O USO DA IMUNOINFORMÁTICA

Esther Santos Santana  
Fabiano Ricardo Fontes Santos  
Daniela Droppa-Almeida

**DOI 10.22533/at.ed.7271911115**

**CAPÍTULO 6 ..... 68**

ANÁLISE EPIDEMIOLÓGICA DE CANDIDEMIA EM PACIENTES SUBMETIDOS À INTERNAÇÃO NO HOSPITAL DAS CLÍNICAS EM GOIÂNIA - GO

Lucas Daniel Quinteiro de Oliveira  
Maria do Rosário Rodrigues Silva  
Benedito Rodrigues da Silva Neto

**DOI 10.22533/at.ed.7271911116**

**CAPÍTULO 7 ..... 82**

*ENTEROCOCCUS* SP ISOLATED FROM AQUATIC ENVIRONMENT : RESISTANCE TO TOXIC METALS

Luciana Furlaneto-Maia  
Gabriela Batista Gomes Bravo  
Sharise Beatriz Roberto  
Naiara de Oliveira Batista  
Alex Kiyomassa Watanabe  
Márcia Cristina Furlaneto

**DOI 10.22533/at.ed.7271911117**

**CAPÍTULO 8 ..... 98**

ESTUDO DA COMUNIDADE LIQUÊNICA DA UEMG – IBIRITÉ: ANÁLISE MORFOLÓGICA E ECOLÓGICA COMO CARACTERIZAÇÃO DA POLUIÇÃO ATMOSFÉRICA

Letícia Maria Soares Azevedo  
Camila Mara dos Reis  
Daniela de Oliveira Costa  
Reisila Simone Migliorini Mendes  
Marisa Cristina da Fonseca Casteluber

**DOI 10.22533/at.ed.7271911118**

**CAPÍTULO 9 ..... 108**

*KLEBSIELLA PNEUMONIAE*: A NOVA AMEAÇA RESISTENTE

Luana Marcela Andrade de Santana  
Nathalia Santos Silva  
Karla Bárbara Calú Barreto  
Dayane dos Santos  
Daniel Guimarães Ribeiro  
Isana Carla Leal Souza

**DOI 10.22533/at.ed.7271911119**

**CAPÍTULO 10 ..... 112**

OCORRÊNCIA DE *FASCIOLA HEPATICA* NA REGIÃO DA CAMPANHA GAUCHA/RS

Brenda Luciana Alves da Silva  
Mikalele Simas Santos  
Marcele Ribeiro Corrêa  
Fernanda Lucero Rodrigues  
Gustavo Freitas Lopes  
Lourdes Caruccio Hirschmann  
Anelise Afonso Martins

**DOI 10.22533/at.ed.72719111110**

**CAPÍTULO 11 ..... 117**

PROPRIEDADES RELACIONADAS À SEGURANÇA MICROBIOLÓGICA DE LINHAGENS DE *Staphylococcus aureus* ISOLADAS DE QUEIJO ARTESANAL

Jéssica Lee de Freitas  
Bianca Aguiar Alves  
Celso Tadeu Barbosa dos Santos  
Alessandra Barbosa Ferreira-Machado  
Aline Dias Paiva

**DOI 10.22533/at.ed.72719111111**

**CAPÍTULO 12 ..... 126**

*Staphylococcus aureus*: UMA VISÃO GERAL DOS MECANISMOS DE VIRULÊNCIA E RESISTÊNCIA

Glauciane Vieira Damasceno  
Elane Rodrigues Oliveira  
Patrícia Vieira de Oliveira  
Bruno Luis Lima Soares  
Gabrielle Damasceno Evangelista Costa  
Adrielle Zagmignan  
Cristiane Santos Silva e Silva Figueiredo  
Rita de Cássia M. de Miranda  
Luís Cláudio Nascimento da Silva

**DOI 10.22533/at.ed.72719111112**

**CAPÍTULO 13 ..... 140**

ENTEROBACTÉRIAS PRODUTORAS DE BETA-LACTAMASE DE ESPECTRO AMPLIADO (ESBL) EM COPROCULTURA DE PACIENTES AMBULATORIAIS

Daniela Cristiane da Cruz Rocha  
Érica Kássia Sousa Vidal  
Karina Lúcia Silva da Silva  
Débora de Castro Costa  
Anderson Nonato do Rosario Marinho

**DOI 10.22533/at.ed.72719111113**

**CAPÍTULO 14 ..... 153**

PERFIL FENOTÍPICO E GENOTÍPICO DE UMA CEPA DE *Escherichia coli* MULTIRRESISTENTE A ANTIBIÓTICOS, ISOLADA DO LAGO ÁGUA PRETA, BELÉM, PARÁ

Ícaro Rainyer Rodrigues de Castro  
Jorianne Thyessa Castro Alves  
Alyne Cristina Sodré Lima  
Vitória Almeida Gonçalves de Moura  
Carla Thais Moreira Paixão  
Wana Lailan Oliveira da Costa  
Adriedson Jameson Chaves de Alcântara  
Carlos Leonardo de Aragão Araújo



Larissa Maranhão Dias  
Artur Luiz da Costa da Silva  
Adriana Ribeiro Carneiro Folador  
DOI 10.22533/at.ed.72719111114

**CAPÍTULO 15 ..... 168**

DESENVOLVIMENTO, PADRONIZAÇÃO E VALIDAÇÃO DE MÉTODO DE PCR EM TEMPO REAL PARA O DIAGNÓSTICO ESPECÍFICO DE *PSEUDOCOWPOXVIRUS* – PCPV EM BOVINOS

Érica Eustáquia de Freitas Passos  
Giliane de Souza Trindade  
Antônio Augusto Fonseca Júnior

DOI 10.22533/at.ed.72719111115

**CAPÍTULO 16 ..... 180**

VERIFICAÇÃO DA TEMPERATURA DE DISTRIBUIÇÃO DE REFEIÇÕES QUENTES OFERTADAS EM UMA INSTITUIÇÃO DE LONGA PERMANÊNCIA PARA IDOSOS E A CORRELAÇÃO COM O CRESCIMENTO MICROBIOLÓGICO

Eliane Costa Souza  
Déborah Maria Tenório Braga Cavalcante Pinto  
Ismaell Avelino de Sousa Sobrinho  
Andressa Lima dos Santos  
Julia Dayane de Miranda Vasconcelos Cardoso  
Mirelly Raylla dos Santos  
Mateus Oliveira Santana

DOI 10.22533/at.ed.72719111116

**CAPÍTULO 17 ..... 188**

A DIVERSIDADE DA CLASSIFICAÇÃO DE RNAS NÃO-CODIFICADORES EM BACTÉRIAS

Amanda Carvalho Garcia

DOI 10.22533/at.ed.72719111117

**CAPÍTULO 18 ..... 202**

AVALIAÇÃO DO POTENCIAL FERMENTATIVO DE LEVEDURAS ISOLADAS DE FRUTAS VISANDO A PRODUÇÃO DE ETANOL A PARTIR DE XILOSE

Rosimeire Oenning da Silva  
Sinésio de Novaes Junior  
Meirielen Nascimento Serpa  
Italo Andrey Souza Inácio Lima  
Raquel Aparecida Loss

DOI 10.22533/at.ed.72719111118

**SOBRE O ORGANIZADOR..... 214**

**ÍNDICE REMISSIVO ..... 215**

## ENTEROCOCCUS SP ISOLATED FROM AQUATIC ENVIRONMENT : RESISTANCE TO TOXIC METALS

### **Luciana Furlaneto-Maia**

Docente do Programa de Pós- Graduação em Engenharia Ambiental - Universidade Tecnológica Federal do Paraná Campus Londrina.

