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The Spread of Emerging Contaminants in the Soil-Groundwater System

Lucia Feriancikova
University of Wisconsin-Milwaukee

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by

Lucia Feriancikova

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ABSTRACT

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by

Lucia Feriancikova

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In recent years the risks of emerging contaminants (ECs) have received substantial attention as potential environmental pollutants that persist in the environment due to their continual release. This research presents the work of three studies that provide critical insight into the spread of ECs, particularly antibiotic resistant bacteria derived from dairy manure and potentially harmful particles originated from nanomaterials in the soil-groundwater system. The adhesion of particles to mineral surfaces was quantified with the extended Derjaguin-Landau-Verwey-Overbeek (XDLVO) theory that includes Lifshitz-van der Waals, Lewis acid-base, electrostatic double layer and steric repulsion interactions. The transport of ECs was conducted in column transport experiments and the quartz sands served as the porous media.

The first study specifically evaluated the effects of outer membrane protein (OMP) TolC on the transport of *E.coli* within saturated sands. The results showed that OMP TolC altered the surface tension components of *E.coli* cells which eventually led to higher

mobility when the ionic strength was 20 mM or higher, suggesting that antibiotic resistant bacteria expressing OMP TolC could spread more widely within sandy aquifers. The second study evaluated the transport of manure-derived tetracycline resistant (tet^R) and susceptible (tet^S) *E.coli* in unsaturated porous media with specific focus on pore-water chemistry and moisture content. The experimental results showed that under both high and low soil moisture content terms, tet^R *E.coli* displayed higher mobility than tet^S *E. coli* under higher ionic strength conditions. An increase in soil moisture content from 0.12 to 0.23 as well as decrease in ionic strength of solution led to minimal release of previously retained *E. coli* cells. A transport model was fitted to the experimental results using the computer program HYDRUS-1D.

The third study detailed deposition and remobilization of graphene oxide (GO) nanoparticles within saturated sands. The kinetics of GO was examined as a function of ionic strength and the remobilization of previously retained GO particles was investigated via chemical perturbation. The results revealed that deposition of GO particles on the surface of the quartz sands was highly dependent on ionic strength while the retention was limited by GO particles deposition capacities. The results of chemical perturbation suggested that GO particles could be remobilized in aqueous environment.

The combined results from these three studies highlight the potential of ECs being spread in the soil-groundwater system and therefore pose serious public health risks.

To my parents

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

A	Hamaker constant (mJ m^{-2})
a_b	Radius of bacterial cells (nm)
AB	Acid-Base intertaction
C	Effluent concentration of *Escherichia coli* or graphene oxide suspension (cell/mL)
C_o	Influent concentration of *Escherichia coli* or graphene oxide suspension (cell/mL)
C_T	Concentration of tracer in the pore water (μg/cm^{-3})
c_m	Solute (μg/cm^{-3}) or cell concentration (cell/mL) of mobile region
c_{im}	Solute (μg/cm^{-3}) or cell concentration (cell/mL) of immobile region
D	Dispersion coefficient (m^2 s^{-1})
e	Electron charge
EDL	Electrostatic Double Layer interaction
$\Delta G_{h_0}^{AB}$	Hydrophobicity interaction free energies per unit area (J m^{-2})
ΔG_{iwi}	Free energy of interaction between two cells in water
h	Separation distance between two surfaces interacting together (nm), water pressure head (kg/m.s^2)
h_0	Minimum equilibrium distance between the cell and sand surface due to repulsion (nm)
i	Subscript representing known surface tension parameter for water, sand or bacteria
I	Ionic strength
k	Boltzmann's constant
k_a	First-order deposition (attachment) rate coefficient (min^{-1})

k_d Deposition rate coefficient, the first-order entrainment (detachment) rate coefficient (min^{-1})

k_r Release rate coefficient (min^{-1})

$\mathrm{K(h)}$ Unsaturated hydraulic conductivity (cm min^{-1})

K_r Relative hydraulic conductivity (-)

K_s Saturated hydraulic conductivity (cm min^{-1})

l Empirical coefficient

L Length of the column representing the packed bed (cm), length of the brush (e.g. LPS) (nm)

L_C Length of bacterial cell (µm)

LW Lishitz-van der Waals interaction

n Porosity of the silica sands, the empirical coefficient

N_A Avogadro's constant

s Average distance between anchoring sites (e.g. LPS) (nm)

S Total concentration of the solute content, concentration of retained graphene oxide particles, quantity of immobilized *Escherichia coli* cells in the solid phase (N_c M^{-1})

S_0 Maximum concentration of retained graphene oxide particles (µg/g)

t Time (min)

T Absolute temperature (K)

q Specific discharge (cm/min), volumetric flux density

v Average linear pore water velocity, specific discharge (cm/min)

ω First-order mass transfer rate between mobile and immobile regions (min^{-1})

W_C Width of bacterial cell (µm)

x Spatial coordinate (cm)

α Empirical coefficient

γ_i^L Interfacial tension parameter for each probe liquid (water, glycerol, and diiodomethane)

γ_i^+ Electron accepting interfacial tension parameter

γ_i^- Electron donating interfacial tension parameter

γ_b^{LW} Interfacial tension parameter of bacteria (θ)

γ_s^{LW} Interfacial tension parameter of sand (mJ m^{-2})

γ_w^{LW} Interfacial tension parameter of sand (mJ m^{-2})

ε Porosity of the sand

ε_0 Dielectric permittivity of vacuum

ε_w Dielectric constant of water

θ Contact angle (deg)

θ Volumetric moisture or water content (cm^3 cm^{-3} min^{-1})

θ_m Mobile region water content

θ_{im} Immobile region water content

κ^{-1} Debye length (nm)

λ Characteristic wavelength (nm)

λ_w Characteristic decay length for AB interactions in water (nm)

π Pi

ρ Soil bulk density (kg m^{-3})

$\boldsymbol{\Phi}^{AB}$ Acid-Base intertaction energy (J)

$\boldsymbol{\Phi}^{EDL}$ Electrostatic Double Layer interaction energy (J)

$\boldsymbol{\Phi}^{LW}$ Lishitz-van der Waals interaction energy (J)

$\boldsymbol{\Phi}^{steric}$ Steric repulsion interaction energy (J)

$\boldsymbol{\Phi}^{total}$ Total interaction energy (J)

ψ_b Surface potential of bacterial cells (V)

ψ_p Surface potential of particles (e.g. graphene oxide) (V)

ψ_s Surface potential of sand (V)

ζ Zeta potential or surface charge potential

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CHAPTER 1

Introduction

1.1 Introduction

According to World Health Organization (WHO), waterborne diseases claim the lives of 1.8 million people globally each year from which 90% are children under the age of 5 [WHO, 2011a]. Millions of people are exposed to dangerous levels of biological and chemical contaminants in drinking water due to inadequate management of urban, industrial or agricultural wastewater. Global driving forces including climate change, population growth, demographic changes and urbanization as well as the negative side effects of technological advancement will most likely increase the risk of contaminants exposure in drinking water supplies. In order to minimize the health risks associated with waterborne diseases and deaths, safe drinking water should be among the highest priorities for every nation on earth.

Water quality also represents a public health concern in the United States as well. Since the Congress passed the Safe Drinking Water Act in 1974, many chemicals have been regulated and contamination caused by pathogenic bacteria was significantly reduced. A huge number of new and unregulated chemicals and contaminants, however, are continuously being released into the environment. According to Environmental Protection Agency (EPA), more than 60,000 chemicals are used within the United States. Hundreds of them have become a health concern for the risk they pose to human and biota.

This research focuses on the spread of two groups of emerging contaminants within the subsurface system. The first group is associated with bacterial antibiotic resistance derived from livestock manure. The second group represents potentially harmful nanomaterials. The overall goal of this research is to better understand the fate and transport characteristics of manure-derived antibiotic resistant bacteria (ARB) as well as nanoparticles under varying physical and chemical conditions in the soil-groundwater environment.

1.2 Spread of antibiotic resistant bacteria in the soil-groundwater system

In the United States, the meat production and consumption tripled over the last four decades and increased 20 percent in just the last 10 years [Worldwatch Institue, 2013]. As a result, the structure of animal agriculture has significantly changed, shifting to larger and more concentrated feeding operations. In order to reduce the impact of disease and promote the growth in animal husbandry, large quantities of antibiotics are commonly used in animal feed. For instance, in the United States, the use of antibiotics for livestock and poultry increased from approximately one million pounds in 1950 to as much as 44 million pounds in 1986 [USEPA 2005; Levy, 1992; U.S. Congress, OTA, 1995; McEwen and Fedorka-Cray, 2002]. As a consequence, high levels of antibiotics contributed to emergence of antibiotic resistance bacterial pathogens in the environment. Several published studies have shown the occurrence of pathogenic bacteria (human and animal origin) resistant to major classes of antibiotics. For instance Schroeder et al. [2002] tested 752 *E.coli* isolates from humans and animals for resistance to several antibiotics of clinical importance. Approximately half of the isolates showed resistance to one or more antibiotics including penicillins, sulfonamides, cephalosporins, tetracyclines, and aminoglycosides, with the highest frequencies of antibiotic resistance in humans and turkeys and the lowest in non-food animals. Walczak et al. [2011] tested *E.coli* derived from the manure for their susceptibility to 7 representative antibiotics (e.g. Gentamicin, Ciprofloxacin, Cephalothin, Tetracycline, Erythromycin, Ampicillin and Sulfomethoxazole) and found the resistance to all major lines of antibiotics.

Because the antibiotics are only partially metabolized in the livestock and poultry, high concentrations are found in animal manure. In traditional livestock rearing, manure is spread onto land as a vital fertilizer for crops. Due to large animal waste production relative to local land areas, large volumes of manure are temporarily stored in waste storage pits. By way of precipitation, irrigation practices and storage pits leaks, ARB can be released to surface waters via runoff or they can infiltrate into the soil. Once they penetrate through the soil profile, they can reach and contaminate groundwater and pose risks to human health [Anderson and Sobsey, 2006; Campagnolo et al., 2002; Jongbloed and Lenis, 1998; Krapac et al., 2002; Sayah et al., 2005; Sapkota et al., 2007; Thurston-Enriquez et al., 2005]. The additional health risk can be amplified by the horizontal gene transfer when antibiotic resistance is passed to a diverse group of microorganisms [Levy, 1998]. This can lead to development and spread of multi-resistant bacteria that are difficult to treat with available antibiotics.

Small private wells in rural areas especially face the high risk of contamination by ARB via runoff or infiltration into soil. These areas depend on untreated or partially treated groundwater as the primary source of drinking water. Thus, they are more susceptible to microbial contamination. According the Center of Disease Control and Prevention (data collected from 1971 to 2006), a total of 52% of the waterborne diseases outbreaks were linked to the untreated or inadequately treated groundwater from which the majority was caused by microorganisms. The presence of ARB in drinking water sources has been already documented. Bacteria resistant to amoxicillin, chloramphenicol, ciprofloxacin, gentamicin, sulfisoxazole, and tetracycline were found in surface water sources of drinking water in Michigan and Ohio [Xi et al. 2009]. The findings from Xi et al. study showed higher levels of ARB in treated tap water compared to source water. It was suggested that bacteria continued to grow in the drinking water distribution system [Xi et al. 2009].

The transport of bacteria in saturated porous media has been studied extensively and the results suggest that their mobility is strongly influenced by a wide range of factors and processes such as properties of the solid matrix, water chemistry (e.g. ionic strength, pH), temperature, flow conditions, as well as cell type, motility, morphology and surface properties [Becker et al., 2004; Bolster et al., 2009; Foppen and Schijven, 2006; Gannon et al., 1991; Kim and Walker, 2009; Lawrence and Hendry, 1996; Mills et al., 1994; Torkzaban et al., 2008]. The study of Walczak et al. [2011a, b] ***hypothesized*** that outer membrane protein (OMP) TolC in *E.coli* strains associated with antibiotic resistance increased the mobility within saturated quartz sands. This finding indicated that the potential effects that OMP TolC could have on the mobility of bacterial cells, and thus contribute to the spread of antibiotic resistant bacteria in groundwater system.

Leaching through the unsaturated soils is an important pathway through which bacteria can reach the underlying groundwater aquifers. Within the unsaturated soils, the bacterial cells are exposed to various stresses that can have impact on their mobility [Walczak et al., 2012b]. The processes and factors that influence the mobility of bacteria in partially saturated porous media are usually more complicated within the vadose zone than saturated soil due to the presence of air-water interfaces. The most critical factors that affect deposition of colloid-sized particles are: (i) volumetric moisture content associated with air-water interfaces that provide an important adsorption sites for retention; (ii) flow rate; (iii) porewater ionic strengths; and (iv) colloid as well as grain size and composition [Wan and Wilson, 1994; Wan and Tokunaga, 1997; Saiers and Lenhart, 2003].

Many uncertainties and gaps are in knowledge of fate and transport of ARB in natural environment. This work aims to contribute to better understanding of mechanisms and processes that govern the mobility of ARB in soil-groundwater system. The study is focused on factors influencing the effects of cell surface properties, particularly OMP TolC on transport of *E.coli* within saturated porous media. This protein was associated with enhanced resistance to antimicrobial agents (i.e. tetracycline, erythromycin, ampicillin, kanamycin) [de Cristobal et al., 2006; Chollet et al., 2004;

Fralick, 1996; Nishino et al., 2003], and was previously reported to potentially enhance the mobility of *E.coli* within saturated sands [Walczak et al., 2011a; 2011b]. In this research, I investigate the effects of soil-water content and pore water chemistry on the transport of tetracycline resistant (tet^R) and tetracycline susceptible (tet^S) *E.coli* under steady-state and transient flow. The study is complemented by developing and testing a mathematical model describing the transport of tet^R and tet^S *E.coli* isolates under steady-state flow conditions.

