

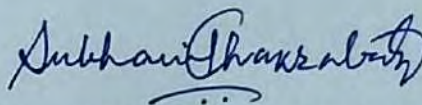
---

## DECLARATION

I hereby declare that the thesis entitled “**SCREENING AYURVEDA BASED THERAPEUTIC PREPARATIONS AGAINST MULTIPLE ANTIBIOTIC-RESISTANT GASTRO-ENTERIC DISEASE CAUSING BACTERIA AND TO REVEAL THE MODE OF ACTION OF THE POTENTIAL PREPARATION(S)**” is an authentic research work carried out by me in the Department of Biotechnology, University of North Bengal, Darjeeling – 734013, West Bengal, India, under the supervision of Prof. (Dr.) Ranadhir Chakraborty, Department of Biotechnology, University of North Bengal, Darjeeling – 734013, West Bengal, India. I also affirm that the thesis is an original work and has not been submitted in part or full for any degree, diploma or any other academic award to this or any other University or Institution.

Place: *SILIGURI*

Date: *27.12.2023*



Subhanil Chakraborty, M.Pharm.,

Senior Research Fellow (Professional)

Department of Biotechnology

University of North Bengal



समानो मन्त्रः समितिः समानी

**UNIVERSITY OF NORTH BENGAL**

**Department of Biotechnology**

☎ +91- 353 - 2776354, ☎ +91- 0353 - 2699001

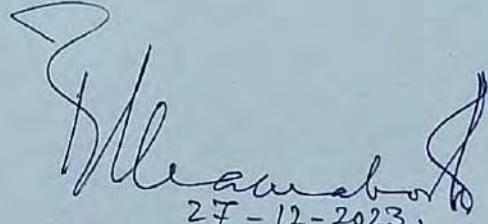
RAJA RAMMOHUNPUR  
P.O. NORTH BENGAL UNIVERSITY  
DIST. DARJEELING  
WEST BENGAL, INDIA, PIN - 734 013  
VISIT US : [www.nbu.ac.in](http://www.nbu.ac.in)

**Prof. (Dr.) Ranadhir Chakraborty**

## CERTIFICATE

The research work presented in this thesis entitled “**SCREENING AYURVEDA BASED THERAPEUTIC PREPARATIONS AGAINST MULTIPLE ANTIBIOTIC-RESISTANT GASTRO-ENTERIC DISEASE CAUSING BACTERIA AND TO REVEAL THE MODE OF ACTION OF THE POTENTIAL PREPARATION(S)**” has been carried out under my direct supervision by **Mr. Subhanil Chakraborty**. This work is original and has not been submitted for any degree or diploma to this or any other University or Institution.

Date: 27-12-2023

  
27-12-2023  
(**Ranadhir Chakraborty**)

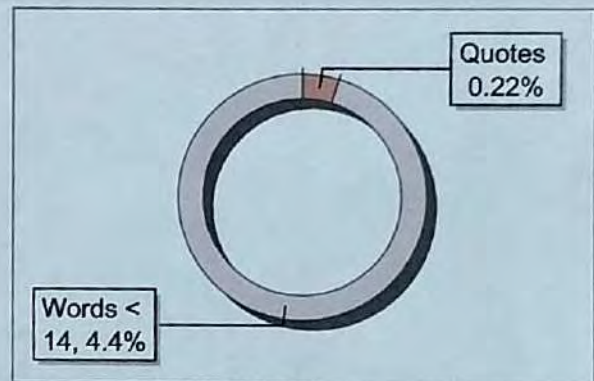
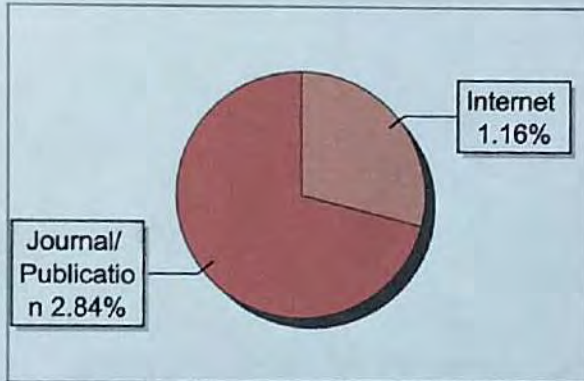
**Supervisor**  
**Ranadhir Chakraborty, Ph.D**  
Professor, Biotechnology  
University of North Bengal  
Siliguri- 734013, West Bengal