### **Gabriela Batista Gomes Bravo**

Discente Programa de Pós- Graduação em Engenharia Ambiental – Universidade Tecnológica Federal do Paraná Campus Campo Mourão.

### **Sharise Beatriz Roberto**

Discente Programa de Pós- Graduação em Engenharia Ambiental – Universidade Tecnológica Federal do Paraná Campus Campo Mourão.

### **Naiara de Oliveira Batista**

Discente Programa de Pós- Graduação em Engenharia Ambiental – Universidade Tecnológica Federal do Paraná Campus Campo Mourão.

### **Alex Kiyomassa Watanabe**

Discente Programa de Pós- Graduação em Engenharia Ambiental – Universidade Tecnológica Federal do Paraná Campus Campo Mourão.

### **Márcia Cristina Furlaneto**

Docente do Programa de Pós-graduação em Microbiologia – Universidade Estadual de Londrina.

**ABSTRACT:** Environmental pollution by toxic metals began due to the accelerated development of industrial activities through the irregular disposal of waste generated by activities such as mining, metallurgical processes, chemical industries, agriculture and also by

contaminated effluents. This pollution can affect human and other animal health through the accumulation of toxic metals in water, sediment and soil. Microorganism bioremediation stands out as a tool for the decontamination of toxic metal environments. The use of biosorption or bioaccumulating bacteria has gained much attention from researchers because of their potential to provide an effective and cost-effective means for the remediation of toxic metals. Therefore, the use of bacteria with proven remediation potential and survivability in the contaminated environment is of utmost importance for successful bioremediation. The objective of this project is to identify the biosorption capacity of toxic metals by bacteria of the genus *Enterococcus* sp isolated from the aquatic environment, by the analysis of toxic metal resistance by the Gradient Plate technique, following the maximum concentrations required by CONAMA Resolution 357/2005. The results showed that 93% of the isolates showed growth for zinc metal; 97.2% for copper and 98.6% for lead. These results reveal that the *Enterococcus* bacteria analyzed have resistance to the tested toxic metals characterizing a potential for bioremediation, considering that many bacteria found naturally in the environment may be closely related to the bioremediation process reducing the toxicity of the metals.

## INTRODUCTION

Bacteria of the genus *Enterococcus* are Gram-positive cocci that are arranged in pairs or short chains. They are facultative anaerobes and their growth can occur at different temperatures (10 to 45°C) and in high salt concentrations. They are often found in the gastrointestinal tract of humans in high concentrations in human and animal feces. They are opportunistic pathogens that cause thousands of infections, which pose great risks to human health. (AHMED et al, 2012; BOEHM, SASSOUBRE, 2014).

Kimiran-Erdem et al. (2006) described that a characteristic of these microorganisms is their resistance to physical and chemical stress, such as the presence of antibiotics and toxic metals, unlike other fecal bacteria that are found in the environment. Microorganisms have developed metal resistance and detoxification mechanisms for their survival due to the presence of toxic metals in the environment. Microbial resistance to metals can be divided into three categories: intrinsic resistance mechanisms (which do not require metal stress, resistance mechanisms that require metal stress, and resistance mechanisms that depend on the type of metal and its activation. Resistance determinants are encoded on the chromosome, but some can be encoded on mobile genetic elements such as plasmids and transposons (ROANE, et al., 2009).

Anthropogenic activities involving mining, improper waste disposal, effluents containing metals, application of pesticides and fertilizers in abundance, industries (metallurgical, batteries, chemicals, etc.) are the main causes of environmental pollution by toxic metals. Although metals are natural constituents of the earth and some of them are essential to the life of organisms, excess can have harmful effects on human health (Table 1) (KANG et al., 2016; KAR et al., 2008; MORAIS et al. , 2012; NAIK, DUBEY, 2013).

Conventional methods for removing toxic metals from the environment include precipitation, flocculation and filter membranes, but are costly processes. New technologies have been developed to reduce or recover environmental contamination by toxic metals, such as bioremediation by microorganisms. This process includes the degradation of the pollutant by biochemical reactions (HALTTUNEN, et al., 2006; PEREIRA and FREITAS, 2006).

<b>Heavy Metals</b>	<b>Main polluting sources</b>	<b>Harm to human health</b>
<b>Copper (Cu)</b>	Mining, Pesticide Production, Chemical Industries, Pipe Corrosion, Household Sewage, Algaecides, Fungicides and Metal Refining.	Anemia, Stomach and intestinal irritation, Liver and kidney damage and Poisoning.
<b>Lead (Pb)</b>	Pesticides, fumes, automotive emissions, mining, coal burning, painting, industrial effluents and tobacco.	Mental retardation in children, Encephalopathy, Congenital paralysis, Neuronal deafness, Nervous system damage, Gastrointestinal, liver and kidney damage, and Epilepsy.
<b>Chrome (Cr)</b>	Industrial Effluents, Aluminum & Steel Production, Inks, Explosive Pigments and Photography.	Allergies, Cancer and Poisoning.
<b>Zinc (Zn)</b>	Refineries, Mining, Waste Incineration and Metal Coatings.	Respiratory, Gastric and Cardiac Changes

Table 1: Heavy metals, their main polluting sources and their effect on human health.

adapted from Singh et al. (2011), Nies (1999) e Biondo (2008)

Bacteria are capable of remediating metal contaminated environments, including aquatic environments, sediment and soil. In soils and sediments such remediation may occur in situ or ex situ through metal oxidation or leaching, such as acid and sulfate production and volatilization. Bacteria utilize immobilization strategies including metal sequestration due to the ability of some intracellular or extracellular complex metal bacteria. Another way of immobilization is to create an anaerobic reduction or condition in the environment that results in the reduction or precipitation of the metal. In aquatic environments, the most common way of toxic metal bioremediation may be by the formation of microbial biofilm (ROANE, et al., 2009).

Bacteria adapt to toxic metals through a variety of resistance systems, mediated by chromosomes, transposon and plasmids. Some mechanisms of bacterial resistance to metals are: permeable barrier exclusion, intra- and extracellular sequestration, active transport or efflux pumps, and reduced sensitivity of cellular targets to metallic ions (Figure 1) (BRUINS, et.al, 2000).

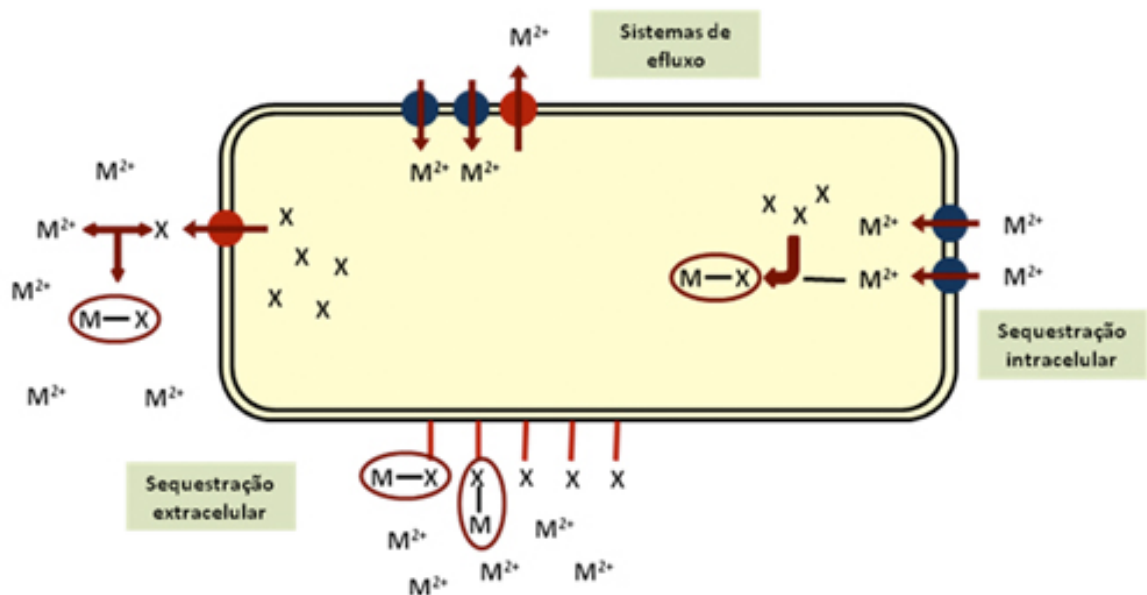


Figure 1 - Representative scheme of the main mechanisms of tolerance in bacteria; M<sup>+</sup>: toxic metal; X: Cell constituents that interact with metals.