1.3 The transport of potentially toxic particles derived from nanomaterials

In the past decade, a new group of industrial synthetic materials (nanomaterials) of unique properties was manufactured to offer advancement in sectors such as medicine, consumer products, energy materials, and manufacturing. These materials are assembled from particles (nanoparticles) in an unbound state that have at least one dimension between 1 and 100 nm [NNI, 2006a, b, c]. The nanoparticles were intentionally engineered to have specific physical (e.g. mechanical strength, elasticity) and chemical (e.g. chemical reactivity, melting temperature, or electrical conductivity) properties that are mainly due to their large surface area per unit of volume. However the research shows that physicochemical characteristics (i.e. size, shape, surface area, charge, solubility, oxidant generation potential and degree of agglomeration) of some nanoparticles can influence their effects in biological systems [NIOSH, 2009].

It is predicted that the manufacturing, transport, application and disposal practices of nanomaterials will inevitably lead to their release into the natural environment. There are many uncertainties associated with the fate of nanomaterials released to the natural environment. Nanoparticles can be sorbed to the soil matrix and become immobile or they can travel further and enter the groundwater system. The strength of sorption to soil is dependent on the size, chemistry, applied particle surface treatment, and the conditions under which they are applied.

The primary focus of this research is to investigate the transport of graphene oxide (a single layer of hexagonal packed carbon atoms) within saturated porous media. This nanomaterial has attracted increasing attention for its unique properties and has potential to become the first realistic commercial product in recent years [Berger, 2008]. Graphene has been described as a chemically stable and biologically recalcitrant material. As a result of its shape and large surface area, it has a great potential to be toxic. Recent studies show significant toxicity via proposed toxic mechanisms such as oxidative stress, physical cell membrane damage as well as attachment to cell membranes [Zhang et al., 2010; Akhavan and Ahaderi, 2010; Wang et al., 2011; Hu et al., 2011]. These studies imply that graphene oxide should be regarded as a potential environmental and health hazard and studied further from a risk perspective. Thus, it is important to investigate more thoroughly the factors influencing the mobility and toxicity of graphene oxide nanoparticles. The scope of this research is to examine the effects of ionic strength of solution on the mobility of graphene oxide within saturated packed sands as well as its remobilization due to chemical perturbation.

1.4 Research objectives

The primary object of the present work is to investigate the factors influencing the mobility of contaminants of emerging health concern: manure- derived antibiotic resistant bacteria and potentially toxic nanoparticles through unsaturated and saturated porous media using flow through column system.

The proposed research is divided into specific objectives:

- to quantify the effects of OMP *TolC* on the transport of *E.coli* within saturated sands
- to investigate the effects of pore water chemistry and soil moisture content on the mobility of tetracycline resistant (tet^R) and susceptible (tet^S) *E.coli* within partially saturated sands under steady-state flow condition
- to study the remobilization of retained bacterial cells within partially saturated sands under chemical (reduction in ionic strength) and physical (increase in flow rate) perturbation
- to examine graphene oxide (GO) deposition kinetics under various ionic strength conditions within saturated quartz sands
- to determine remobilization kinetics of previously retained GO nanoparticles due to chemical perturbation

- to explain mobility of *E.coli* cells and GO nanoparticles through the energy interactions between each contaminant and the surface of sands using extended DLVO (XDLVO) calculations

1.5 Dissertation organization

This study is organized into separate, stand-alone chapters representing relatively independent topics of the research interest. The chapters are structured with their own introduction, methods, experimental results, discussion and conclusion. Some of the chapters represent recently published manuscripts.

Chapter 2 represents the review of extended Derjaguin-Landay-Verwey-Overbeek (XDLVO) theory and its applications. It describes DLVO and non-DLVO interaction forces and their calculations. The equations presented in the chapter were used to calculate interaction energies between bacterial cell-sand and GO-sand surfaces. In addition, the chapter summarizes and describes techniques used to determine surface properties of bacterial cells, sands and GO in this research.

Chapter 3 is associated with the effects of OMP *TolC* on *E.coli* transport within sands saturated with various concentrations of NaCl solution. The transport results of wild-type *E.coli* K12 strain with TolC protein are compared to *E.coli* K12 transposon mutant (*tolC::kana*) and the markerless deletion mutant (*ΔtolC*). The effect of kanamycin resistance on the transport is investigated as well. The contact angle and zeta potential measurements are used to determine the hydrophobic force parameter between bacterial cell corresponding to each *E.coli* K12 strain and the surface of quartz sands. The XDLVO calculations are used to explain the transport behavior of three *E.coli* strains within saturated sands.

Chapter 4 corresponds to tet^R and tet^S *E.coli* transport in vadoze zone. The emphasis is placed on the role of soil moisture content, pore water chemistry and dynamic processes as chemical perturbation and imbibition. The results of tet^R *E.coli* are compared to those of tet^S *E.coli* isolate to investigate the possible relationship between cell surface properties and physico-chemical properties of liquid and air. The effects of various soil moisture content and pore water chemistry on the bacterial transport is evaluated by application of contaminant transport model simulations using HYDRUS 1D program.

Chapter 5 deals with the deposition kinetics of GO particles within saturated sand pack under various concentrations of electrolyte solution. The remobilization of previously retained GO particles due to reduction of electrolyte concentration is examined as well. The Langmuir-type of transport model is applied to describe transport behavior of GO within saturated sands. The surface potentials, interfacial tension parameters and the size of the GO particles are measured to calculate the interaction energies between GO particles and quartz sands using XDLVO theory. The deposition and remobilization of GO particles within saturated quartz sands is explained through XDLVO interaction energy profiles.

1.6 References

Aardema, B.W., Lorenz, M.G., and Krumein, W.E. Protection of sediment-adsorbed transforming DNA against enzymatic inactivation. *Appl. Environ. Micorbiol*., **1983**, 46, 417-420.

Akhavan. O.; and Ghaderi, E. Toxicity of graphene and graphene oxide nanowalls against bacteria, *ACS Nano*, **2010**, 4, 5731 – 5736.

Anderson ME, Sobsey MD. Detection and occurrence of antimicrobially resistant E. coli in groundwater on or near swine farms in eastern North Carolina. *Water Sci. Tech*., **2006** 54:211–218.

Becker, M.W., Collins, S.A., Metge, D.W., Harvey, R.W., Shapiro, A.M. Effect of cell physicochemical characteristics and motility on bacterial transport in groundwater. *Journal of Contaminant Hydlology* **2004**, 69, 195 – 213.

Berger, M. LCDs might be graphene's first realistic commercial product. Electronic article published by Nanowerk, 2008 (http://www.nanowerk.com).

Bolster, C.H., Haznedaroglu, B.Z., Walker, S.L. Diversity in cell properties and transport behavior among 12 different environmental *Escherichia coli* isolates. *Journal of Environmental Quality* **2009**, 38, 465 – 472.

Campagnolo, E.R.; Johnson, K.R.; Karpati, A.; Rubin, C.S.; Kolpin, D.W.; Meyer, M.T. Antimicrobial residues in animal waste and water resources proximal to large-scale swine and poultry feeding operations. *Sci Total Environ*., **2002**, 299, 89–95.

Chollet, R., Chevalier, J., Bryskier, A. and Pages, J.M. The AcrAB-TolC pump is involved in macrolide resistance but not in telithromycin efflux in *Enterobacter aerogenes* and *Escherichia coli*. *Antimicrobial Agents and Chemotherapy* **2004**, 48(9), 3621-3624.

de Cristobal, R.E.; Vincent , P.A. and Salomon, R.A. Multidrug resistance pump AcrAB-TolC is required for high-level, Tet(A)-mediated tetracycline resistance in *Escherichia coli. Journal of Antimicrobial Chemotherapy* **2006**, 58(1), 31 – 36.

Environmental Protection Agency (EPA), **(2005)**. Operations: Review. EPA/600/R-06/021 September2005. U.S. Environmental Protection Agency, Cincinnati, OH 45268 .

Environmental Protection Agency (EPA), **(2013)**. U. S. Contaminants of Emerging Concern (CEDs) in Fish: Polybrominated Diphenyl Ethers (PBDEs). EPA-820-F-13-003.

Foppen, J.W., Schijven, J.F. Evaluation of data from the literature on the transport and survival of *Escherichia coli* and thermotolerant coliforms in aquifers under saturated coditions. *Water Research* **2006**, 40, 401 – 426.

Fralick, J.A. Evidence that TolC is required for functioning of the Mar/AcrAB efflux pump of *Escherichia coli*. *Journal of Bacteriology* **1996**, 178(19), 5803-5805.

Gannon, J.T., Manilal, V.B., Alexander, M. Relationship between cell-surface properties and transport of bacteria through soil. *Applied and Environmental Microbiology* **1991**, 57, 190 – 193.

Hu, W.B.; Fan, C.H.; Peng, C.; Lv, M.; Li, X.M.; Zhang, Y.J.; Chen, N.; Huang, Q. Protein corona-mediated mitigation of cytotoxicity of graphene oxide, *ACS Nano* **2011**, 5, 3693 – 3700.

Jongbloed AW, Lenis NP. Environmental concerns about animal manure. *J. Anim. Sci.,* **1998**, 76, 2641–2648.

Kim, H.N., Walker, S.L. *Escherichia coli* transport in porous media: Influence of cell strain, solution chemistry, and temperature. *Colloids and Surfaces B-Biointerfaces* **2009**, 71, 160 – 167.

Krapac, I.G.; Dey, W.S.; Roy, W.R.; Smyth, C.A.; Storment, E.; Sargent, S.L. Impacts of swine manure pits on groundwater quality. *Environ Pollution*, **2002**, 120, 475–492.

Lawrence, J.R., Hendry, M.J. Transport of bacteria through geologic media. *Canadian Journal of Microbiology* **1996**, 42, 410 – 422.

Levy, S.B. The challenge of antibiotic resistance. *Scientific American*, **1998**, 278(3), 46 - 53.

Levy, S.B. The antibiotic paradox. How miracle drugs are destroying the miracle. New York: Plenum Press, **1992**.

McEwen, S.A. and P.J. Fedorka-Cray. Antimicrobial use and resistance in animals, In: The need to Improve Antimicrobial Use in Agriculture: Ecological and Human Health Consequences, M. Barza and S.L. Gorbach (Eds.), *Clin. Infect. Dis.,* **2002***,* 34,(3), 93-106.

Mills, A.L., Herman, J.S., Hornberger, G.M., Dejesus, T.H. Effect of solution ionic-strengths and iron coatings on mineral grains on the sorption of bacterial-cells to quarz sand. *Applied and Environmental Microbiology* **1994**, 60, 3300 – 3306.

Nishino, K., Yamada, J., Hirakawa, H., Hirata, T. and Yamaguchi, A. Roles of TolC-dependent multidrug transporters of *Escherichia coli* in resistance to beta-lactams. *Antimicrobial Agents and Chemotherapy* **2003**, 47(9), 3030-3033.

National Nanotechnology Initiative. (**2006a)**. What is Nanotechnology? (http://www.nano.gov/html/facts/home_facts.html).

National Nanotechnology Initiative. (**2006b)**. About the NNI. (http://www.nano.gov/html/about/home_about.html)

National Nanotechnology Initiative. (**2006c)**. Environmental, Health and Safety Research Needs for Engineered Nanoscale Materials. (http://www.nano.gov)

Niosh, N. I. (2009). Approaches to Safe Nanotechnology. Managing the Health and Safety Concerns Associated with Engineered Nanomaterials. *DHHS (NIOSH)*, **2009,**125.

Romanowski, G.; Lorenz, M.G.; Wackernagel, W. Adsorption of plasmid DNA to mineral surfaces and protection against DNase I. *Appl. Evniron. Microbiol.,* **1991**, 57, 1057-1061.

Saiers, J.E., and Lenhart, J.J. Ionic-strenght effects on colloid transport and interfacial reactions in partially saturated porous media. *Water Resour. Res*. **2003**, 39, 1256. doi:10.1029/2002WR0011887.

Sapkota, A.R.; Curriero, F.C.; Gibson, K.E. and Schwab, K.J. Antibiotic-resistant enterococci and fecal indicators in surface water and groundwater impacted by a concentrated swine feeding operation. *Environmental Health Perspectives*, **2007**, 115, (7), 1040-1045.

Sayah, R.S.; Kaneene, J.B.; Johnson, Y.; Miller, R. Patterns of antimicrobial resistance observed in *Escherichia coli* isolates obtained from domestic- and wild-animal fecal samples, human septage, and surface water. *Appl. Environ. Microbiol.,* **2005**, 71, 1394–1404.

Schroeder, C.M.; Zhao, C.; DebRoy, C.; Torcolini, J.; Shao, S.; White, D.G.; Wagner, D.D.; McDermott, P.F.; Walker, P.D.; and Meng, J. Antimicrobial resistance of *Escherichia coli* O157 isolated from humans, cattle, swine, and food, *Appl.Environ. Microbial*., **2002**, 68, 576-581.

Thurston-Enriquez J.A.; Gilley, J.E.; Eghball, B. Microbial quality of runoff following land application of cattle manure and swine slurry. *J. Water Health*, **2005**, 3, 157–171.