## Submission Information

Author Name Subhanil Chakraborty  
Title SCREENING AYURVEDA BASED THERAPEUTIC PREPARATIONS AGAINST MULTIPLE ANTIBIOTIC-RESISTANT GASTRO-ENTERIC DISEASE-CAUSING BACTERIA AND TO REVEAL THE MODE OF ACTION OF THE POTENTIAL PREPARATION(S)  
Paper/Submission ID 1214605  
Submitted by nbuplg@nbu.ac.in  
Submission Date 2023-12-14 14:14:39  
Total Pages 101  
Document type Thesis

## Result Information

Similarity 4 %

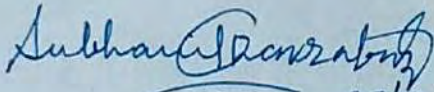



## Exclude Information

Quotes	Excluded
References/Bibliography	Excluded
Sources: Less than 14 Words %	Not Excluded
Excluded Source	4 %
Excluded Phrases	Not Excluded

## Database Selection

Language	English
Student Papers	Yes
Journals & publishers	Yes
Internet or Web	Yes
Institution Repository	Yes

  
27/12/2023  
(SUBHANIL CHAKRABORTY)

  
27/12/2023  
Ranadhir Chakraborty, Ph.D  
Professor, Biotechnology  
University of North Bengal  
Siliguri- 734013, West Bengal

*Dedicated  
To  
My Family*

*My Father  
Late Sri Murari Mohan  
Chakraborty*

*And*

*Honorable  
(Late)  
Prof. Ashim K. Chakravarty*

# Acknowledgment

This thesis entitled

**"SCREENING AYURVEDA BASED THERAPEUTIC PREPARATIONS AGAINST MULTIPLE ANTIBIOTIC-RESISTANT GASTRO-ENTERIC DISEASE-CAUSING BACTERIA AND TO REVEAL THE MODE OF ACTION OF THE POTENTIAL PREPARATION(S)"** is the most significant scientific adventure in my life and I am truly honored to acknowledge the persons who supported me all through with their co-operation, guidance and empathy for the successful conception of the research work.

I first arrived in University of North Bengal ten years back to meet **Professor (Dr.) Ranadhir Chakraborty** at the Department of Biotechnology, University of North Bengal. Little did I know then, this person will become the pole star of my life while supervising and guiding my doctoral research in most unique and eloquent way. He put me like "The charge of the light brigade" into my scientific endeavor with a childlike enthusiasm, unending inspiration and contagious curiosity.

It is my humble duty and great pleasure to express my indebtedness and respect to my prudent mentor Prof. Dr. Ranadhir Chakraborty, Department of Biotechnology, NBU, for his active guidance, painstaking supervision, valuable advice and constant encouragement that he rendered for the present work. His constant vigilance and care have been lavishly bestowed upon me in every stage of this work. He is the key person to steer my academic career in right direction. Any words of gratitude would not be enough to express my thanks for his tremendous support and advice. I would also like to take this opportunity to sincerely thank the better half of my guide, Dr. Ratna Sarkar for her kind words of inspiration and mother like care.

I take immense pleasure to show great appreciation to all respected teachers of my department. Any thanksgiving in response would feel microscopic to the support and

learnings I received from them. I am indebted to Dr. Dipanwita Saha for introducing me to the world of "fantastic fungi" and Dr. Shilpi Ghosh for leading me through the "paradigm of proteins". Any word of acknowledgement would fall short for the support I gratefully accepted from Dr. Anoop Kumar. He treated me like a younger brother and always showered me with his teaching and mentoring, I would like to congratulate and thank Dr. Manab Deb Adhikary for being inspirational in joining this galaxy of stars.

I feel pride to have acquainted with the most dynamic duo I have ever come across, Dr. Ashish Kumar Nanda and Late Dr. Ashim Kumar Chakravarty. I learned a lot from them and in return, they expected me to challenge them with logical contradictions. All I received from them is "the gift of the magi". I am indebted to Dr. Min Bahadur from Department of Zoology, NBU for all his guidance related to animal studies and related permissions and Late Dr. Palash Mandal from Department of Botany, NBU for identification of my plants.

I am honored to always being on the receiving end of love, care and immense support rendered by all non-teaching staffs like Dipak da, Raja Da, Biswajit Da, late Sujay da and most importantly my brother Sri Arup Ghosh.