Adapted from [www.esb.ucp.pt/en/projects](http://www.esb.ucp.pt/en/projects).

The exclusion mechanism impermeable barrier associated with changes in the cell wall and membrane. This mechanism is characterized as an attempt by the body to protect essential cellular components that are sensitive to metals (BRUINS, et.al, 2000).

Biosorption is a type of toxic metal bioremediation that can occur through the physicochemical interaction between the metal and the constituents of the membrane or cell wall of microorganisms, providing an alternative for treatment and recovery of contaminated areas (OISHI, 2014).

Some factors influence the biosorption mechanism of metals, such as biomass (living cells or non-living cells), types of biomaterials, chemical properties of metal solutions and environmental conditions such as pH and temperature. The metals biosorption process in living cells occurs into two procedures. The first is through the adsorption of metal ions on the surface of cells, before the metal ions adhere to the cell membrane or the cytoplasm adhere to cell wall containing a variety of polysaccharides and proteins which provide local assets that make ionic bonds. The second step, the metal ions penetrate the cell membrane and enter into the cells. The mechanisms involved in biosorption are coordination, complexation, ion exchange, physical adsorption and microprecipitation inorganic (Das et al., 2007).

The use of bacteria with proven remediation potential and survivability in the contaminated environment provides an alternative for treatment and recovery of contaminated areas. The present study aims to analyze the possible ability of *Enterococcus* bacteria to carry out biosorption of toxic metals, due to their survival characteristics in extreme environments.

## OBJECTIVE OF PROJECT

This work aims to evaluate the resistance of *Enterococcus* sp. isolated from the aquatic environment to toxic metals (lead, copper, chrome and zinc) with potential for bioremediation.

## METHODOLOGY

### Study area

The municipality of Apucarana is located in the north central region of the state of Paraná. According to the Brazilian Institute of Geography and Statistics (2014), this municipality has an area of 558,389 km<sup>2</sup>, BORDERING the municipalities of Arapongas, California, Cambira, Londrina, Mandaguari, Marilândia do Sul, Novo Itacolomi, Rio Bom and Sabáudia. The municipality still covers in its territory the districts of Correia de Freitas, Pirapó, São Pedro and Vila Reis.

The region has several rivers, streams and lakes used by the population for leisure and supply system (Figure 2). The studies concentrated on the Ivaí rivers (Corrego do Jaboti); Pirapó and Rio Bom (Ribeirão Biguaçu), because they cover the urban and rural areas.

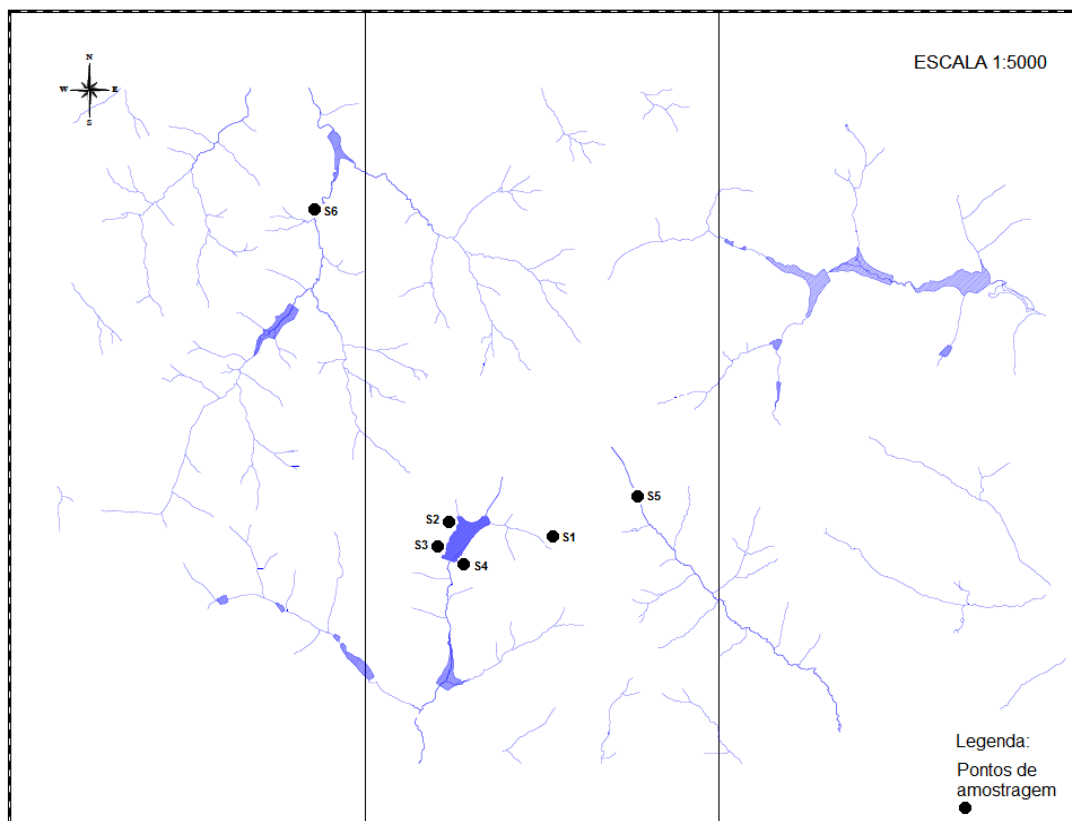


Figure 2 - Hydrographic map of the municipality of Apucarana / Paraná - Brazil. Source: Portal of the Apucarana City Hall, 2015

## CHARACTERIZATION OF COLLECTION PLACES

### Córrego Jaboti - Santo Expedito Echologic Park

The Jaboti stream (Santo Expedito Ecological Park) rises near the Cristo Rei Cemetery, leading to Jaboti Lake. At the stream site, Apucarana City Hall installed Parque Santo Expedito, which is characterized by religious tourism. Jaboti stream follows a valley bordered on its left bank by an agricultural area, and a partially urbanized area on its right bank.

The park has a playground, square, ecumenical chapel, stage, grotto with the image of Santo Expedito, gazebo with the image of Jesus Christ, sand soccer field, parking, water spout approximately 5m from the source of the stream. Jaboti, one of the spouts being the point of study (Figure 3); and due to this short distance it is considered as spring. The park also has natural water pools (PORTAL OF APUCARANA MUNICIPAL PREFECTURE, 2015).