Torkzaban, S., Tazehkand, S.S., Walker, S.L., Bradford, S.A. Transport and fate of bacteria in porous media: Coupled effects of chemical conditions and pore space geometry. *Water Resources Research* **2008**, 44, W04403.

United States Congress. **(1995)**. Office of Technology Assessment, Impacts of Antibiotic-Resistant Bacteria, OTA-H-629 (Washington, DC: U.S. Government Printing Office, September 1995).

United States Environmental Protection Agency. **(2005)**. Detecting and Mitigating the Environmental Impact of Fecal Pathogens Originating from Confined Animal Feeding .

Walczak J.J., and Xu S.P. Manure as a Source of Antibiotic-Resistant *Escherichia coli* and *Enterococci*: a Case Study of a Wisconsin, USA Family Dairy Farm, *Water Air and Soil Pollution*, **2011**, 219, 579-589.

Walczak, J.J., Bardy, S.L., Feriancikova, L., Xu, S. Transport of *Escherichia coli* isolated from Lake Michigan in saturated porous media: Influence of tetracycline resistance. *Water Air and Soil Pollution* **2011a**, DOI: 10.1007/s11270-011-0825-6.

Walczak, J.J., Bardy, S.L., Feriancikova, L., Xu, S.P. Influence of tetracycline resistance on the transport of manure-derived *Escherichia coli* in saturated porous media. *Water Reserch* **2011b**, 45, 1681 – 1690.

Walczak, J.J., Wang, L., Bardy, S.L., Feriancikova, L., Li, J., Xu, S. The effects of starvation on the transport of *Escherichia coli* in saturated porous media are dependent on pH and ionic strength. *Colloids Surf B Biointerfaces* **2012a**, 90, 129 – 136.

Walczak, J.J., Wang, L., Feriancikova, L., Li, J., Xu, S. Influence of desiccation on the transport *of Escherichia coli* through saturated sand packs. *Water, Air & Soil Pollution* **2012b**, 223, 3, 1353-1362.

Wan, J., and Wilson, J.L. Colloid transport in unsaturated porous media. *Water Resour. Res.* **1994**, 30, 857 – 864.

Wan, J., and Tokunaga, T.K. Film straining of colloids in unsaturated porous media: Conceptual model and experimental testing. *Environ. Sci. Technol*. **1997**, 31, 2413 – 2420.

Wang, K.; Ruan, J.; Song, H.; Zhang, J.L.; Wo, Y.; Guo, S.W.; Cui, D.X. Biocampatibility of graphene oxide. *Nanoscale Res. Lett*. **2011**, 6.

World health Organization (WHO), **(2011a)**. Cause-specific mortality: regional estimates for 2008. Geneva, World Health Organization. (http://www.who.int/healthinfo/global burden disease/estimates regional/en/index.html)

Worldwatch Institute, **(2013)**. Global Meat Production and Consumption Continue to rise. New analysis highlights importance of limiting industrial livestock production to improve personal and environmental. (http://www.worldwatch.org/global-meat-production-and-consumption-continue-rise-1)

Xi, C., Y. Zhang, C. F. Marrs, W. Ye, C. Simon, B. Foxman, and J. Nriagu. Prevalence of antibiotic resistance in drinking water treatment and distribution systems. *Applied and Environmental Microbiology*, **2009**, 75, (17), 5714-5718.

Zhang, Y.; Ali, S.F.; Dervishi, E. Cytotoxicity effects of graphene and single-wall carbon nanotubes in neural phaeochromocytoma-derived pc 12 cells. *ACS Nano* **2010**, 4, 3181 – 3186.

CHAPTER 2

The Derjaguin-Landau-Verwey-Overbeek theory

2.1 Introduction

The adhesion of particles to solid surfaces is a critical process that determines the fate and mobility of the particles within the natural environment.

The classical Derjaguin-Landau-Verwey-Overbeek (DLVO) and related theories of colloid stability [Derjaguin and Landau, 1941; Verwey and Overbeek, 1948] have been commonly used in quantifying the energy interactions between particles and solid surfaces, which in turn strongly influence particle adhesion kinetics.

The aim of this chapter is to review the extended DLVO calculation, its application on the experimental observations, and the techniques used to characterize surface properties of bacterial cells. This chapter is organized into following sections: bacterial adhesion, XDLVO theory and its interactions, XDLVO calculation related to experimental observations and surface properties of bacterial cells.

2.2 XDLVO theory

The classical DLVO calculation takes into account two types of force: the Lifshitz-van der Waals (LW) force which is mostly attractive and the electrostatic double layer (EDL) force which depends on the surface charges of the colloids and the solid matrix. The extended DLVO theory considers the Lewis acid-base (AB) or hydrophobic interactions.

2.2.1 van der Waals interaction

The LW force is a long range dispersive force extending from 1.5 – 130 nm (Israelachvili and Tabor, 1972) and is dominant at small separation distances between two surfaces (e.g. bacterial cell and sand). Generally, LW force is insensitive to the ionic strength and pH of an electrolyte solution. The magnitude of vdW force is a function of Hamaker constant, A [J], which depends on the properties of the two interacting particles. The calculation of the Hamaker constant differs between microscopic objects (atoms) and macroscopic objects (with diameter greater than ~ 0.5 nm) [Lifshitz, 1955]. In the macroscopic method the atomic structure is ignored and the forces between large bodies are derived in terms of bulk properties such as their dielectric constants and refractive indices [Israelachvili and Tabor, 1972]. The current research deals with particles with diameter greater than ~ 0.5 nm and the van der Waals will be referred to as Lifshitz van der Waals forces (LW).

2.2.2 Electrostatic Double Layer interaction

Most surfaces immersed in electrolyte solution develop a surface charge. The charged surfaces create a concentration gradient in electrolyte solution called electrostatic double layer consisting of Stern and Gouy layers. When the surface charge is negative the concentration of counter-ions in Stern layer is the highest at the surface and decreases linearly with distance. The Gouy layer; also called diffuse layer, is where counter-ions diffuse freely with the distance however not linearly as in the Stern layer. The final surface charge is balanced through the equal number of co-ions and counter-ions. When two surfaces approach each other, the diffuse parts of their double layers start to interact. The resulting force prevailing between two charged surfaces such as surface of the sand and colloid particle is the EDL force. In contrary to LW force it is dominant at long separation distances and its magnitude is a function of pH solution or ionic strength.

The salt concentration or ionic strength of a solution affects two fundamental parameters important for EDL interaction. Zeta potential, ζ, represents the surface charge of particles and reflects the concentration of counter-ions in the double layer. It becomes less negative with increasing ionic strength. The second is the Debye-Hückel length, ϰ ($1/m^{-1}$), parameter describing the concentration of ions in the diffuse layer.

2.2.3 AB interaction

An acid-base interaction represents a hydrophobic force which arises due to the inability of hydrophobic molecules to form hydrogen bonds with water molecules. The interaction is based on proton transfer (proton acceptor or proton donor) to and from suitable groups in the solid- water interfaces, and is dependent on the separation distance as well as the hydrophobicity of the interacting groups.

It has been known that the resulting strong attraction between two hydrophobic groups (e.g. hydrocarbon chains) in aqueous media exceeds LW attraction. For instance, the interfacial energy of hydrophobic forces between hydrocarbons in water at room temperature was experimentally measured as ~ 10 kJ/mol, much higher than LW energy (~ 0.2 kJ/mol) [Ghosh, 2009]. As a result the hydrophobic force is probably the strongest of all physical nonspecific interaction forces.

Although AB interactions have been assumed short-range, direct measurements have shown that they may be up to two orders of magnitude greater than EL and LW interactions [van Oss et al.; van Oss, 1994; Butt et al., 1995]. For example, an experimentally measured longer range of hydrophobic-biospecific interaction between two mixed lipid bilayers was found to be a cause of stress (osmotic or mechanical) resulting in lateral expansion of bilayers into the aqueous phase. The stretched bilayers exposed additional hydrophobic groups to the aqueous phase, and thus resulted in an additional hydrophobic contribution to the adhesion force. It is interesting to note that hydrophobic force can arise locally. Specifically, the effect of stretching occurred through protein's conformational changes due to Ca^{2+} ion binding. [Israelachvili, 1992].

2.3 Calculation of energy interactions using XDLVO theory

The XDLVO theory can be expressed as the sum of LW (ϕ^{LW}), EDL (ϕ^{EDL}) and AB (ϕ^{AB}) forces:

$$\phi^{total} = \phi^{LW} + \phi^{EDL} + \phi^{AB} \qquad (1)$$

where ϕ^{LW}, ϕ^{EDL}, and ϕ^{AB} represent the interaction energies between two surfaces (particle and substrate) across a liquid medium. The total interaction potential can be then calculated as a function of distance between two surfaces interacting together.

For a sphere-plate system (e.g., bacterium-sand), the three forces can be calculated as [Redman et al., 2004]:

$$\phi^{\mathrm{LW}} = -\frac{Aa_b}{6h}\left[1-\frac{5.32h}{\lambda}ln\left(1+\frac{\lambda}{5.32h}\right)\right] \tag{2}$$

$$\phi^{\mathrm{EDL}} = \pi\varepsilon_0\varepsilon_w a_b\left\{2\psi_b\psi_s ln\left[\frac{1+\exp(-\kappa h)}{1-\exp(-\kappa h)}\right]+(\psi_b^2+\psi_s^2)ln[1-\exp(-2\kappa h)]\right\} \tag{3}$$

$$\phi^{\mathrm{AB}} = 2\pi a_b\lambda_w\,\Delta G_{h_0}^{AB} exp\left(\frac{h_0-h}{\lambda_w}\right) \tag{4}$$

For a plate-plate system (two flat surfaces, e.g. nanoparticle of plate shape – sand), the forces can be calculated as [Israelachvili, 1992]:

$$\phi^{\mathrm{LW}} = -\frac{A}{12\pi h^2} \tag{5}$$

$$\phi^{\mathrm{EDL}} = \frac{\varepsilon_0\varepsilon_w\kappa}{2}\left\{2\psi_p\psi_s\frac{1}{\sinh(\kappa h)}+\left(\psi_p^2+\psi_s^2\right)[1-\coth(\kappa h)]\right\} \tag{6}$$

$$\phi^{\mathrm{AB}} = \Delta G_{h_0}^{AB} exp\left(\frac{h_0-h}{\lambda_w}\right) \tag{7}$$

where A is the Hamaker constant reflecting the strength of van der Waals forces; a_b is the radius of bacterial cells; λ is the characteristic wavelength and was set as 42.5 nm; h is the separation distance between two surfaces interacting together (e.g. the cell and sand; graphene oxide particle and sand), where ε_0 is the dielectric permittivity of vacuum; ε_w is the dielectric constant of water; κ^{-1} is the Debye length ($(0.302/\sqrt{I})$ nm at 22 ^{o}C, *I*=ionic strength); ψ_b, ψ_p and ψ_s are the surface potentials of the bacterial cells, particle (graphene oxide) and sand, λ_w is the characteristic decay length for AB interactions in water and equals to 0.6 nm; h_0 represents the minimum equilibrium distance between the cell and sand surface due to repulsion and is equaled to 0.157 nm; and $\Delta G_{h_0}^{AB}$ represents the hydrophobicity interaction free energies per unit area corresponding to h_0.

The Hamaker constant was calculated from the LW interfacial tension parameters of bacteria (or graphene oxide with subscript, *p*) γ_b^{LW}, water γ_w^{LW} and sand γ_s^{LW} [van Oss, 1993]:

$$A = 24\pi h_0^2\left(\sqrt{\gamma_b^{LW}} - \sqrt{\gamma_w^{LW}}\right)\left(\sqrt{\gamma_s^{LW}} - \sqrt{\gamma_w^{LW}}\right) \tag{8}$$

The values of LW interfacial tension parameter for water (21.8 mJ m^{-2}) [Morrow et al., 2005], and quartz sand (39.2 mJ m^{-2}) were measured previously and have been used in this research [van Oss, 1993]. The γ_b^{LW} values were calculated from measured contact angles (θ).

The values of the Debye length vary with ionic strength and were calculated using the equation:

$$\kappa^{-1} = \sqrt{\frac{\varepsilon_0 \varepsilon_w kT}{2N_A I e^2}} \tag{9}$$

Where k is Boltzmann's constant, T is absolute temperature, N_A is the Avogadro number, I is ionic strength and e is the electron charge.

The theory of AB interactions is based on proton transfer thus for the free energy $\Delta G_{h_0}^{AB}$ calculations the values of electron accepting and electron donating interfacial tension parameters are required. For each liquid or solid interacting together a triplet components: γ_i^{LW}, γ_i^+, and γ_i^- have to be defined, where subscript i represents water, sand or bacteria. The surface free energy $\Delta G_{h_0}^{AB}$ of the material corresponding to liquid-solid adhesion can be written as [van Oss, 1993]:

$$\Delta G_{h_0}^{AB} = 2\left[\sqrt{\gamma_w^+}\left(\sqrt{\gamma_b^-} + \sqrt{\gamma_s^-} - \sqrt{\gamma_w^-}\right) + \sqrt{\gamma_w^-}\left(\sqrt{\gamma_b^+} + \sqrt{\gamma_s^+} - \sqrt{\gamma_w^+}\right) - \sqrt{\gamma_b^-\gamma_s^+} - \sqrt{\gamma_b^+\gamma_s^-}\right] \quad (10)$$

The previously reported values of electron accepting (γ_i^+) and electron donating (γ_i^-) interfacial tension parameters for water (25.5; 25.5 mJ m^{-2}) and sand (1.4; 47.8 mJ m^{-2}) were used in this research, respectively [van Oss, 1993; Morrow et al., 2005]. The values of interfacial tension parameter for bacterial cell had to be determined through measuring the contact angles (θ) using three different probe liquids (water, glycerol and diiodomethane) with known surface tension parameters [van Oss, 1993; Morrow et al., 2005]. The values of calculated contact angles for bacterial cells and reported values for water and sand were plugged into equation solving for each probe liquid separately:

$$\gamma_i^L(1 + cos\theta) = 2\sqrt{\gamma_i^{LW}\gamma^{LW}} + 2\sqrt{\gamma_i^+\gamma^-} + 2\sqrt{\gamma_i^-\gamma^+} \quad (11)$$

where the subscript i represents known surface tension parameter for each probe liquid: water ($\gamma_i^L = 72.8, \gamma^{LW} = 21.8, \gamma^+ = \gamma^- = 25.5$ mJ m^{-2}), glycerol ($\gamma_i^L = 64.0, \gamma^{LW} = 34.0, \gamma^+ = 3.92, \gamma^- = 57.4$ mJ m^{-2})and diiodomethane ($\gamma_i^L = 50.8, \gamma^{LW} = 50.8, \gamma^+ = \gamma^- = 0$ mJ m^{-2}) [van Oss, 1993].