I suppose, any meagre word would not fit the gravity to express how indispensable, my lab mate friends' presence was for my research. My special thanks to my ever-enthusiastic lab mates, Anup bhai, Amit, Biprans da, Rudra, Tilak Da, Sreeparna di, Suparna di, Bhaskar da, Arvind bhaiya, Subhajit, Vivek Ranjan, Prayaas, Partha, Sriradha, Chandana, Shilpa, Anusuya, Soumya, Anukul, Deep and my childhood friend Sudipta for their immense co-operation and co-ordination for the research work.

I am also thankful to all other scholars especially Somnath bhai, Gargee di, Moushree, Deepika, Shanta, Nithya, Upasna, Swarnab, Aditi, Ayan and my sister Khushboo Lepcha for their continuous co-operation and support throughout my time at NBU.

I offer cordial thanks to Dr. Anindya Sundar Ghosh of IIT, Kharagpur, Dr. Biswanath Chakraborty of Kalyani University, Dr. Ranjan Nandi of NICED and Dr. Shanti Mandal, who were an important advisor during my project work and provided me with

their valuable support through their scholars and themselves to facilitate characterization of my samples.

Words of thanks would be too meager for profound support and blessings rendered to me by my parents Mrs. Saraswati Chakraborty and late Mr. Murari Mohan Chakraborty, who remain deprived of my time and attention during the preparation of this thesis. My entire family including my in-laws were also very supportive.

I would like to convey my sincere thanks to Dr. A. Mukherjee, Scientist and Head of INSPIRE Division, Department of Science and Technology, New Delhi, for awarding me INSPIRE Fellowship vide sanction order DST/INSPIRE Fellowship/2016/IF 160786 and University of North Bengal for providing the infrastructural facilities.

Finally, yet most importantly, I would like to express my heartfelt thanks to my beloved wife Dr. Babli Roy for her enduring love and unending enthusiasm to inspire me at every stage of the research and helping me silently and invisibly to navigate through every obstacle I faced. Without her 360° support, I would have been long lost.

Before I finish, I want to express my gratitude to all the biologists, the scientists and research scholars in this field of work whose studies have guided me to complete this work. However, the words might not reach, but I feel it is important to thank my holy abode, the nature and the mountains of the Himalayas. I have possibly left out the names of many other people who helped me in a way or other during this research work and I express my sincere thanks and heartfelt sorry to all of them.

Place: SILIGURI

Date: 27/12/2023

  
(Subhanil Chakraborty)

**“Do not go gentle into that good night, Old age should burn and rave at close of day; Rage, rage against the dying of the light.”**

Gastro-enteric diseases, particularly Diarrhea effortlessly overwhelm the public health system in India by easy means of spreading through either food or drinking water and leading to the scale of the epidemic; causing enormous loss of life even today. Even after decades of research, the problem of efficiently combating multiple antibiotics resistant pathogens by the existing arsenal remains to be resolved. There are several references in the literature, printed age-old books and internet, describing remedies from enteric diseases using traditional knowledge and practice.

Different ayurveda preparations, elixirs and mixtures of natural products and minerals were used in the control of gastro-enteric diseases. The present research project is to screen most suitable preparations/candidates and explore the efficacy of those age old Indian natural remedial preparations in the control of gastro-enteric pathogens with main emphasis on the genus *Salmonella*, *Escherichia*, and *Shigella*. The major problem of treating gastro-enteric diseases today is the emergence of multiple antibiotics resistant pathogen and growing complexity of resistance mechanism and perplexing mixed etiology.

The activity of the screened preparations was checked against multiple drug resistant pathogens along with testing the MIC values, MBC values and other regular safety, efficacy and antimicrobial assays. The mode of action of the potential preparation(s) were ascertained using combination of methods of electron microscopy and high through-put technologies including chemical analysis and fluorescence based cytological profiling. Physico-chemical characteristics of the effective preparation(s) were determined using different analytical methods for identification of active components of the preparation with a view of developing the Ayurveda based potential preparation AP-01 into more patient-compliant dosage forms for future uses.