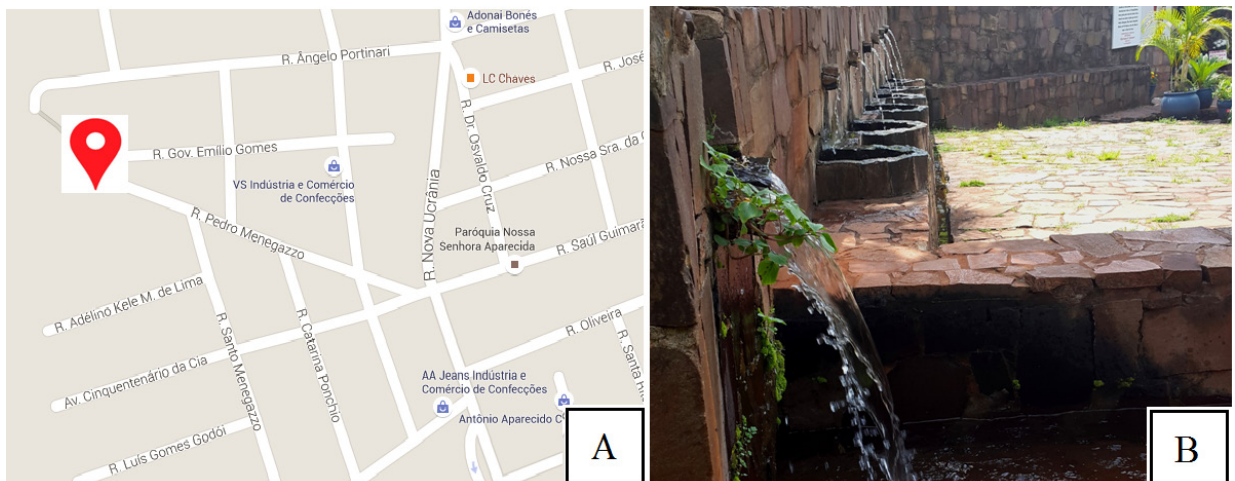


Figure 3 - Location of the collection point (Jaboti stream) (A) and stream overview (B). The red dot indicates the location of the Jaboti stream at the coordinates  $23^{\circ}34'3.83''\text{S}$  /  $51^{\circ}27'46.7''\text{W}$ ; altitude 773m.

Source: Google Earth.

### Jaboti Lake

Three points were chosen for collection in Lake Jaboti, named points A, B and C (Figure 4). The Jaboti Park has afforestation and infrastructure, as well as a playground, outdoor gym, events room, toilets, snack bars, hiking trail, bike path, public telephone, watercraft, known as “pedal boat”, and fishing is allowed in this area. local, all to attract visitors to the area; in addition to the Apucarana Cultural and Sports Association (ACEA), this entire area being limited by Avenida Jaboti. A barragem para formação do lago foi construída na bacia do ribeirão Barra Nova, com

altura de 23m, comprimento de crista de 16m e largura da base de 155m. O local de vazão da barragem está situado na porção sul do lago (PORTAL DA PREFEITURA MUNICIPAL DE APUCARANA, 2015).



Figure 4 - Location and overview of collection points on Jaboti Lake. (A) at coordinates  $23^{\circ}34'9.95''$  (S) /  $51^{\circ}28'25.54''$ W; altitude 742m. (B) at coordinates  $23^{\circ}34'2.36''$  S /  $51^{\circ}28'31.2''$  W; altitude 742m. (C) at coordinates  $23^{\circ}33'52.92''$ S /  $51^{\circ}28'25.81''$ W; altitude 742m.

Source: Google Earth Adaptation.

### Barreiro dam - redemption park

The supply of Apucarana is made through the Pirapó River, and surface springs, such as Caviúna stream, as well as Serra Geral aquifer wells. Redemption Park (Figure 5) is a religious theme park; The same is the revitalization of the degraded permanent preservation area on the banks of the Barreiro dam, belonging to the Pirapó river basin, which supplies Apucarana as previously mentioned, as well as the region. The park was established with the objective of revitalizing the surroundings of the old “dump” of the study city, as well as the recovery of the upper course of the Pirapó River.





Figure 5 - Location of the collection point (Barreiro dam) (A) and overview of the repression (B). The red dot indicates the location of the dam at coordinates 23°31'13.97"S / 51°29'22.32"W; altitude 631m.

Source: Google Earth Adaptation.

### Ribeirão biguaçu - park of the bible

Ribeirão Biguaçu (Bible Park) is another collection point (Figure 6), and it is one of the tourist elements of Apucarana that attracts people from other cities to visit it, not only being restricted to the local population (TORRES, 2013). According to Faria and Faria (2006), the Biguaçu river basin belonging entirely to the municipality of Apucarana - PR, being one of the tributaries of the Bom river.

The Biguaçu Valley was channeled through the erosion control program, as one of the streets that give access to the current Park (João Antonio Braga Cortes Street), on the outskirts of the "Country Club", was taken by a huge erosion; and this situation caused great inconvenience to the residents of the region, because people had to change the route until they reached the other side of the city (FERREIRA, 2006).

In the surroundings of the Biguaçu stream there is a region that is divided into two parks, the São Francisco de Assis Park and the Bible Park. These are religious themed environmental parks and have urban afforestation and landscaping, a fountain, trash cans, a hiking trail, a water mirror, benches, lamps and a locker room.



Figure 6 - Location of the collection point (Biguaçu stream) (A) and general view of the stream (B). The red dot indicates the location of the stream at the coordinates 23°33'31.54"S /

## SAMPLE COLLECTION

One hundred twenty water samples were collected in the months of October and November 2014 and February and March 2015, predetermined in the previous items, according to occupation and use by the population. Water collection was carried out in polyethylene terephthalate bottles pretreated with 0.1% Tween 80 solution. After collection, the samples were packed in an isothermal box containing ice and sent to the UTFPR Microbiology Laboratory - Londrina campus.

## QUANTIFICATION AND IDENTIFICATION OF *ENTEROCOCCUS SP.*

The densities of *Enterococcus sp.* were determined based on the filter membrane technique. To this end, 100 mL of water was filtered through a nitrocellulose membrane with 0.45  $\mu\text{m}$  porosity and 47mm diameter (SARTORIUS STEDIM BIOTECH®). The membranes were deposited on the surface of the kanamycin esculin azide agar (KEA) culture medium (HIMEDIA) and incubated at 37 ° C for 24 / 48h.

The bacterial isolates were submitted to phenotypic identification tests: observation of the morphotintorial characteristics by Gram staining and catalase enzyme production, following protocol described by Facklam et al. (1999). Catalase enzyme production was verified by depositing a drop of hydrogen peroxide (3% v / v  $\text{H}_2\text{O}_2$ ) on the bacterial suspension. The absence of bubble formation is indicative of negative reaction, characteristic of *Enterococcus sp.*

## TOXIC METAL CONCENTRATIONS

Metal concentrations were defined according to CONAMA Resolution 357 of March 17, 2015, in its Art. 5 which classifies the bodies of water used for recreation and leisure between classes III and IV. Table 2 below shows the concentrations allowed by CONAMA Resolution 357/2005.

The solutions were prepared with sterile ultrapure water and filtered with 0.22  $\mu\text{m}$  porosity disposable membranes and stored under refrigeration.

Toxic metal	Lead ( $\text{Pb}(\text{NO}_3)_2$ )	Cooper ( $\text{CuSO}_4$ )	Zinc ( $\text{ZnSO}_4$ )	Chrome ( $\text{K}_2\text{Cr}_2\text{O}_7$ )
concentrations (mg/L)	0,033	0,013	5	0,05

Table 2 - Toxic metal concentrations allowed by CONAMA Resolution 357/2005

## GRADIENT PLATE TECHNIQUE

The gradient plate technique was used for initial tests to verify the possible resistance of the isolates to metals. According to Szybalski and Bryson (1952), this method evaluates the reduction in the amount of metals required for the experiment.