The surface potential ($\psi_b, \psi_s,$) and size (a_b) of bacterial cells were required to be measured for LW, EDL and AB interaction energy calculations.

The size of bacterial cells was measured from images of cells suspended in the electrolyte solutions. The images were obtained using a Nikon Eclipse 50i microscope that was equipped with a Photometric CoolSnap ES digital camera and MetaMorph software. The width and length of a minimum of 30 cells was determined using the ImageJ software. The cells were suspended in a wide range of ionic strength solution to examine its effect on their size. Then the equivalent radii of the cells were calculated [Haznedaroglu, et al., 2008] as $\sqrt{\frac{L_C W_C}{\pi}}$, where L_C and W_C represent the length and width of the cell.

2.4 References

Butt, H.-J.; Jaschke, M.; and Ducker, W. Measuring surface forces in aqueous electrolyte solution with the atomic force microscope. *Bioelectrochem. Bioenerget*. **1995**, 38, 191 – 201.

Derjaguin, B.V.; Landay, L. *Acta Physicochim.* URSS **1941**, 14, 633

Ghosh, P. Colloid and Interface Science, *PHI Learning, New Delhi*, **2009**, Chapter 5.

Haznedaroglu, B.Z.; Bolster, C.H.; and Walker, S.L. The role of starvation of Escherichia coli adhesion and transport in saturated porous media. *Water Research* **2008**, 42, 1547 – 1554.

Israelachvili, J.N. Intermolecular and Surface Forces. Academic, New York. **1992**.

Lifshitz, E.M. The theory of molecular attractive forces between solids. *J. Exper. Theoret. Phys. USSR*, **1955**, 29, 94 – 110.

Morrow, J.B.; Stratton, R.; Yang, H.H.; Smets, B.F.; Grasso, D. Macro- and nanoscale observations of adhesive behavior for several *E.coli* strains (O157: H7 and environmental isolates) on mineral surfaces. *Environ. Sci. Technol*. **2005**, 39 (17), 6395 – 6404.

Redman, J.A.; Walker, S.L.; Elimelech, M. Bacterial adhesion and transport in porous media: Role of the secondary energy minimum. *Environ. Sci. Technol*. **2004**, 38 (6), 1777 – 1785.

Van Oss, C.J. Acid-base interfacial interaction is aqueous media. *Colloids Surfaces A: Physicochem. Eng. Aspects.* **1993**, 78, 1 – 49.

Van Oss, C.J. Interfacial Forces in Aqueous Media. *New York: Marcel Dekker*. **1994**.

Verwey, E.J.W.; Overbeek, J.Th.G. Theory of the Stability of Lyophobic Colloids. *Elsevier Publishing Company, Inc., Amsterdam*, **1948**.

CHAPTER 3

Effects of Outer Membrane Proteins (OMP) TolC on the Transport of Escherichia coli within Saturated Quartz Sands

3.1 Introduction

Groundwater accounts for ∼48% of the global drinking water supply [United Nations Water Development, 2009]. Groundwater, however, is susceptible to microbial contamination [Macler and Mercle, 2000; Macler and Pontius, 1997; Craun et al., 2010]. It was reported that since 1920, about 50% of the waterborne disease outbreaks in the U.S. were caused by contaminated, untreated, or inadequately treated groundwater [Craun et al., 2010]. Each year, groundwater contamination is responsible for an estimated 750 000 to 5.9 million illnesses and 1400–9400 deaths in the U.S. [Macler and Mercle, 2000]. A thorough understanding of the transport of microbial cells within groundwater systems is essential to the assessment of the public health risks associated with groundwater microbial contamination as well as the design, evaluation, and implementation of appropriate mitigation measures.

The outer membrane of Gram-negative bacteria such as *Escherichia coli* and *Salmonella* is composed of lipopolysaccharide (LPS), proteins, and filamentous structures such as fimbriae/pili and flagella [Madigan, and Brock, 2009] Several recent studies suggested that various bacterial surface structures could significantly influence the transport behavior of bacterial cells by affecting the attachment of the cells to aquifer solid matrix [Walczak et al., 2011b; Walczak et al., 2011a; Lutterodt et al., 2009; Kim et al., 2009a; Kim et al., 2009b; Haznedaroglu et al., 2010]. Haznedaroglu et al. [2010] reported that flagella could enhance the deposition of *Salmonella enterica* and thus lower its mobility within quartz sands. For *E. coli* O157:H7, Kim et al. [2009a, 2009b] observed that the surface macromolecules such as LPS could alter cell surface properties, cell–solid energy interactions, and subsequently cell transport behavior in saturated porous media. Lutterodt et al. [2009] suggested that the positive charges originating from OMP Ag43 could promote the attachment of *E. coli* cells to the negatively charged quartz surfaces and lower their mobility within quartz sands. Walczak et al.[2011a, 2011b] showed that tetracycline-resistant and tetracycline-susceptible *E. coli* strains that were isolated from various environmental sources displayed distinct OMP profiles and the tetracycline-resistant *E. coli* strains consistently showed higher mobility within saturated quartz sands. The OMP TolC, which has a molecular mass of ~52 kDa, was identified as a potential factor in reducing the deposition of *E. coli* to the surface of quartz sands. Recent studies on the relationship between cell outer membrane protein and transport within saturated porous media, however, were usually quantitative and speculative [Walczak et al., 2011a, b; Lutterodt et al., 2009].

TolC is the membrane component of several types of multidrug efflux pumps (e.g., the AcrAB-TolC pump), which are responsible for bacterial resistance to a variety of antibiotics such as tetracycline, erythromycin, and ampicillin [Chollet et al., 2004; de Cristobal et al., 2006; Fralick et al., 1996; Nishino et al., 2003]. The possibility that TolC could enhance the mobility of bacterial cells within the saturated porous media has broad environmental implications with regard to the spread of antibiotic resistant bacteria within groundwater aquifers and warrants further investigation. The primary goal of this research is to quantify the effects of OMP TolC on the transport of *E. coli* within saturated sands in an unambiguous manner using TolC deletion mutants. The

XDLVO theory was then applied to examine how OMP TolC influenced *E. coli* mobility through altering the energy interactions between the *E. coli* cells and the surface of sands.

3.2 Materials and methods

3.2.1 The E.coli Strains

In this research, the wild-type strain was *E. coli* K12 (strain W25113), which was used to make the Keio Collection of single-gene knockouts [Baba et al., 2006]. The strain JW5503 (tolC::kan) was obtained from the Keio collection: in this strain, the tolC open reading frame was replaced with a kanamycin cassette (amplified from plasmid pKD13) flanked by FLP recombination sites [Baba et al., 2006]. To construct the markerless deletion of tolC (i.e., to excise kanamycin resistance), *E. coli* JW5503 was transformed with plasmid pCP20, and the kanamycin resistant colonies were selected at 30 °C. pCP20 has temperature-sensitive replication and thermal induction of FLP recombinase expression [Cherepanov et al., 1995; Datsenko et al., 2000]. The transformants were cultured at 43 °C, after which the loss of both pCP20 and the kanamycin resistance cassette were confirmed via polymerase chain reaction (PCR) and ampicillin/kanamycin sensitivity testing. The markerless strain lacking TolC was referred to as ΔtolC.

The *E. coli* cells preserved in 20% glycerol under −80 °C was streaked onto Luria–Bertani (LB) (Fisher Scientific) agar plates. After overnight incubation at 37 °C, cells from a freshly formed colony were transferred to culture tubes containing 15 mL LB broth.

The culture tubes were shaken at 90 rpm and incubated at 37 °C for 6 h. The starter culture was used to inoculate LB broth (1:500 dilution ratio). Following the incubation at 37 °C for 18 h on an orbital shaker (90 rpm), the *E. coli* cells were harvested by centrifugation (4000 × g, 10 min, 4 °C). To remove the growth medium, the bacterial pellet was rinsed 4 times with the appropriate electrolyte solution. The concentration of cells was then adjusted to ∼4 × 107 cell/mL for the column transport experiments. The pH of the cell suspensions was ∼5.7.

3.2.2 Column transport experiments

The silica sands used for the column experiments were purchased from U.S. Silica and had a size range of 0.2 – 0.3 mm. The sands received from the manufacturer were alternately cleaned using concentrated nitric acid to remove metal hydroxides and diluted NaOH solution to remove natural clay particles [Xu et al., 2008], rinsed with deionized water, and dried at 80 °C. The porosity of the sand was 0.37 as determined using the bulk density method [Weight, 2008]. A pair of glass chromatography columns (Kontes, Vineland, NJ) measuring 15 cm in length and 2.5 cm in diameter were vertically oriented and then wet-packed with the clean silica sands. Care was taken to eliminate the possibility of trapped air bubbles. Once packed, >30 pore volumes (PV) of appropriate background electrolyte (i.e., 1, 5, 20, 50, or 100 mM NaCl) was injected into the columns to equilibrate them. The downward flow was driven by gravity and the Darcy velocity was maintained at 0.31 cm/min using peristaltic pumps (Master-Flex, Vernon Hills, IL). The flow velocity that was employed in the column experiments is on the high end of natural groundwater flow, and is on the same order of magnitude as that encountered in riverbank filtration [Havelaar, et al., 1995]. Upon the completion of the equilibration step, the transport experiments were initiated by injecting the *E. coli* cell suspensions to the top of the columns and concentrations of the bacterial cells in the effluent were determined through measuring the absorbance at a wavelength of 220 nm using a Shimadzu UV-1700 spectrophotometer. The injection of *E. coli* cell suspension (~3.5 PV) lasted for 60 min, after which the columns were flushed with bacteria-free background electrolyte solution until the absorbance of effluent returned to the background values. The clean-bed deposition rate coefficients (k_d) of the *E. coli* cells within the saturated sand packs were estimated from the steady-state breakthrough concentrations in the effluent [Walker et al., 2005; Kretzschmar et al., 1997; Castro et al., 2007]:

$$k_d = -\frac{v}{\varepsilon L} ln\left(\frac{C}{C_0}\right) \tag{12}$$

where ε is porosity, v is the specific discharge, L is the column length, and C/C_0 is the normalized breakthrough concentration relevant to clean-bed conditions, which was obtained from the average bacterial breakthrough concentrations between 1.8 and 2.0 PV [Walker et al., 2005; Kretzschmar et al., 1997; Castro et al., 2007].

The retained *E. coli* cells can be remobilized when the ionic strength of the solution is lowered [Redman et al., 2004]. For each *E. coli* strain, upon the completion of the column experiments using 100 mM NaCl, the 1 mM NaCl solution was injected to the columns and the concentrations of the released *E. coli* cells were monitored similarly using the spectrophotometer. The results obtained were used to evaluate the reversibility of *E. coli* retention within the sand packs.

3.2.3 XDLVO Calculations

The mobility of *E.coli* cells within the saturated sands is determined by the energy interactions between the cells and the surface of the sands. According to the XDLVO theory, the energy interactions between the *E.coli* cells and the surface of quartz sands are the summation of the Lifshitz-van der Waals (LW) interaction, the electrostatic double layer (EDL) interaction and the Lewis acid-base (AB) interaction:

$$\phi^{total} = \phi^{LW} + \phi^{EDL} + \phi^{AB} \tag{1}$$

The LW, EDL, and AB interaction energies (ϕ^{LW}, ϕ^{EDL}, and ϕ^{AB}) for the cell-sand (sphere-plate geometry) system can be calculated using the following equations [Redman et al., 2004; Ong et al., 1999; Bayoudh et al., 2006, 2009; Farahat et al., 2009; Elimelech et al., 1994; Huang et al., 2010; Morrow et al., 2005].

$$\phi^{\mathrm{LW}} = -\frac{Aa_b}{6h}\left[1 - \frac{5.32h}{\lambda} ln\left(1 + \frac{\lambda}{5.32h}\right)\right] \tag{2}$$

$$\phi^{\mathrm{EDL}} = \pi\varepsilon_0\varepsilon_w a_b\left\{2\psi_b\psi_s ln\left[\frac{1+\exp(-\kappa h)}{1-\exp(-\kappa h)}\right] + (\psi_b^2 + \psi_s^2) ln[1 - \exp(-2\kappa h)]\right\} \tag{3}$$

$$\phi^{\mathrm{AB}} = 2\pi a_b \lambda_w \Delta G_{h_0}^{AB} exp\left(\frac{h_0 - h}{\lambda_w}\right) \tag{4}$$

where *A* is Hamaker constant; a_b is the radius of the bacterial cells; λ is the characteristic wavelength and was set as 42.5 nm; h is the separation distance between the cell and sand surface; ε_0 is the dielectric permittivity of vacuum; ε_w is the dielectric constant of water; κ^{-1} is the Debye length ($(0.302/\sqrt{I})$ nm at 22 ^{0}C, *I*=ionic strength); ψ_b and ψ_s are the surface potentials of the bacterial cells and sand, respectively; λ_w(=0.6 nm) is the characteristic decay length for AB interactions in water; h_0 represents the minimum equilibrium distance between the cell and sand surface due to Born repulsion and equals to 0.157 nm; and $\Delta G_{h_0}^{AB}$ represents the hydrophobicity interaction free energies per unit area corresponding to h_0.