Table 1.1: Plant derived ingredients and their quantities for preparing potential poly herbal formulation for treating gastro-enteric disorders related mainly to diarrhea.....	15
Table 2.1: Details of collected plant materials for development of Ayurveda based Polyherbal formulation.....	22
Table 2.2: Name of primary poly herbal formulations and their ingredients .....	25
Table 2.3: Phytoconstituent contents of poly herbal formulations.....	25
Table 2.4 Specific gravity, pH and total alcohol content of poly herbal preparations.....	26
Table 3.1: MTT Assay based Cytotoxicity study of fermented polyherbal formulation .....	40
Table 3.2: Effect of AP-01 on castor oil induced diarrhoea in Sprague Dawley rats.....	42
Table 3.3: Residual effect of AP-01 on body weight, food and water intake and gastric motility of Sprague Dawley rats.....	44
Table 3.4: Antibiotics resistance patterns based on CLSI/EUCAST zone of Inhibition breakpoint.....	45
Table 3.5: MIC and MBC of polyherbal AP-01 against bacterial strains of study.....	46
Table 3.6: Zone of inhibition shown by different volumes of AP-01 while keeping DMSO as negative control and Meropenem as positive control.....	46
Table 4.1: Antibiotic resistance profile of <i>Pseudomonas aeruginosa</i> HW01.....	61
Table 4.2: Comparative analysis and determined MIC of individual component and the polyherbal AP-01 against <i>Pseudomonas aeruginosa</i> HW01.....	63
Table 4.3: Level of C-reactive protein (CRP) in the blood of different group animals on second, fourth, sixth- and eighth-day following burn and infection with <i>P. aeruginosa</i> HW01.....	70

Table 4.4 Presence of <i>P. aeruginosa</i> viable colonies in seven consecutive days of post-burn wound surface in experimental rats.....	71
Table 5.1: Common approaches for elucidating MOAs of new antibiotics.....	79
Table 5.2: MIC of Antibiotics and AP-01 for bacterial Cytological Profiling.....	80
Table 5.3: Details of measured cellular phenotypic parameters.....	82
APPENDIX	
Table A 1.1: Number of plant taxa used to treat several different types of gastro-intestinal disorders.....	119
Table A 1.2: Phases of diagnosis for chronic diarrhea or dysentery.....	119
Table A 2.1: Taxonomical classification of plants used for preparing PHF AP-01.....	123
Table A 4.1: pH of burn wound surface of Sprague Dawley rats .....	127
Table A 5.1: Stability studies of AP-01 when kept in a closed lid dark colored glass container at room temperature.....	130
Table A 5.2: Combined data of cell membrane parameters for bacterial cytological profiling of untreated <i>Escherichia coli</i> K12 and when treated with different antibiotics and AP-01.....	130
Table A 5.3: Combined data of DNA parameters for bacterial cytological profiling of untreated <i>Escherichia coli</i> K12 and when treated with different antibiotics and AP-01.....	131
Table A 5.4: Combined data of fluorescence stain parameters for bacterial cytological profiling of untreated <i>Escherichia coli</i> K12 and when	

treated with different antibiotics and AP-01.....	131
Table A 5.5: Combined data of cell membrane parameters for bacterial cytological profiling of untreated <i>Bacillus subtilis</i> DSM402 and when treated with different antibiotics and AP-01.....	132
Table A 5.6: Combined data of DNA parameters for bacterial cytological profiling of untreated <i>Bacillus subtilis</i> DSM402 and when treated with different antibiotics and AP-01.....	132
Table A 5.7: Combined data of fluorescence stain parameters for bacterial cytological profiling of untreated <i>Bacillus subtilis</i> DSM402 and when treated with different antibiotics and AP-01.....	133