To assemble the plate, two layers of agar medium were used. The first lower layer is composed of 10 mL of Muller Hilton agar medium and is slanted gel (Figure 7A). The upper layer was composed of 20 mL of Muller Hilton agar plus metal solutions with the minimum concentrations required by the legislation described in Table 1, thus forming a metal concentration gradient (Figure 7B).

After mounting the plate, the isolates were inoculated in horizontal lines from the least concentrated to the most concentrated (Figure 7C).

Subsequently, bacterial isolates that presented resistance were inoculated in concentrations 10 to 40 thousand times higher than recommended by Conama.

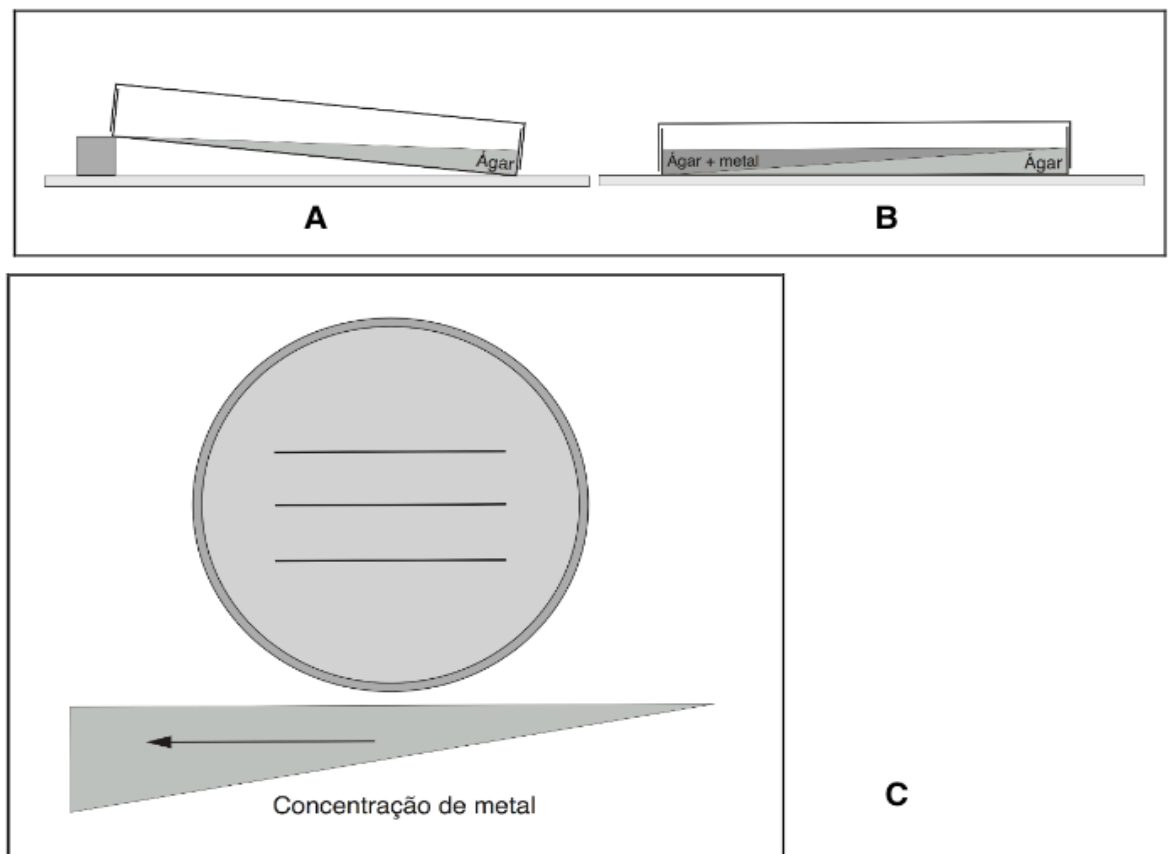


Figure 7 - Toxic metal gradient plate (A and B); C Representation of the inoculum lines on the gradient plate

## RESULTS AND DISCUSSION

Characteristic colonies of *Enterococcus* sp. on KEA agar, they are black in color due to the hydrolysis of esculin in dextrose and esculetin, which reacts with ferric citrate producing a brownish black precipitate (Figure 8A). A total of 327 presumptive

*Enterococcus* sp. were obtained from the 120 water samples analyzed. Seventy-six (23.24%) isolates had phenotypic characteristics of Gram staining and *Enterococcus* sp. Catalase test (Figure 8).

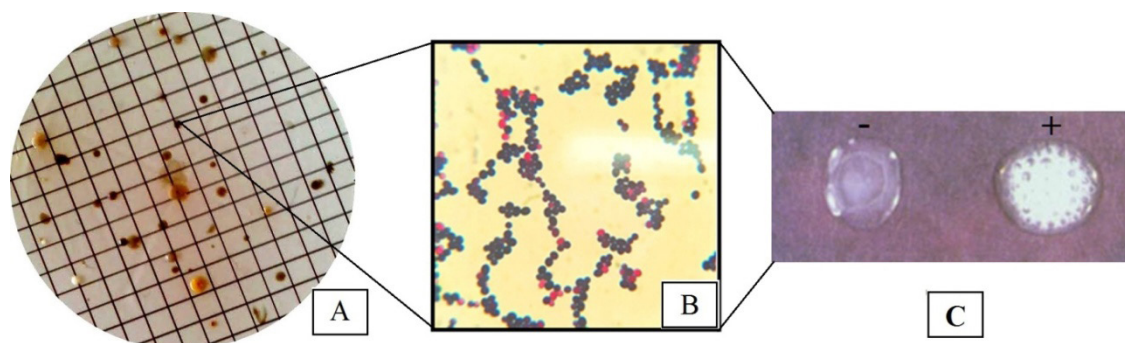


Figure 8 - Characteristic colonies of *Enterococcus* sp. using KEA culture medium (A); followed by Gram staining (Gram positive cocci) (B) and catalase test (C).

Several studies show that there is prevalence of *E. faecalis* and *E. faecium* in water samples (FERGUSON et al., 2013; YAMANAKA, 2011). However, in the present study, these were not the prevalent species, showing the genetic diversity among the isolates in the environment, depending on the geographical location.

The presence of enterococci in environmental samples has been considered an indicator of recent fecal contamination (a few days or weeks) complementary to thermotolerant coliforms. This microorganism originates from both animal feces and human fecal origin, and the main counts of enterococci are the quality assessments of water sources and bodies (FALAVINHA; DEGENHARDT, 2014).

Due to the fact that enterococci do not survive in polluted environments, the probable source of contamination of these environments is generally related to anthropogenic activities that occurred at the time of sampling or earlier days, or another probable contamination by animals living in the collection sites (HASMAN et al., 2006).

The main applications of *Enterococcus* counting are assessments of the quality of springs and water bodies, and the quality of treated water and the evaluation and monitoring of the hygienic conditions of industrial systems (SILVA et al., 2000).

In this study, 72 bacterial isolates from water bodies were tested. The results revealed that 97.2% showed continuous growth in the gradient plate with the tested metals (Figure 9).