The values of a_b, ψ_b, ψ_s, A, and $\Delta G_{h_0}^{AB}$ were required for the interaction energy calculations. To determine cell sizes (a_b), images of the *E. coli* cells suspended in 1 and 100 mM NaCl were obtained using a Nikon Eclipse 50i microscope that was equipped with a Photometric CoolSnap ES digital camera and MetaMorph software. The length and width of ~30 cells were determined using the ImageJ software and the equivalent radii of the cells were calculated as ((LC × WC)π), where LC and WC represent the length and width of the cell, respectively [Hazendaroglu et al., 2008; Wang et al., 2011]. In this research, zeta potential values were used in place of surface potentials for the XDLVO calculations [Walker et al., 2004]. *E. coli* cell suspensions were prepared in a similar fashion as the column transport experiments, the quartz sands were pulverized, and the colloid-sized quartz particles were suspended in the NaCl solutions [Porubcan et al., 1993]. The zeta potential values of the bacterial cells and quartz particles were then measured using a ZetaPALS analyzer (Brookhaven Instruments Corporation).

The Hamaker constants were calculated from the LW surface tension parameters of bacteria (γ_b^{LW}), water (γ_w^{LW}) and sand (γ_s^{LW}) [van Oss, 1993]:

$$A = 24\pi h_0^2\left(\sqrt{\gamma_b^{LW}} - \sqrt{\gamma_w^{LW}}\right)\left(\sqrt{\gamma_s^{LW}} - \sqrt{\gamma_w^{LW}}\right) \quad (8)$$

The values of $\Delta G_{h_0}^{AB}$ can be obtained from the electron-accepting (γ_i^+) and electron-donating (γ_i^-) surface tension parameters [van Oss, 1993]:

$$\Delta G_{h_0}^{AB} = 2\left[\sqrt{\gamma_w^+}\left(\sqrt{\gamma_b^-} + \sqrt{\gamma_s^-} - \sqrt{\gamma_w^-}\right) + \sqrt{\gamma_w^-}\left(\sqrt{\gamma_b^+} + \sqrt{\gamma_s^+} - \sqrt{\gamma_w^+}\right) - \sqrt{\gamma_b^-\gamma_s^+} - \sqrt{\gamma_b^+\gamma_s^-}\right] \quad (10)$$

where the subscripts of b, w, and s represent bacteria, water, and sand, respectively. For water, the values of γ_w^{LW}, γ_w^+, and γ_w^- are 21.8, 25.5, 25.5 mJ m^{-2}, respectively [Morrow et al., 2005]. For quartz sands, the previously reported values of γ_s^{LW}(39.2 mJ m^{-2}), γ_s^+(1.4 mJ m-2), and γ_s^- (47.8 mJ m^{-2}) were used in this research [Morrow et al., 2005]. To determine the values of γ_b^{LW}, γ_b^+ and γ_b^- for each *E. coli* strain, bacterial lawns were produced by filtering cells onto porous membrane, which was subsequently dried at room temperature for ~15 min. The contact angles (θ) of two polar and one nonpolar probe liquids with known surface tension parameters on the bacterial lawns were measured using a Rame-Hart goniometer [Ong et al., 1999; Morrow et al., 1999; van Oss, 1993]:

$$\gamma_i^L(1 + cos\theta) = 2\sqrt{\gamma_i^{LW}\gamma^{LW}} + 2\sqrt{\gamma_i^+\gamma^-} + 2\sqrt{\gamma_i^-\gamma^+} \quad (11)$$

where the subscripts i represents water ($\gamma_i^L = 72.8, \gamma^{LW} = 21.8, \gamma^+ = \gamma^- = 25.5$ mJ m^{-2}), glycerol ($\gamma_i^L = 64.0, \gamma^{LW} = 34.0, \gamma^+ = 3.92, \gamma^- = 57.4$ mJ m^{-2})and diiodomethane ($\gamma_i^L = 50.8, \gamma^{LW} = 50.8, \gamma^+ = \gamma^- = 0$ mJ m^{-2}), respectively [van Oss, 1993].

3.3. Results and discussion

3.3.1 Column Transport Experiments

The normalized effluent *E. coli* concentrations under various ionic strength conditions are shown in Figure 1 (left panels). For all of the *E.coli* strains, the increase in ionic strength led to lower breakthrough concentrations and lower recovery of bacterial cells in the effluent. For instance, the breakthrough concentrations (between 1.8 and 2.0 PV) of the wild-type strain decreased from 87.0(±1.7)% to 11.2(±0.6)% when ionic strength increased from 1 mM to 100 mM. Accordingly, integration of the breakthrough curves showed that 86.3(±2.9)% and 12.8(±0.6)% of the wild-type *E. coli* cells traveled through the sand columns under 1 and 100 mM NaCl conditions, respectively. Upon the completion of the column experiments using 100 mM NaCl, the 1 mM NaCl solution was injected into the columns, and the concentrations of the released *E. coli* cells were monitored (Figure 1, right panels). The pulse-type release of the previously retained *E. coli* cells led to extremely high cell concentrations in the effluent. Integration of the release curves showed that, at the end of the release experiments, 28.0(±2.6)%, 50.9(±7.8)%, and 60.4(±0.5)% of the cells remained immobilized for the wild-type, tolC::kan, and ΔtolC *E.coli* strains, respectively. In comparison, the column experiments performed using 1 mM NaCl showed that ~13.7(±2.9)%, 9.4(±0.9)%, and 11.7(±1.7)% of the wildtype, tolC::kan, and ΔtolC cells were retained, respectively. The fact that higher fractions of the cells remained retained following the release experiments suggested that cell immobilization was only partially reversible. The clean-bed deposition rate coefficients (k_d) were calculated from the early breakthrough concentrations using Eq.12 (Figure 2). Student's t-test performed using Microsoft Excel showed that the deposition rate coefficients were similar ($p > 0.05$) for the tolC::kan and ΔtolC strains under all ionic strength conditions (1−100 mM NaCl). This indicated that the insertion of the kanamycin resistance cassette into the *E. coli* chromosome and the gain of kanamycin resistance had little effect on the mobility of *E. coli* within saturated quartz sands. When the ionic strength was between 1 and 5 mM, the wildtype *E. coli* strain also had similar k_d values as the TolC-deletion *E. coli* strains (Student's t-test, $p > 0.05$). The removal of OMP TolC, however, led to significant increase in values of k_d (i.e., decrease in *E. coli* mobility) when the ionic strength was between 20 and 100 mM (Student's t-test, $p < 0.05$). This finding was consistent to previously published results that suggested that OMP TolC could enhance the transport of *E.coli* isolated from various natural sources such as dairy manure [Walczak et al., 2011a, 2011b]. To elucidate the mechanisms behind the effects of OMP TolC on the mobility of *E. coli*, we characterized the *E.coli* cells and examined the energy interactions between the *E.coli* cells and quartz sands using the XDLVO theory.

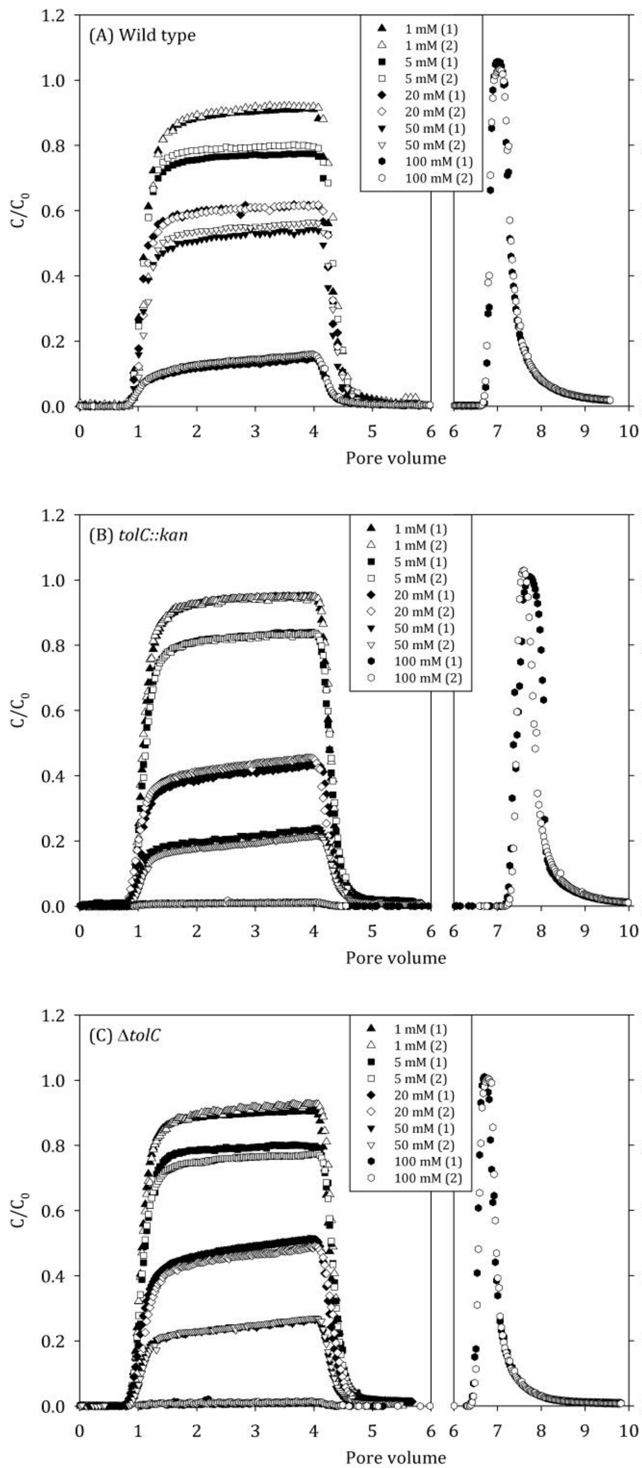

Figure 1. Breakthrough curves of (A) wild-type, (B) tolC::kan, and (C) *ΔTolC E.coli* cells suspended in 1, 5, 20, 50, and 100 mM NaCl, respectively (left panels). C represents *E.coli* concentrations in the effluent and C_o represents influent *E.coli* concentrations. Upon the completion of the 100 mM NaCl experiments, the 1 mM NaCl solution was injected into the columns, and the release kinetics of the previously retained bacterial cells are shown in the right panels.

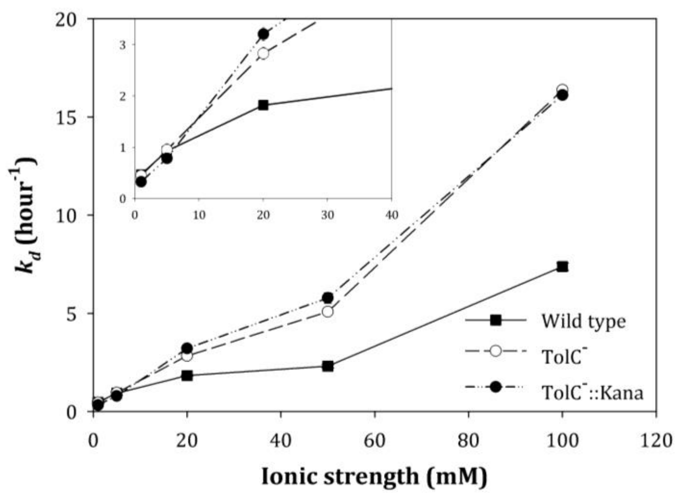

Figure 2. Average deposition rate coefficients (k_d) for the three *E.coli* strains under ionic strength conditions of 1, 5, 20, 50, and 100 mM. The error bars, which represent the standard deviations, are smaller than the symbols.

3.3.2. Cell Characterization

Results from the cell size measurements under 1 and 100 mM NaCl conditions suggested that ionic strength had minimal effects (Student's t-test, $p > 0.05$) on the size of the *E. coli* cells. For instance, the equivalent diameter of the wild-type *E. coli* cells was 2.04(±0.19) µm in 1 mM NaCl and 2.01(±0.17) µm in 100 mM NaCl, respectively. For each *E. coli* strain, all of the size measurements were thus pooled together and a single diameter value was calculated. The average sizes of the wild-type, tolC::kan, and ΔtolC strains were 2.04(±0.19) µm, 1.98(±0.22) µm, and 2.02(±0.17) µm, respectively. The results from Student's t-test indicated that the removal of OMP TolC and/or the presence of kanamycin resistance did not significantly alter cell size. When suspended in 1, 5, 20, 50, and 100 mM NaCl (nonbuffered, pH ≈ 5.7), the zeta potential values of the *E. coli* cells were negative, suggesting that their surfaces were negatively charged (Figure 3). Given the slightly acidic pH of the cell suspensions, these negative charges should originate from the deprotonation of acid−base functional groups such as carboxylic and phosphoric groups [Hong and Brown, 2006]. With the increase in ionic strength, the zeta potential values of the *E. coli* cells generally became less negative due to the compression of the electric double layer [Wang et al., 2011]. Additionally, all three *E. coli* strains displayed comparable zeta potential values under the same ionic strength conditions (Student's t-test, p > 0.05).