---

<b>Figure 1.1:</b> Flow diagram describing the work flow of methodologies used in this study	<b>16</b>
<b>Figure 2.1:</b> Comparison of growth between untreated and Poly herbal preparation (AP-01) treated <i>Escherichia coli</i> K12 bacteria keeping similar growth parameters	<b>26</b>
<b>Figure 3.1:</b> FTIR spectra of poly herbal formulation AP-01	<b>37</b>
<b>Figure 3.2:</b> <sup>1</sup> H NMR spectra of poly herbal formulation AP-01	<b>38</b>
<b>Figure 3.3:</b> LC – MS spectra of polyherbal formulation AP-01	<b>39</b>
<b>Figure 3.4:</b> Comparative normal and wet faecal materials of all animal groups	<b>41</b>
<b>Figure 3.5:</b> Kaolin expulsion through faeces as a marker of gastric motility	<b>43</b>
<b>Figure 3.6:</b> Anti-swimming motility effect shown by AP-01 on <i>Salmonella typhi</i> 01263	<b>47</b>
<b>Figure 4.1:</b> Swarming motility assay of <i>Pseudomonas aeruginosa</i> HW01, (A) Control (in absence of AP-01), (B) in presence of polyherbal preparation AP-01	<b>62</b>
<b>Figure 4.2:</b> Growth curve of <i>Pseudomonas aeruginosa</i> HW01, in presence of 80 µl/ml (v/v) polyherbal preparation AP-01 and in absence of AP-01	<b>64</b>
<b>Figure 4.3:</b> Agar well diffusion assay of <i>Chromobacterium violaceum</i> in presence of 70 µl AP-01 in well A showing clear zone of inhibition	<b>65</b>
<b>Figure 4.4:</b> Broth dilution assay of <i>Chromobacterium violaceum</i> in presence of AP-01 showing violacein production in both tubes A (Control) and B, arresting the production of violacein at a concentration of 40 µl/ml in tube C and complete inhibition of growth at the concentration of 70 µl/ml in tube D	<b>65</b>
<b>Figure 4.5:</b> Decrease in residual wound area with progression of burn wound healing in not infected burn wound over the wound surface of untreated burn (first column), burn treated with antibiotics (second column), burn treated with polyherbal preparation AP01(third column)	<b>67</b>
<b>Figure 4.6:</b> Decrease in residual wound area with progression of burn wound healing over the wound surface of <i>Pseudomonas aeruginosa</i> HW01 infected burn (first column), <i>Pseudomonas</i>	

---

infected burn treated with antibiotic (second column), *Pseudomonas aeruginosa* HW01 infected burn treated with polyherbal preparation AP01(third column) **68**

**Figure 4.7:** Graphical representation of in vivo wound healing assay, comparison of residual wound area from day 0 to day 14 among untreated burn wound, antibiotics treated burn wound and polyherbal AP-01 treated burn wound. **69**

**Figure 4.8:** Graphical representation of in vivo wound healing assay, comparison of residual wound area from day 0 to day 14 among untreated *Pseudomonas* infected burn wound, antibiotics treated infected burn wound and polyherbal AP-01 treated infected burn wound. **69**

**Figure 5.1:** Fluorescence microscopy using FM4-64 and DAPI stains on untreated *Escherichia coli* K12 cells showing penetration of DAPI in both living and non-living cells **85**

**Figure 5.2:** Fluorescence microscopy using FM4-64 and SYTOX Green stains on untreated *Escherichia coli* K12 cells **86**

**Figure 5.3:** Fluorescence microscopy using FM4-64 and SYTOX Green stains on AP-01 treated *Escherichia coli* K12 cells **86**

**Figure 5.4:** Fluorescence microscopy using FM4-64 and DAPI stains on AP-01 treated *Bacillus subtilis* DSM402 cells **87**

**Figure 5.5:** Fluorescence microscopy using FM4-64 and SYTOX Green stains on AP-01 treated *Bacillus subtilis* DSM402 cells **87**

**Figure 5.6:** Three dimensional PCA graph, PC1 (49.22%), PC2 (21.73%) and PC3 (12.55%), using unweighted variables from protein synthesis inhibitors, membrane active compounds and polyherbal formulation AP-01 when treated upon *Escherichia coli* cells. **89**

**Figure 5.7:** A scree plot of eigenvalue and cumulative variability (%) of all factors in PCA of data from treatment to *Escherichia coli* cells. **89**

**Figure 5.8:** Three dimensional PCA graph, PC1 (43.29%), PC2 (20.18%) and PC3 (12.63%), using unweighted variables from protein synthesis inhibitors, membrane active compounds and polyherbal formulation AP-01 when treated upon *Bacillus subtilis* cells. **90**