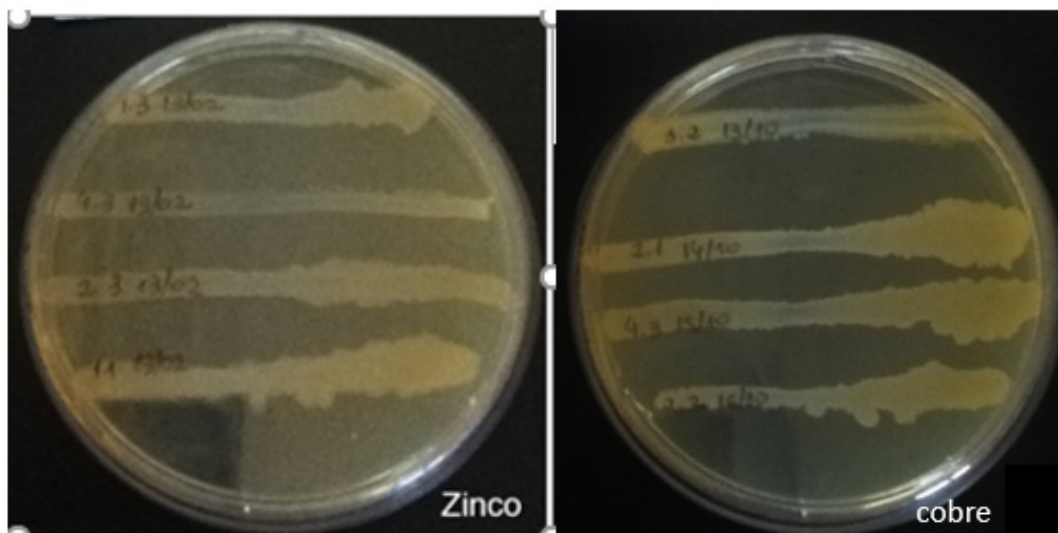


Figure 9 - Representative photo of growth on the gradient agar plate; Isolates of the genus *Enterococcus* growing in various concentrations of zinc and copper metal present in the culture medium. Arrow represents higher and lower concentration of metal in the gradient plate.

The figure 10 shows the growth of bacteria exposed to the maximum concentration allowed by CONAMA Resolution 357/2005. It can be observed that all isolates showed microbial development, with different intensities.

Figure 11 represents the growth of *Enterococcus* sp. at concentrations 40,000 times as permitted by legislation for chrome, lead and copper, and at concentrations 10,000 times for zinc metal. The results show that there was still growth for lead and copper at very high concentrations, which may characterize a bacterial resistance to these metals.

Environmental pollution by toxic metals has been growing rapidly along with industrialization as many companies still release their contaminated effluent directly into the environment. According to Banerjee et al. (2015), toxic metals accumulated in bacteria may be a more viable and cheaper alternative for wastewater treatment. Based on the preliminary results presented in this work, it is possible to identify bacteria with resistance to high concentrations of metals, which makes them a great potential for bioremediation.

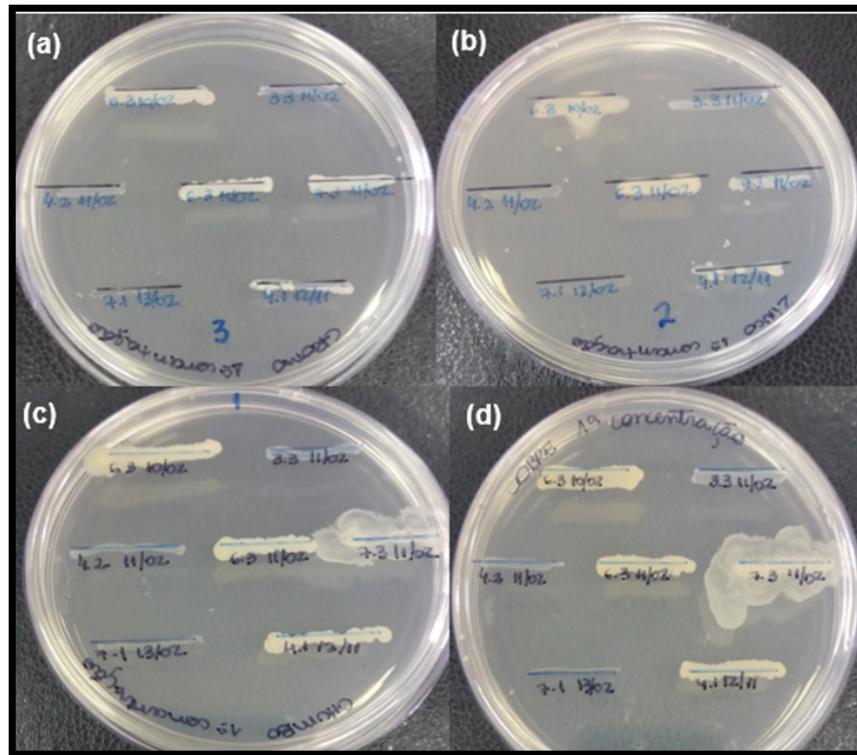


Figure 10 - Growth in plate with the concentration allowed in CONAMA Resolution 357/2005. (a) Chrome metal growth plate, (b) Zinc metal growth plate, (c) Lead metal growth plate and (d) Copper metal growth plate.

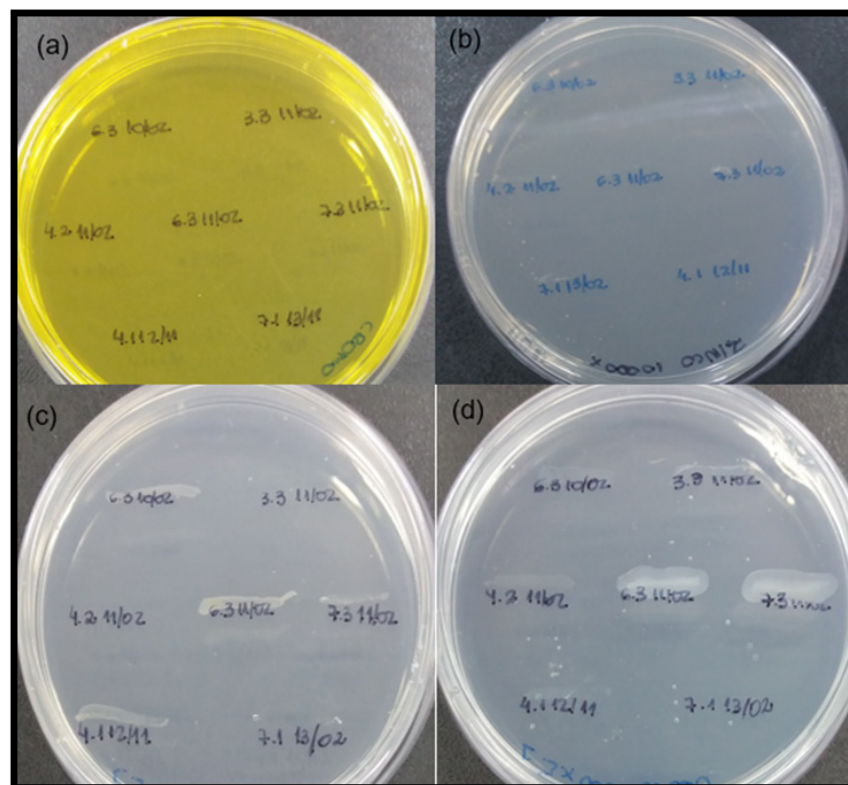


Figure 11 - Growth in plate with concentration allowed in CONAMA Resolution 357/2007. (a) 40,000 times concentrated chrome metal growth plate, (b) 10,000 times concentrated zinc metal growth plate, (c) 40,000 times concentrated metal growth plate and (d) metal growth plate covers 40 thousand times concentrated.

Bacterial resistance to toxic metals is an important factor to be considered in the study of remediation of contaminated areas, as this resistance is directly related

to the survivability and bacterial growth at high concentrations of toxic metals (KANG et al., 2016).