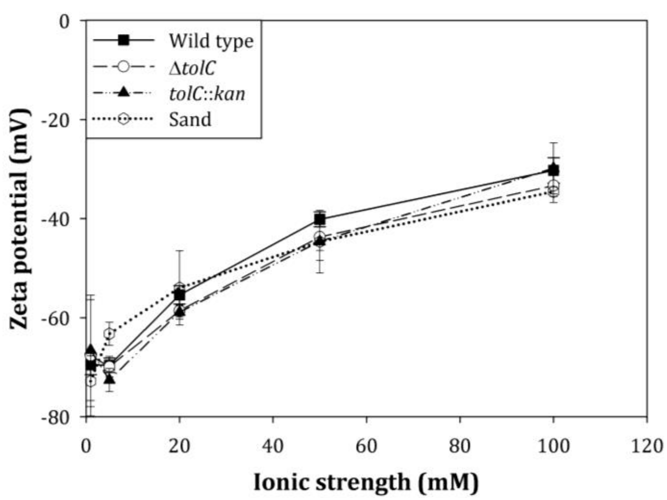

Figure 3. Zeta potential values of the *E.coli* cells and the quartz sands in 1, 5, 20, 50, and 100 mM NaCl. Error bars represent the standard deviation of a minimum of 5 measurements.

The OMP TolC is a 471-residue trimer that contains an α-helical domain, a mixed α/β domain and a β domain [Koronakis et al., 2000]. The α-helical domain, which forms a tunnel through the periplasm, is anchored to the bacterial wall. The β-barrel, which extends to the outside of the outer membrane, has a length of ~4 nm [Koronakis et al., 2000]. Because the exterior of the β domain is largely nonpolar [Koronakis et al., 2000], it is expected that the deletion of TolC from the outer membrane would not significantly alter cell surface charge and zeta potential. Similarly, because the kanamycin resistance in the tolC::kan strain is conferred by the Tn5 neomycin phosphotransferase, an aminoglycoside modifying enzyme that exists and functions inside the *E. coli* cell [Datsenko et al., 2006; Wright, 2008], the kanamycin resistance had little effect on cell zeta potential. The results of the contact angle measurements are shown in Table 1. Student's t-test indicated that there was significant difference ($p < 0.05$) in the diiodomethane contact angle between the wild-type and TolC-deletion *E. coli* strains. It was interesting to note that the wild-type, which was able to produce the nonpolar OMP TolC, had a higher contact angle of the nonpolar diiodomethane than the two TolC-deletion mutants. A similar trend was observed in Ong et al. [1999] and Johanson et al.,[2012]. Ong et al. observed *E. coli* D21f1, which lacks the charge-containing LPS, had a higher contact angle of diiodomethane than the LPS-producing *E. coli* D21 [Ong et al., 1999]. Johanson et al. reported that *Enterococcus faecium* that produced the hydrophobic enterococcal surface protein (esp) had a higher contact angle of diiodomethane than the corresponding esp deletion mutant [Johanson et al., 2012]. The values of γ_b^{LW}, γ_b^+ and γ_b^- for each *E. coli* strain were then calculated from the contact angle measurements using Eq. 11 (Table 1). These values, together with the zeta potential values and cell size measurements were then used to quantify the energy interactions between the *E. coli* cells and the quartz sands.

3.3.3. XDLVO energy interactions between E.coli cells and quartz sands

The values of $\Delta G_{h_0}^{AB}$ were 23.8 mJ m^{-2}, 26.4 mJ m^{-2}, and 23.8 mJ m^{-2}, and the Hamaker constants were 0.78 × 10^{-21} J, 2.72 × 10^{-21} J, and 2.92 × 10^{-21} J for the wild-type, tolC::kan, and ΔtolC *E. coli* strains, respectively (Table 1). The values $\Delta G_{h_0}^{AB}$ showed that the AB force between the *E. coli* cells and the surface of quartz sands was repulsive. Equation 8 suggests that the Hamaker constant is a function of the LW surface tension components of the bacterial cell, water, and quartz sands. Because the electron-accepting (γ_i^+) and electron-donating (γ_i^-) surface tension components for diiodomethane are both zero, the LW surface tension parameter for each *E. coli* strain was calculated from Eq.11 that corresponded to diiodomethane. The difference in the Hamaker constants thus was the result of the difference in the diiodomethane contact angles measured on the bacterial lawns of the three *E. coli* strains.

Table 1 Contact angle measurements, surface tension components, Hamaker constant (A) and $\Delta G_{h_0}^{AB}$ for the three *E.coli* strains

properties		*wild-type*	*tolC::kana*	*ΔtolC*
contact angle (deg) (n ≥ 4)	water	18.7 (±1.4)	19.0 (±3.0)	19.6 (±1.5)
	glycerol	21.4 (±8.4)	25.9 (±2.0)	20.6 (±2.8)
	diiodomethane	67.4 (±3.9)	55.4 (±8.7)	54.1 (±2.8)
surface tention components (mJ m^{-2})	γ_b^{LW}	24.33	31.2	32
	γ_b^+	6.51	3.63	4.3
	γ_b^-	47.9	48.3	44.8
Hamaker constant, **A (10^{-21} J)**		0.78	2.72	2.92
$\Delta G_{h_0}^{AB}$ (mJ m^{-2})		23.8	26.4	23.8

[a] Numbers in parentheses are the standard deviation of the contact angle measurements.

The results obtained in this research indicated that variations in cell surface structures such as OMPs could alter cell surface tension components and subsequently the energy interactions between the cells and the surface of quartz sands. A similar relationship was reported in several previous publications [Ong et al., 1999; Johanson et al., 2012].Ong et al., [1999] for instance, observed that the wild-type *E. coli* D21 and its LPS-deletion mutant (strain D21f2) had different surface tension values. As a result, for four different types of surfaces (i.e., mica, glass, polystyrene, and Teflon), the Hamaker constants for strain D21 were approximately two times the magnitude of the Hamker constants for strain D21f2. Johanson et al. [2012] reported that for *Enterococcus faecium*, the removal of the surface protein esp increased the Hamaker constant for the cell−water−quartz system from 4.2 × 10^{-21} J to 4.8 × 10^{-21} J and the value of $\Delta G_{h_0}^{AB}$ from 24.1 to 31.4 mJ m^{-2}. The XDLVO energy interactions between the *E. coli* cells and the surface of quartz sands were calculated and shown in Figure 4. For all of the ionic strength conditions, there existed sizable energy barriers for the attachment of *E. coli* cells to quartz sands. The magnitude of the energy barrier was comparable for all three *E. coli* strains under the same ionic strength condition, but decreased from ∼6.4 × 104 kT to ∼5.4 × 104 kT when the ionic strength increased from 1 mM to 100 mM. The presence of the substantial energy barriers made it difficult for the *E. coli* cells to be deposited into the primary energy minimum, and the immobilization of the *E. coli* cells should thus occur primarily through their entrapment within the secondary energy minimum [Redman et al., 2004; Wang et al., 2011; Morrow et al, 2005; Azeredo et al, 1999]. When the ionic strength was within 1−5 mM, the three *E.coli* strains shared similar XDLVO energy interaction profiles (Figure 4A,B). For the higher ionic strength range (20−100 mM), the XDLVO calculations showed that the two TolC deletion strains had similar interaction energy profiles; and their secondary energy minimum was always deeper than the wildtype strain. For each *E. coli* strain, the depth of the secondary energy minimum also increased with ionic strength. The XDLVO calculations were thus consistent with the experimental observations that (i) the three *E. coli* strains had similar mobility under the low ionic strength conditions; (ii) the TolCdeletion strains had higher deposition rates than the wild-type strain under high ionic strength conditions; and (iii) the deposition of the *E. coli* cells increased with ionic strength (Figure 2). Overall, our data suggested that the deposition rate coefficients (k_d) were negatively related to the depth of the secondary energy minimum. The XDLVO calculations predicted the absence of the secondary minimum for the ionic strength of 1 mM NaCl (Figure 4A). Inspection of the XDLVO interaction energy profiles revealed that the lowest point was ~0.5 kT. In theory, this indicated that there should be no cell immobilization at the secondary energy minimum. The experimental results showed that the transport of the *E. coli* cells was not conservative and ~12% of the *E. coli* cells were immobilized. Similar discrepancies between the interaction energy calculations and particle transport results were previously reported [Farahat et al., 2009; Sharma et al., 2003]. For instance, Farahat et al. observed that *E. coli* cells could attach to quartz under pH > 4.5 when the XDLVO energy calculations showed the absence of secondary energy minimum [Faharat et al., 2009]. A wide range of factors such as heterogeneity in cell properties (e.g., the zeta potential of some cell might be less negative than the average values), charge heterogeneity, and roughness on the surface of quartz sands, XDLVO forces as well as flow hydrodynamics could have contributed to the deposition of a fraction of *E. coli* cells when the average XDLVO profile predicted the absence of secondary energy minimum [Torzaban et al., 2008; Dong, 2002; Bhattacharjee and Ko, 1998; Wang and Keller, 2009]. The XDLVO calculations were also consistent with the results obtained from the release experiments. When the ionic strength was lowered from 100 mM NaCl to 1 mM, the depth of the secondary energy minimum decreased, and a fraction of the *E. coli* cells that were previously retained was remobilized [Redman et al., 2004]. Compared to the DLVO theory, the extra force that is considered by the XDLVO theory is the AB force (Eq.4). In this research, the AB force was repulsive, and the inclusion of this force significantly increased the magnitude of the energy barrier. However, because the AB force decreased more rapidly with the separation distance than the LW and EDL forces, and because the secondary energy minimum was generally located 7 nm or further away from the sand surface, the AB force has very small effects on the depth of the secondary energy minimum. For tolC::kan, the depth of the secondary energy minimum was −7.34 kT and −7.57 kT for the XDLVO theory and DLVO theory, respectively. For Gram-negative bacteria such as *E. coli*, outer membrane structures such as LPS and proteins can exert steric interactions for the cell-surface system [Wang et al., 2011; Strauss et al., 2009]. Such steric interactions are not considered by the XDLVO calculations and can significantly influence the transport behavior of bacterial cells within porous media [Wang et al., 2011]. The *E. coli* K12 strain that was used in this study did not express the O-antigen of the LPS, and the length of the LPS was estimated as 3 ±2 nm [Strauss et al., 2009]. The length of OMP TolC that is extended to the outside of the membrane is ~4 nm [Koronakis et al., 2000]. The XDLVO calculations showed that the secondary energy minimum was usually located >7 nm from the surface of the sands (Figure 4). Therefore, the steric forces could increase the magnitude of the energy barrier, but should have negligible impact on the location and depth of the secondary minimum. This is confirmed by the calculation of the steric forces using the formula that was derived by Wang et al. [2011] (Figure S1 of the Supporting Information).

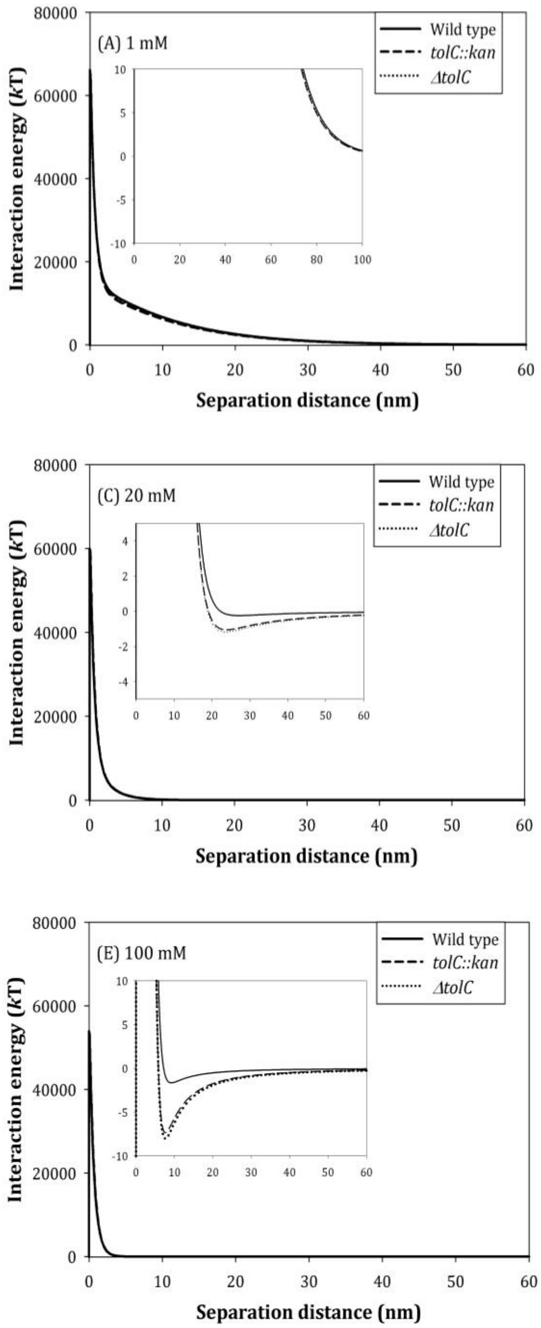

Figure 4. The calculated XDLVO interaction energy profiles as a function of separation distance for (A) 1 mM, (B) 5 mM, (C) 20 mM, (D) 50 mM, and (E) 100 mM ionic strength conditions. The interaction energy was expressed in *kT*, where *k* is the Boltzman constant, and *T* is absolute temperature in Kelvin. Insets show the secondary energy minimum.