---

<b>Figure 5.9:</b> A scree plot of eigenvalue and cumulative variability (%) of all factor in PCA of data from treatment to <i>Bacillus subtilis</i> cells.	<b>90</b>
<b>Figure 5.10:</b> Cluster map of AP-01, polyherbal formulation (PHF) combining PC1, PC2 and PC3 values of from both the PCAs of treated and untreated <i>Escherichia coli</i> and <i>Bacillus subtilis</i> cells depicting AP-01 s presence in the cluster of bacterial protein synthesis inhibitors Kanamycin and Amikacin, suggestive of main mode of action of AP-01.	<b>91</b>
<b>Figure 5.11 A:</b> Scanning electron micrograph of untreated <i>Bacillus subtilis</i> cells	<b>92</b>
<b>5.11 B:</b> SEM image of AP-01 treated <i>Bacillus subtilis</i> showing effect of AP-01 on membrane.	<b>92</b>
<b>Figure 5.12 A:</b> Scanning electron micrograph of untreated <i>Klebsiella pneumoniae</i> PB12 cells	<b>93</b>
<b>Figure 5.12 B:</b> SEM image of AP-01 treated <i>Klebsiella pneumoniae</i> PB12 showing effect of AP-01 on membrane structure.	<b>94</b>
<b>APPENDIX</b>	
<b>Figure A 1.1:</b> Comparison of growth of <i>Klebsiella pneumoniae</i> PB12 (oligotrophic) bacteria between untreated and treated with PHF, AP-01 keeping similar growth parameters.	<b>120</b>
<b>Figure A 1.2:</b> Image of dried <i>Holarrhena antidysenterica</i> bark	<b>120</b>
<b>Figure A 1.3:</b> Image of dried bark of <i>Gmelina arborea</i>	<b>121</b>
<b>Figure A 1.4:</b> Image of dried flowers of <i>Woodfordia fruticosa</i>	<b>121</b>
<b>Figure A 1.5:</b> Image of dried flowers of <i>Madhuca indica</i>	<b>122</b>
<b>Figure A 1.6:</b> Image of dried fruits of <i>Vitis vinifera</i>	<b>122</b>
<b>Figure A 2.1:</b> Hydro-alcoholic extracts of individual plant components of AP-01	<b>123</b>
<b>Figure A 3.1:</b> General therapeutic algorithm for diarrhea	<b>124</b>

---

<b>Figure A 3.2:</b> Broth dilution assay of GTPR strain <i>Escherichia coli</i> 01241	125
<b>Figure A 3.3:</b> Broth dilution assay of GTPR strain <i>Salmonella typhi</i> 01396	125
<b>Figure A 3.4:</b> Broth dilution assay of GTPR strain <i>Shigella boydii</i> 01399	126
<b>Figure A 3.5:</b> Broth dilution assay of GTPR strain <i>Salmonella typhi</i> 01263	126
<b>Figure A 4.1:</b> Graphical representation of better wound healing by AP-01 in terms of lower residual wound area after 14 days of intervention	127
<b>Figure A 4.2:</b> Graphical representation of better wound healing by AP-01 on <i>Pseudomonas aeruginosa</i> HW01 infected burn wound in terms of lower residual wound area after 14 days of intervention	128
<b>Figure A 4.3:</b> Comparative growth study of <i>Klebsiella pneumoniae</i> PB12 (a facultatively oligotrophic bacterium isolated from river water, reported for diverse oligotrophic traits) without presence of AP-01 (control) and in the presence of 25%, 50% and 100% of MIC of AP-01 represented in a time (in hours) vs viable cell count [ Log (CFU/mL)] graph.	128
<b>Figure A 4.4:</b> Comparative growth study of <i>Klebsiella pneumoniae</i> PB12 without presence of AP-01 and in presence of 25%, 50% and 100% of MIC of AP-01 represented in a time (in hours) vs Optical density at 600nm wave length graph.	129
<b>Figure A 4.5:</b> Comparative growth study of <i>Klebsiella pneumoniae</i> PB12 strain without presence of AP-01 and in presence of 25%, 50% and 100% of MIC of AP-01 represented in a time (in hours) vs viable cell count (CFU/mL) graph.	129
<b>Figure A 5.1:</b> AP-01 treated <i>Bacillus subtilis</i> DSM402 cells during fluorescence microscopy	133
<b>Figure A 5.2:</b> AP-01 treated <i>Escherichia coli</i> K12 cells during fluorescence microscopy	134
<b>Figure A 5.3:</b> Kanamycin treated <i>Escherichia coli</i> K12 cells during fluorescence Microscopy	134
<b>Figure A 5.4:</b> Linezolid treated <i>Escherichia coli</i> K12 cells during fluorescence microscopy	135
<b>Figure A 5.5:</b> Chloramphenicol treated <i>Escherichia coli</i> K12 cells during fluorescence Microscopy	135
<b>Figure A 5.6:</b> Ampicillin treated <i>Escherichia coli</i> K12 cells during fluorescence	