Environmental pollution by toxic metals has been growing rapidly along with industrialization as many companies still release their contaminated effluent directly into the environment. According to Banerjee et al. (2015), bioremediation of toxic metals by bacteria may be a more viable and cheaper alternative for wastewater treatment.

## CONCLUSION

Based on the results presented in this work, bacteria with resistance to high concentrations of metals can be identified, which makes them a great potential for bioremediation. The ability of bacteria to survive extreme environments such as the presence of toxic metals clearly shows the importance of studying the resistance to these pollutants, as they can be used in the natural bioremediation process of these environments.

## ACKNOWLEDGMENT

Moralez, A. T. P. for the suggestions of the experimental part of this work, as a requirement of the postdoctoral.

## REFERENCES

AHMED, W.; HODGERS, L.; SIDHU, J.P.S.; TOZE, S. Fecal Indicators and Zoonotic Pathogens in Household Drinking Water Taps Fed from Rainwater Tanks in Southeast Queensland, Australia. **Applied and Environmental Microbiology**. v. 78. jan. 2012.

BANERJEE, Goutam; PANDEY, Shubhant; RAY, Arun Kumar; KUMAR, Ravi. Bioremediation of heavy metals by a novel bacterial strain *Enterobacter cloacae* and its antioxidant enzyme activity, flocculant production, and protein expression in presence of lead, cadmium, and nickel. **Water Air Soil Pollut.** v.266: 91, 2015.

BIONDO, Ronaldo. **Engenharia genética de *Cupriavidus metallidurans* CH34 para biorremediação de efluentes contendo metais pesados**. 2007. Tese (Doutorado em Biotecnologia) – Instituto de Ciências Biomédicas, Universidade de São Paulo, São Paulo, 2007.

BOEHM, Alexandria B.; SASSOUBRE, Lauren M. **Enterococci from commensals to leading causes of drug resistant infection: Enterococci as Indicators of Environmental Fecal Contamination**. Boston, MA, p. 73-88, 2014.

CONAMA BRASIL. Resolução 357, de 17 de março de 2005. **Diário Oficial da União República Federativa do Brasil**, Brasília, DF, 18 mar. Disponível em: <<http://www.mma.gov.br/port/conama/res/res05/res35705.pdf>>. Acesso em: 23 de fev.2017.

DAS, Nilanjana; VIMALA, R.; KARTHIKA, P. Biosorption of heavy metals – an overview. **Indian Journal of Biotechnology**. v. 7, p. 159-169, 2007.

FACKLAM, R. R.; SAHM, D. F.; TEIXEIRA, L. M. **Enterococcus**. Manual of Clinical Microbiology, v. 7, pg. 297–305, 1999.

FALAVINHA, G.; DEGENHARDT, R. Qualidade microbiológica da água de nascentes e poços da comunidade de Barro Branco, Capinzal, SC. **Unoesc & Ciência – ACBS**, v. 5, nº2, 2014.

FERGUSON, D. M.; GRIFFITH, J. F.; MCGREE, C. D.; WEISBERG, S. B.; HAGEDORN, C. Comparison of *Enterococcus* Species Diversity in Marine Water and Wastewater Using Enterolert and EPA Method 1600. **Journal of Environmental and Public Health**, 2013.

FERREIRA, J. M. **Parque Biguaçu: uma proposta de educação ambiental na escola de tempo integral, Apucarana – PR**. 2006. 72f. Monografia (Bacharel em Geografia) – Universidade Estadual de Londrina, departamento de Geociências, Londrina, 2006.

HALTTUNEN, T.; SALMINIEN, S.; TAHVONEN, R. Rapid removal of lead and cadmium from water by specific lactic acid bacteria. **International Journal of Food Microbiology**. v. 114, p. 30-35, 2007.

HASMAN, Herik; KEMPF, Isabelle, CHIDAINE, Berangere; CARIOLET, Roland, ERSBOLL, Annette Kjaer; HOUE, Hans; HANSEN, Hans Christian Bruun; AARESTRUP, Frank Moller. Copper resistance in *Enterococcus faecium*, mediated by the *tcrB* gen. is selected by supplementation of pig feed with copper sulfate. **Applied and environmental microbiology**. v. 72, p. 5784-5789, 2006.

KANG, C.-H.; KWON, Y.-J.; SO, J.-S. Bioremediation of heavy metals by using bacterial mixtures. **Ecological Engineering**, v. 89, p. 64–69, 2016.

KAR, D. et al. Assessment of heavy metal pollution in surface water. **International Journal of Environmental Science and Technology**. v. 5, n. 1, p. 119–124, 2008.

KIMIRAN - ERDEM, Ayten; ARSLAN, Elif Ozlem; YURUDU, Nazmiye Ozlem Sanli; ZEYBEK, Zuhai; DOGRUOZ. Nihal; COTUK, Aysin. Isolation and Identification of Enterococci from Seawater Samples: Assessment of their resistance to antibiotics and heavy metals. **Environmental Monitoring Assesss**, v. 125, p.219-228, 2006.

MORAIS, Simone; GARCIA E COSTA, Fernando; PEREIRA, Maria de Lourdes. Heavy metals and human health. **Environmental Health - Emerging Issues and Practice**. p. 227–246, 2012.

NAIK, Milind Mohan; DUBEY, Santoh Kumar. Lead resistant bacteria: Lead resistance mechanisms, their applications in lead bioremediation and biomonitoring. **Ecotoxicology and Environmental Safety**. v. 98, p. 1-7, 2013.

NIES, D.H. Microbial heavy-metal resistance. **Applied Microbiology Biotechnology**, v. 51, p. 730-750, 1999.

OISHI, Bruno Oliva. **Estudo da capacidade de sorção de cobre por *Pseudomonas putida* sp. em reator**. 2014. 126 f. Tese (Doutorado em Biotecnologia) – Instituto de Ciências Biomédicas, Universidade de São Paulo, São Paulo, 2014.

PEREIRA, Aline Ramalho Brandão; FREITAS, Diego Antonio França. Uso de microrganismos para a biorremediação de ambientes impactados. **Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental**. v. 6, p. 975-1006, 2012.

ROANE, Timberley M.; RESING, Christopher; PEPPER, Ian L. MAIER, Raina M. Microorganisms and Metal Pollutants. **Environmental Microbiology**. p. 421-441, 2009.

SINGH, R. et al. Heavy metals and living systems: An overview. **Indian Journal of Pharmacology**, v. 43, n. 3, p. 246–253, 2011.



SZYBALSKI, Waclaw; BRYSON, Vernon. Genetic studies on microbial cross resistance to toxic agents. **Microbial cross resistance to toxic agentes**. v. 64, p. 489-499, 1952.

TORRES, E. C. Um território em busca de suas paisagens: O córrego do Biguaçu em Arapongas – PR – Brasil. ENCuentro DE GEÓGRAFOS DE AMÉRICA LATINA, 14, 2013, **Anais Eletrônicos...**Perú, 2013.

YAMANAKA, E. H. Incidência, Fatores de Virulência e Resistência a Antibióticos de *Escherichia coli* e *Enterococcus* spp. Isolados como Indicadores de Contaminação Fecal em Água de Consumo de Fontes Alternativas de Curitiba e Região Metropolitana. 2011. 148f. Dissertação (Mestrado em Ciências Biológicas) – Universidade Federal do Paraná, Curitiba, 2011.