3.4. Environmental implications

The extensive use of antibiotics in both food animal production and human medicine has led to the selection of antibiotic-resistant bacteria in manure and wastewater [Mellon et al., 2001; Boczek et al., 2007; Walczak and Xu, 2011; Salmore et al., 2006]. Many previous studies showed that the improper storage, management, and use of wastewater and manure could lead to the contamination of groundwater by a variety of bacteria that were resistant to the major lines of antibiotics that are currently being used to treat human diseases [Sapkota et al., 2007; Anderson et al., 2006].The spread of antibiotic-resistant bacteria in the environment is raising serious public health concerns across the world [Institute of Medicine, WHO, 2003]. Drug efflux pumps represent one of the most effective and widespread mechanisms for antibiotic resistance in bacterial cells [Walsh, 2003]. Particularly, efflux pumps that span the cytoplasm, periplasm, and outer membrane could transport antibiotics to the outside environment and therefore lead to bacterial resistance against high levels of antibiotics. The OMP TolC was reported to be the outer membrane component of several common efflux pumps (e.g., the AcrAB-TolC pump) that are responsible for bacterial resistance to various antibiotics such as tetracycline, macrolide, and ampicillin [Chollet et al., 2004; de Cristobal et al., 2006; Fralick et al., 1996; Nishino et al., 2003]. It was observed that the total dissolved solid (TDS) of groundwater that was influenced by manure storage and application was often 1000 mg/L or higher (20 mM NaCl is equivalent to a TDS of 1170 mg/L) [Harter et al., 2002]. Findings from this research suggested that antibiotic resistant bacteria with the OMP TolC could have higher mobility and display wider spread within sandy aquifers influenced by manure. Several recent publications highlighted the diversity in the transport behavior of bacterial isolates obtained from various environmental sources within saturated porous media [Bolster et al., 2010; Bolster et al., 2009; Walczak et al., 2011a, b]. Such variations pose challenges to the modeling and prediction of the spread of bacteria within the groundwater system. There is a growing body of evidence, including the findings from this research, which suggests that cell-surface structures such as LPS and OMP can have significant impact on the mobility of bacterial cells within aquifer materials [Walczak et al., 2011a; 2011b; Lutterodt et al., 2009; Walker et al., 2004; Johanson et al., 2012; Abu-Lail and Camesano, 2003]. It is likely that the mechanisms underlying the variations in the transport of environmental bacterial isolates are related to the variations in the cell surface structures [Lutterodt et al., 2009]. The improved understanding of the relationship between the surface structure of bacterial cells and their attachment to natural mineral surfaces could enable us to better assess the public health risks associated with groundwater microbial contamination.

3.5 References

Abu-Lail, N.I.; Camesano, T.A. Role of lipopolysaccharides in the adhesion, retention, and transport of *Escherichia coli* JM109. *Evniron. Sci. Technol*. **2003**, 37 (10), 21732 – 2183.

Anderson, M.E.; Sobsey, M.D. Detection and occurrence of antimicrobially resistant *E.coli* in groundwater on or near swine farms in eastern North Carolina. *Water Sci. Technol.* **2006**, 54 (3), 211 – 218.

Azeredo, J.; Visser, J.; Oliveira, R. Exopolymers in bacterial adhesion: Interpretation in terms of DLVO and XDLVO theories. *Colloids Surf. B.* **1999**, 14 (1 – 4), 141 – 148.

Baba, T.; Ara, T.; Hasegawa, M.; Takai, Y.; Okumura, Y.; Baba, M.; Datsenko, K. A.; Tomita, M.; Wanner, B. L.; Mori, H. Construction of *Escherichia coli* K-12 in-frame, single-gene knockout mutants: the Keio collection. *Mol. Syst. Biol.* **2006**, 2, 0008.

Bhattacharjee, S.; Ko, C.H.; Elimelech, M. DLVO interaction between rough surfaces. *Langmuir* **1998**, 14 (12), 3365 – 3375.

Bayoudh, S.; Othmane, A.; Bettaieb, F.; Bakhrouf, A.; Ben Ouada, H.; Ponsonnet, L. Quantification of the adhesion free energy between bacteria and hydrophobic and hydrophilic substrata. *Mater. Sci. Eng. C* **2006**, 26 (2-3), 300 – 305.

Bayoudh, S.; Othmane, A.; Mora, L.; Ben Ouada, H. Assesing bacterial adhesion using DLVO and XDLVO theories and the jet impingement technique. *Colloids Surf. B* **2009**, 73, 1, 1 – 9.

Bodzek, L.A.; Rice, E.W.; Johnston, B.; Johnston, J.R. Occurrence of antibiotic-resistant uropathogenic *Escherichia coli* clonal group A in wastewater effluents. *Appl. Environ. Microbiol.* **2007**, 73 (13), 4180 – 4184.

Bolster, C.H.; Cook, K.L; Marcus, I.M.; Haznedaroglu, B.Z.; Walker, S.L. Correlating transport behavior with cell properties for eight porcine *Escherichia coli* isolates. *Environ. Sci. Technol*. **2010**, 44 (13), 5008 – 5014.

Bolster, C.H.; Haznedaroglu, B.Z.; Walker, S.L. Diversity in cell properties and transport behavior among 12 different environmental *Escherichia coli* isolates. *J. Environ. Qual*. **2009**, 38 (2), 465 – 472.

Castro, F.D.; Tufenkji, N. Relevance of nontoxigenic strains as surrogates for *Escherichia coli* O157:H7 in groundwater contamination potential: Role of temperature and cell acclimation time. *Environ. Sci Technol*. **2007**, 41 (12), 4332 – 4338.

Cherepanov, P. P.; Wackemagel, W. Gene disruption in Escherichia coli – Tcr and Km(R) cassettes with the option of Flp-catalyzed excision of the antibiotic-resistance determinant. *Gene* **1995**, 158 (1), 9 – 14.

Chollet, R.; Chevalier, J.; Bryskier, A.; Pages, J.M. The AcrAB-TolC pump is involved in macrolide resistance but not in telithromycin efflux in *Eterobacter aerogenes* and *Escherichia coli*. *Antimicrob. Agents Chemother*. **2004**, 48 (9), 3621 – 3624.

Craun, G.F.; Brunkard, J.M.; Yoder, J.S.; Roberts, V.A.; Carpenter, J.; Wade, T.; Calderon, R.L.; Roberts, J.M.; Beach, M.J.; Roy, S.L. Causes of outbreaks associated with drinking water in the United States from 1971 to 2006. *Clin. Microbiol. Rev.* **2010**, 23, 3, 507 – 528.

de Cristobal, R. E.; Vincent, P. A.; Salomon, R. A. Multidrug resistance pump Acr AB-TolC is required for high-level, Tet(A)-mediated tetracycline resistance in *Escherichia coli. J. Antimicrob. Chemother.* **2006**, 58 (1), 31–36.

Datsenko, K. A.; Wanner, B. L. One-step inactivation of chromosomal genes in *Escherichia coli* K-12 using PCR products. *Proc. Natl. Acad. Sci. U.S.A*. **2000**, 97 (12), 6640–6645.

Dong, H.L. Significance of electrophoretic mobility distribution to bacterial transport in granular porous media. *J. MIcrobiol. Methods* **2002**, 51 (1), 83 – 93.

Elimelech, M. Particle deposition on ideal collectors from dilute flowing suspensions-Mathematical formulation, numerical-solution, and simulations. *Sep. Technol.* **1994**, 4 (4), 186 – 212.

Farahat, M.; Hirajima, T.; Sasaki, K.; Doi, K. Adhesion of *Escherichia coli* onto quartz, hematite and corundum: Extended DLVO theory and flotation behavior. *Colloids Surf. B* **2009**, 74 (1), 140 – 149.

Foppen, J.W.; Lutterodt, G.; Roling , W.F.M.; Uhlenbrook, S. Towards understanding inter-strain attachment variations of *Escherichia coli* during transport in saturated quartz sand. *Water Res*. **2010**, 44 (4), 1202 – 1212.

Fralick, J. A. Evidence that TolC is required for functioning of the Mar-AcrAB efflux pump of *Escherichia coli*. *J. Bacteriol*. **1996**, 178 (19), 5803–5805.

Harter, T.; Davis, H.; Mathews, M.C.; Meyer, R.D. Shallow groundwater quality on dairy farms with irrigated forage crops. *J. Contam. Hydrol*. **2002**, 55 (3 – 4), 287 – 315.

Havelaar, A.H.; Vanolphen, M.; Schijven, J.F. Removal and inactivation of viruses by drinking-water treatment processes under full-scale conditions. *Water Sci. Technol*. **1995**, 31 (5 – 6), 55 – 62.

Haznedaroglu, B. Z.; Zorlu, O.; Hill, J. E.; Walker, S. L. Identifying the role of flagella in the transport of motile and nonmotile *Salmonella enterica serovars*. *Environ. Sci. Technol*. **2010**, 44 (11), 4184–4190.

Haznedaroglu, B. Z.; Bolster, C.H.; Walker, S.L. The role of starvation on *Escherichia coli* adhesion and transport in saturated porous media. *Water Res*. **2008**, 42 (6-7), 1547 – 1554.

Hong, Y.; Brown, D.G. Cell surface acid-base properties of *Escherichia coli* and *Bacillus brevis* and variation as a function of growth phase, nitrogen source and C:N ratio. *Colloids Surf. B* **2006**, 50 (2), 112 – 119.

Huang, X.F.; Bhattacharjee, S.; Hoek, E.M.V. Is surface roughness a "scapegoat" or a primary factor when defining particle-substrate interactions? *Langmuir* **2010**, 26, 4, 2528 – 2537.

Institute of Medicine The Resistance Phenomenon in Microbes and Infectious Disease Vectors: Implications for Human Health and Strategies for Containment. (http://site.ebrary.com/lib/yale/Doc?id=10032357) Online book.

Johanson, J.J.; Feriancikova, L.; Xu, S. Influence of enterococcal surface protein (esp) on the transport of *Enterococcus faecium* within saturated quartz sands. *Environ. Sci. Technol.* **2012**, 46 (3), 1511 – 1518.

Kim, H. H.; Bradford, S. A.; Walker, S. L. *Escherichia coli* O157:H7 transport in saturated porous media: Role of solution chemistry and surface macromolecules. *Environ. Sci. Technol.* **2009**, 43 (12), 4340–4347.

Kim, H. N.; Hong, Y.; Lee, I.; Bradford, S. A.; Walker, S. L. Surface characteristics and adhesion behavior of *Escherichia coli* O157:H7: Role of extracellular macromolecules. *Biomacromolecules* **2009**, 10 (9), 2556–2564.

Koronakis, V.; Sharff, A.; Koronakis, E.; Luisi, B.; Hughes, C. Crystal structure of the bacterial membrane protein TolC central to multidrug efflux and protein export. *Nature* **2000**, 405 (6789), 914–919.

Kretzschmar, R.; Barmettler, K.; Grolimund, D.; Yan, Y.D.; Borkovec, M.; Sticher, H. Experimental determination of colloid deposition rates and collision efficiencies in natural porous media. *Water Resour. Res.* **1997**, 33, 5, 1129 – 1137.

Lutterodt, G.; Basnet, M.; Foppen, J.W. A.; Uhlenbrook, S. The effect of surface characteristics on the transport of multiple *Escherichia coli* isolates in large scale columns of quartz sand. *Water Res.* **2009**, 43 (3), 595 – 604.

Macler, B.A.; Merkle, J.C. Current knowledge on groundwater microbial pathogens and their control. *Hydrogeol. J.* **2000**, 8 (1), 29 – 40.

Macler, B.A.; Pontius, F.W. Update on the ground water disinfection rule. *J. Am. Water Works Assoc.* **1997**, 89, 1, 16.

Madigan, M.T.; Brock, T.D. Brock Biology of Microorganisms, 12th ed.; Pearson/Benjamin Cummings: San Francisco, CA, **2009**; p. xxviii, p 1061.

Mellon, M.; Benbrook, C.; Benbrook, K.L. Hogging it. Estimates of antimicrobial abuse in livestock. Union of Concerned Scientists: Cambridge, MA, **2001**.

Morrow, J.B.; Stratton, R.; Yang, H.H.; Smets, B.F.; Grasso, D. Macro- and nanoscale observations of adhesive behavior for several *E.coli* strains (O157:H7 and environmental isolates) on mineral surfaces. *Environ. Sci. Technol*. **2005**, 39 (17), 6395 – 6404.

Nishino, K.; Yamada, J.; Hirakawa, H.; Hirata, T.; Yamaguchi, A. Roles of TolC-dependent multidrug transporters of *Escherichia coli* in resistance to beta-lactams. *Antimicrob. Agents Chemother.* **2003**, 47 (9), 3030–3033.

Ong, Y.L.; Razatos, A.; Georgiou, G.; Sharma, M.M. Adhesion forces between *E.coli* bacteria and biomaterial surfaces. *Langmuir* **1999**, 15 (8), 2719 – 2725.

Porubcan, A.A.; Xu, S.P. Colloid straining within saturated heterogenous porous media. *Water Res*. **2011**, 45, 4, 1796 – 1806.

Redman, J.A.; Walker, S. L.; Elimelech, M. Bacterial adhesion and transport in porous media: Role of the secondary energy minimum, *Environ. Sci. Technol.* **2004**, 38 (6), 1777 – 1785.