---

Microscopy	136
<b>Figure A 5.7:</b> Rifampicin treated <i>Escherichia coli</i> K12 cells during fluorescence	
Microscopy	136
<b>Figure A 5.8:</b> Amikacin treated <i>Bacillus subtilis</i> DSM402 cells during fluorescence	
microscopy	137
<b>Figure A 5.9:</b> Cefuroxime treated <i>Bacillus subtilis</i> DSM402 cells during fluorescence	
Microscopy	137
<b>Figure A 5.10:</b> Tetracycline treated <i>Bacillus subtilis</i> DSM402 cells during	
fluorescence microscopy	138
<b>Figure A 5.11:</b> Nalidixic acid treated <i>Bacillus subtilis</i> DSM402 cells during	
fluorescence microscopy	138
<b>Figure A 5.12:</b> Levofloxacin treated <i>Bacillus subtilis</i> DSM402 cells	
during fluorescence microscopy	139

## Abbreviations

---

AGORA	Antimicrobials: A Global Alliance for Optimizing their Rational Use in Intra-Abdominal Infections
AK	Amikacin
AMC	Amoxicillin
AMP	Ampicillin
AT	Aztreonam
BCP	Bacterial Cytological Profiling
CAZ	Cephazolin
CDC	Centre for Disease Control and Prevention
CIP	Ciprofloxacin
CLSI	Clinical Laboratory Standards Institute
CPM	Cefepime
CRP	C-reactive protein
CTX	Ceftriaxone
D	Doxycycline
DAPI	4',6-diamidino-2-phenylindole
DEC	<i>diarrheagenic Escherichia coli</i>
DMSO	Di methyl sulphoxide
DNA	Deoxy-ribo Nucleic Acid
DOR	Doripenem
eCDC	European Centre for Disease Control and Prevention
E	Erythromycin
EAEC	<i>enteroaggregative Escherichia coli</i>
EHEC	<i>enterohemorrhagic Escherichia coli</i>
EIEC	<i>enteroinvasive Escherichia coli</i>
EPEC	<i>enteropathogenic Escherichia coli</i>
ETEC	<i>enterotoxigenic Escherichia coli</i>
EUCAST	European Committee on Antimicrobial Susceptibility Testing

FDA	Food and Drug Administration
FTIR	Fourier Transform Infra-Red
GFP	Green Fluorescent Protein
GI	Gastro Intestinal
GTPR	Gastro-intestinal Tract Pathogens Repository
HCS	High-Content Screening
ICMR	Indian Council of Medical Research
IEC	intestinal epithelial cell line
K	Kanamycin
Kg	Kilo gram
LB	Luria Bertani broth
LBDD	Ligand-based drug design
LCMS	Liquid Chromatography Mass Spectrometry
LE	Levofloxacin
µg	microgram
µl	microliter
ml	milliliter
MAR	Multiple Antibiotics Resistant
MBC	minimum bactericidal concentration
MHA	Muellar-Hinton agar
MIC	minimum inhibitory concentrations
MOA	Mode of Action
MRP	Meropenem
MS	Mass Spectrometry
MTCC	Microbial Type Culture Collection Center
MTT	(3-[4,5-dimethylthiazol-2-yl]-2,5 diphenyl tetrazolium bromide)
nm	nano meter

NA	Nalidixic acid
NCBI	National Center for Biotechnology Information
NDA	New Drug Application
NICED	National Institute of Cholera and Enteric Diseases
NMR	Nuclear Magnetic resonance
NOR	Norfloxacin
OFX	Ofloxacin
ORT	oral rehydration therapy
PBS	Phosphate Buffer Saline
PCA	Principal component analysis
PCR	Polymerase Chain Reaction
PHF	Poly Herbal Formulations
PIT	Piperacillin/Tazobactam
PLC	Public Limited Company
PRWA	Percent residual wound area
R & D	Research and Development
RCPA	Retail chemist prescription audit
RIE	rat intestinal epithelial
RNA	Ribo Nucleic Acid
S	Streptomycin
SBDD	Structural-based drug design
SD	Standard deviation
S.E.M	Standard Error of Mean
SEM	Scanning Electron Microscopy
SXT	Sulphamethoxazole Trimethoprim
Usaid	United States Agency for International Development
v/v	volume per volume
WHO	World Health Organization