## **SOBRE O ORGANIZADOR**

**BENEDITO RODRIGUES DA SILVA NETO** - Possui graduação em Ciências Biológicas pela Universidade do Estado de Mato Grosso (2005), com especialização na modalidade médica em Análises Clínicas e Microbiologia (Universidade Candido Mendes - RJ). Em 2006 se especializou em Educação no Instituto Araguaia de Pós graduação Pesquisa e Extensão. Obteve seu Mestrado em Biologia Celular e Molecular pelo Instituto de Ciências Biológicas (2009) e o Doutorado em Medicina Tropical e Saúde Pública pelo Instituto de Patologia Tropical e Saúde Pública (2013) da Universidade Federal de Goiás. Pós-Doutorado em Genética Molecular com concentração em Proteômica e Bioinformática (2014). O segundo Pós doutoramento foi realizado pelo Programa de Pós-Graduação Stricto Sensu em Ciências Aplicadas a Produtos para a Saúde da Universidade Estadual de Goiás (2015), trabalhando com o projeto Análise Global da Genômica Funcional do Fungo *Trichoderma Harzianum* e período de aperfeiçoamento no Institute of Transfusion Medicine at the Hospital Universitätsklinikum Essen, Germany. Seu terceiro Pós-Doutorado foi concluído em 2018 na linha de bioinformática aplicada à descoberta de novos agentes antifúngicos para fungos patogênicos de interesse médico. Palestrante internacional com experiência nas áreas de Genética e Biologia Molecular aplicada à Microbiologia, atuando principalmente com os seguintes temas: Micologia Médica, Biotecnologia, Bioinformática Estrutural e Funcional, Proteômica, Bioquímica, interação Patógeno-Hospedeiro. Sócio fundador da Sociedade Brasileira de Ciências aplicadas à Saúde (SBCSaúde) onde exerce o cargo de Diretor Executivo, e idealizador do projeto “Congresso Nacional Multidisciplinar da Saúde” (CoNMSaúde) realizado anualmente, desde 2016, no centro-oeste do país. Atua como Pesquisador consultor da Fundação de Amparo e Pesquisa do Estado de Goiás - FAPEG. Atuou como Professor Doutor de Tutoria e Habilidades Profissionais da Faculdade de Medicina Alfredo Nasser (FAMED-UNIFAN); Microbiologia, Biotecnologia, Fisiologia Humana, Biologia Celular, Biologia Molecular, Micologia e Bacteriologia nos cursos de Biomedicina, Fisioterapia e Enfermagem na Sociedade Goiana de Educação e Cultura (Faculdade Padrão). Professor substituto de Microbiologia/Micologia junto ao Departamento de Microbiologia, Parasitologia, Imunologia e Patologia do Instituto de Patologia Tropical e Saúde Pública (IPTSP) da Universidade Federal de Goiás. Coordenador do curso de Especialização em Medicina Genômica e Coordenador do curso de Biotecnologia e Inovações em Saúde no Instituto Nacional de Cursos. Atualmente o autor tem se dedicado à medicina tropical desenvolvendo estudos na área da micologia médica com publicações relevantes em periódicos nacionais e internacionais. Contato: dr.neto@ufg.br ou neto@doctor.com

## ÍNDICE REMISSIVO

### A

Alimentos 13, 119, 120, 124, 154, 180, 182, 183, 184, 185, 186, 187, 212

Allium sativum 14, 15, 16, 19, 20, 21

Análise 4, 12, 13, 21, 58, 59, 65, 68, 76, 80, 98, 99, 102, 105, 106, 107, 114, 116, 120, 143, 150, 168, 170, 173, 174, 175, 176, 177, 187, 189, 212, 214

Antibiograma 117, 118, 121, 122, 123, 149, 156, 159, 160

Antibióticos 14, 16, 19, 20, 97, 108, 110, 119, 124, 125, 128, 129, 130, 132, 133, 141, 142, 146, 149, 150, 151, 153, 154, 155, 156, 158, 159, 160, 161, 163, 164, 166, 197

### B

Bactérias 1, 4, 5, 7, 8, 14, 16, 17, 18, 19, 108, 109, 110, 111, 118, 119, 120, 121, 123, 124, 130, 132, 141, 142, 144, 148, 154, 155, 157, 158, 160, 161, 162, 180, 184, 185, 186, 188, 195, 198, 212

Bacteroides 44, 45, 46, 47, 49, 50, 51, 52, 53, 54, 125

Biofilme 71, 118, 122, 124, 125, 127, 131, 132, 133, 134

Bioindicador 7, 8, 98, 107

Bioinformática 55, 57, 65, 214

Bovinos 112, 113, 114, 116, 161, 162, 168, 169, 178

### C

Candida 68, 69, 70, 71, 72, 74, 75, 76, 77, 78, 79, 80, 81

Candidemia 68, 69, 74, 75, 76, 77, 80, 81

Carbapenêmicos 108, 109, 149, 159

Cloranfenicol 14, 16, 17, 18

Contaminação biológica 1

### D

Dengue 23, 24, 25, 28, 29, 30, 31, 35, 36, 37, 38, 57

Diagnóstico molecular diferencial 168

### E

Enterococcus 8, 82, 83, 85, 86, 90, 91, 92, 93, 96, 97, 117, 118, 122

Epidemiologia 53, 68, 80, 152

Epítomos imunodominantes 55, 57, 59, 61, 64

Escherichia coli 1, 2, 4, 8, 12, 14, 15, 16, 19, 20, 46, 61, 77, 97, 109, 122, 140, 141, 143, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 164, 165, 166, 198, 199, 200, 201, 212

### F

Fasciolose 112, 113, 116

## **G**

Genética molecular 153

## **I**

Infecção 23, 45, 56, 57, 68, 70, 71, 72, 75, 76, 78, 80, 108, 111, 115, 126, 127, 128, 131, 132, 133, 142, 149, 154, 169, 174

Infecção intra-abdominal 45

## **L**

Laboratórios 1, 3, 9, 11, 16, 174, 178

Líquen 98, 100, 102, 107

## **M**

Microbiologia 44, 55, 68, 76, 82, 102, 107, 117, 120, 125, 151, 152, 153, 167, 187, 204, 214

Microrganismos patogênicos 1, 2, 11, 12

Modelo murino 23

## **O**

Oportunista 68, 70, 126, 127

## **P**

Parabacteroides 44, 45, 46, 47

Peptídeos 44, 55, 57, 59, 122, 124, 131, 132

Poluição 98, 99, 100, 101, 103, 104, 105, 106

Proteínas recombinantes 55, 64, 65

Pseudocowpoxvirus 168, 169, 178

## **Q**

q-PCR 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178

Quatro tamises 112, 113, 114, 116

## **R**

Resistência 12, 14, 15, 16, 18, 19, 20, 68, 70, 71, 74, 80, 97, 108, 109, 110, 119, 121, 123, 126, 127, 128, 129, 130, 131, 132, 133, 134, 140, 141, 142, 146, 147, 149, 150, 152, 153, 154, 155, 156, 159, 160, 161, 162, 163, 164, 165, 166, 167, 189, 204

Resistência antimicrobiana 15, 131, 141, 160

Rotinas de higienização 1, 5, 9, 11, 12

Rotinas de Higienização 1, 6

## **S**

Serviços de Saúde para Idosos 180

Sistema nervoso central 23

Staphylococcus aureus 8, 14, 15, 16, 19, 20, 21, 117, 118, 119, 122, 123, 124, 125, 126, 127, 128, 130, 134, 135, 136, 137, 138, 139

Substância antagonista 44, 45

## **V**

Validação 168, 170, 177, 178, 198

## **Z**

Zika vírus 55, 58, 64, 65, 66

Agência Brasileira do ISBN  
ISBN 978-85-7247-772-7



9 788572 477727