Salmore, A.K.; Hollis, E.J.; McLellan, S.L. Delineation of a chemical and biological signature for stormwater pollution in an urban river. *J Water Health* **2006**, 4 (2), 247 – 262.

Sapkota, A.R.; Curriero, F.C.; Gibson, K.E.; Schwab, K.J. Antibiotic-resistant enterococci and fecal indicators in surface water and groundwater impacted by a concentrated swine feeding operation. *Environ. Health Perspect.* **2007**, 115 (7), 1040 – 1045.

Sharma, P.K.; Rao, K.H. Ahesion of *Paeribacillus polymyxa* on chalcopyrite and pyrite: surface thermodynamics and extended DLVO theory. *Colloids Surf. B* **2003**, 29 (1), 21 – 38.

Strauss, J.; Burnham, N.A.; Camesano, T.A. Atomic force microscopy study of the role of LPS O-antigen on adhesion of *E.coli. J. Mol. Recognit*. **2009**, 22 (5), 347 – 355.

Torkzaban, S.; Tazehkand, S.S.; Walker, S.L.; Bradford, S.A. Transport and fate of bacteria in porous media: Coupled effects of chemical conditions and pore space geometry. *Water Resour. Res*. **2008**, 44 (4), W04403.

United Nations Water in a Changing World: The United Nations World Water Development Report 3; **2009**; p.318.

van Oss, C.J. Acid-base interfacial interactions in aqueous-media. *Colloid Surf. A* **1993**, 78, 7 – 49.

Walczak, J.J.; Bardy, S.L.; Feriancikova, L.; Xu, S. Comparison of the transport of tetracycline-resistant and tetracycline-susceptible *Escherichia coli* isolated from Lake Michigan. *Water Air Soil Pollut*. **2011a**, 222 (1-4), 305–314.

Walczak, J.J.; Bardy, S.L.; Feriancikova, L.; Xu, S. Influence of tetracycline resistance on the transport of manure-derived *Escherichia coli* in saturated porous media. *Water Res.* **2011b**, 45 (4), 1681–1690.

Walczak, J.J.; Xu, S. P. Manure as a source of antibiotic-resistant *Escherichia coli* and *Enterococci*: A case study of a Wisconsin, U.S.A. family dairy farm. *Water Air Soil Pollut*. **2011**, 219 (1 – 4), 579 – 589.

Walker, S.L.; Redman, J.A.; Elimelech, M. Influence of growth phase on bacterial deposition: Interaction mechanisms in packed-bed column and radial stagnation point flow systems. *Environ. Sci. Technol*. **2005**, 39 (17) 6405 - 6411.

Walker, S.L.; Redman, J.A.; Elimelech, M. Role of cell surface lipopolysaccharides in *Escherichia coli* K12 adhesion and transport. *Langmuir* **2004**, 20 (18), 7736 – 7746.

Walsh, C. Antibiotics: Actions, Origins, Resistance; ASM Press: Washington, D.C., 2003; 335.

Wang, L.; Xu, S.; Li, J. Effects of phosphate on the transport of *Escherichia coli* O157:H7 in saturated quartz sand. *Environ. Sci. Technol*. **2011**, 45 (22), 9566 – 9573.

Wang, P.; Keller, A. A. Natural and engineered nano and colloidal transport: Role of zeta potential in prediction of particle deposition. *Langmuir* **2009**, 25 (12), 6856 – 6862.

Weight, W.D. Hydrogeology Field Manual, 2nd ed.; McGraw-Hill: New York, **2008**.

World Health Organization 1st Joint FAO/OIE/WHO Expert Workshop on Non-human Antimicrobial Usage and Antimicrobial Resistance: Scientific assessment, (http://www.sho.int/foodsafety/publications/micro/en/amf.pdf) Geneva, Dec 1 – 3, **2003**.

Wright, G.D. Mechanisms of Aminoglycoside Antibiotic Resistance. In bacterial Resistance to Antimicrobials, 2nd ed.; Wax, R.G., Lewis, K., Salyers, A.A., Taber, H., Eds.; CRC Press: Boca Raton, FL, **2008**; 71 – 101.

Xu, S. P.; Liao, Q.; Saiers, J.E. Straining of nanospherical colloids in saturated porous media. *Environ. Sci. Technol*. **2008**, 42 (3), 771 – 778.

CHAPTER 4

Transport of tetracycline-resistant and tetracycline-susceptible *Escherichia coli* within unsaturated porous media

4.1 Introduction

In saturated porous media, the transport of bacterial cells is primarily controlled by the kinetics of cell deposition at the solid-water interfaces. When the soil is partially saturated, several mechanisms contribute to cell deposition. In addition to the solid-water interface, bacterial cells may adhere to the air-water interface. Bacterial cells can also be strained at the edges of pendular rings that form around adjacent grains or by the thin water film that stretches between the pendulum rings [DeNovio et al., 2004]. Published experimental results showed that pore water chemistry and soil moisture content are the most important parameters that control the retention of colloid-sized particles in unsaturated soil [DeNovio et al., 2004; Lenhart and Saiers, 2002]. The goal of this research is to evaluate the influence of pore water chemistry and soil moisture content on the transport of tet^R *E. coli* in unsaturated soil. It was also reported that chemical perturbation, drainage (i.e. drying front) and imbibitions (i.e. wetting front) could mobilize substantial quantities of colloid-sized particles in partially saturated soil [Cheng and Saiers, 2009; Saiers et al., 2003]. The release of the retained bacterial cells under transient chemical and flow conditions was also examined.

4.2 Materials and Methods

4.2.1 The E.coli isolates characterization and preparation

The tet^R and tet^S *E. coli* isolates used in this research were from Walczak et al. [2011b], where their mobility within saturated quartz sands were investigated. The results from the *saturated* experiments showed that the tet^R *E. coli* strain exhibited higher mobility than the tet^S *E. coli* strain. For this research, one tet^R and one tet^S *E. coli* isolates were selected for the experiments. The *E. coli* isolates stored in 20% glycerol under -80^{o}C were streaked onto Muller-Hinton (MH) agar plates. After overnight incubation at 37^{o}C, cells from the freshly formed colonies were transferred to culture tubes containing 15 ml Luria-Bertani (LB) broth. The culture tubes were incubated at 37^{o}C for 6 hours with 90 rpm shaking. The starter cultures were used to inoculate LB broth (dilution ratio 1:500), which was then be incubated at 37^{o}C with 90 rpm shaking. After 18 hours of incubation, the bacterial cells were harvested using centrifugation (5000*g*, 10 minutes, 4^{o}C). To remove the growth medium, the bacterial pellet was rinsed 4 times with the appropriate electrolyte solution. The concentration of cells was adjusted to ~10^7 cells/ml and the suspension was ready for column transport study.

4.2.2. Column transport experiments

All column transport experiments were run in duplicate. Custom-built acrylic columns, measuring 7.6 cm in diameter and 7.6 cm in length, were used for the transport experiments. Two venting holes were drilled on opposite sides at the top of the vertically oriented column. The venting holes were covered with gas-permeable PTFE membranes which allowed for free air exchange and prevented loss of water from the column. On top of the PTFE membrane, the venting holes could be sealed using PVC tape when air exchange was not desired (e.g., when a freshly packed column is equilibrated with background electrolyte solution). A moisture probe (ML2x Thetaprobe, Delta-T Devices) was inserted at the middle of the column to determine volumetric moisture content. Readings from the moisture probe were recorded using a datalogger (Delta-T Devices, Model GP1). Plates made from perforated stainless steel sheet were placed at the bottom and top of the column to support the sands within the column and to distribute the influent solution. Nylon membranes with 20 µm openings (Spectrum Laboratories) were placed on top of the stainless steel plates to hold the sand and to maintain capillary pressure inside the column. Both ends of the columns were sealed using butyl rubber O rings. The inflow (top) and outflow (bottom) rates were regulated using two peristaltic pumps (Masterflex, ColeParmer) (Figure 5).

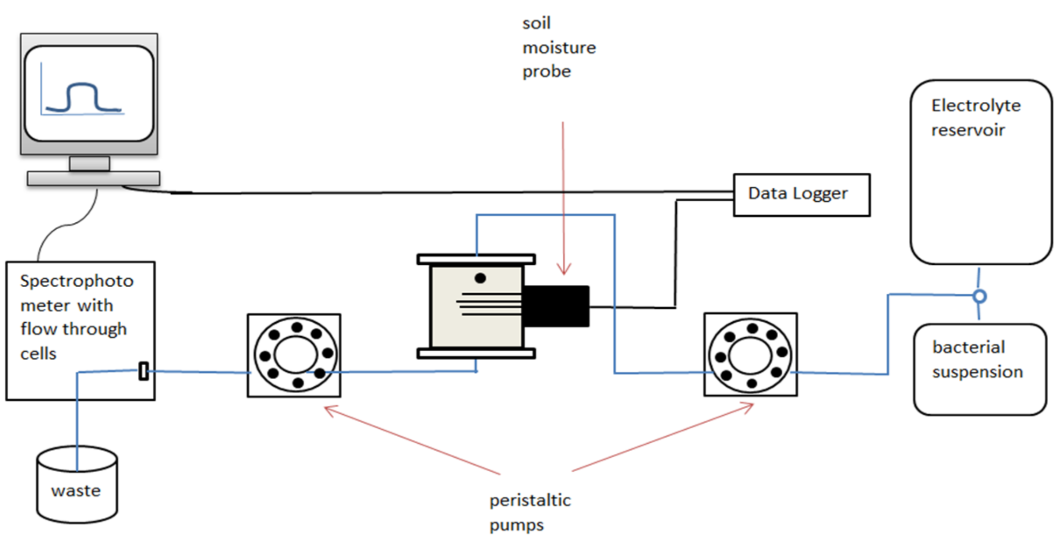

Figure 5. The column transport experiment setup. The set of peristaltic pumps controlled the inflow and outflow to reach desired moisture content (25% and 12%).

The columns were wet-packed by adding natural sands (US Silica, 595-841 µm in diameter) in 50 ml increments into electrolyte solution standing in the column. The porosity of the sand was 0.346. The newly added sands were stirred and mixed with the previously added sands. After each increment, the columns were tapped by hand to allow the newly added sands to settle. The packed sand columns were equilibrated with >4 pore volumes of appropriate electrolyte solution.

The transport of the *E. coli* isolates within the unsaturated soil was investigated under two different soil moisture content levels: ~12(±1)% (~30% saturation level) and ~25(±1)% (~68% saturation level), respectively. Following the equilibration step, the saturated sand columns were slowly drained by setting the outflow rate to be ~50% higher than the inflow rate. It was observed that by setting the inflow rate at 0.3 mL/min and 1.0 mL/min, we were able to achieve the ~12% and ~25% of soil moisture contents, respectively. Once the drying front reached the bottom of the column and the desired moisture content was achieved, the inflow and outflow rates were set to equal. The columns were further stabilized for ~0.5 hour before they were used for the *E. coli* transport experiments.

The *E. coli* cells suspended in the NaCl solutions (1 mM, 5 mM or 10 mM) were introduced to the top of the column. The concentrations of bacterial cells in the effluent was determined by measuring the light extinction at a wavelength of 220 nm with a UV/Vis spectrophotometer (Shimadzu UV-1700) equipped with 1-cm flow-through cuvettes at 60-second intervals [Walczak et al., 2011a, 2011b]. The injection of the cell suspension usually lasted ~ 2 pore volumes (PV) and then influent was switched to the background, cell-free NaCl solution. The experiments were completed when the cell concentration in the effluent approached zero. During the injection experiments, the soil moisture content remained stable.

4.2.3. Modeling component

The uniform movement of water through sand pack at 25% and 12% of moisture content was described by modified form of Richards equation [Richards, 1931]:

$$\frac{\partial \theta(h)}{\partial t} = \frac{\partial}{\partial x}\left[K(h)\left(\frac{\partial h}{\partial x} + 1\right)\right] \tag{13}$$

where h is the water pressure head [L], θ is the volumetric water content [$L^3L^{-3}T^1$], t is the time [T], x is the spatial coordinate [L] and $K(h)$is the unsaturated hydraulic conductivity function [LT^{-1}] given by:

$$K(h,x) = K_s(x)\, K_r(h,x) \tag{14}$$

in which K_r is the relative hydraulic conductivity [-] and K_s the saturated hydraulic conductivity [LT^{-1}]. The soil hydraulic parameters were estimated using van Genuchten [1980] and Mualem [1976] statistical pore-size distribution model where the unsaturated soil-hydraulic function is obtained from the empirical coefficients α, n and l (equal to 0.5) that affect the shape of breakthrough curves. The volumetric flux density (q) was calculated as:

$$q = -K(\theta) \quad (15)$$

assuming that the pressure *h* and volumetric water content θ is uniform everywhere $\left(\frac{\partial x}{\partial z} = 0\right)$.

The transport of the *E. coli* cells within the unsaturated soil was described by the two-region, dual-porosity model that assumes that the liquid phase could be separated into mobile and immobile zones [Pang et al., 2008]. The exchange of *E. coli* cells between θ_m (flowing, inter-aggregate) and immobile θ_{im} (stagnant, intra-aggregate) zones was modeled as a first order process (Note: $\theta = \theta_m + \theta_{im}$). Additionally, I considered the potential detachment of *E. coli* cells that were previously immobilized. The general governing equations for the transport of the tracer and *E. coli* cells within the unsaturated soil were:

$$\theta_{im}\frac{\partial c_{im}}{\partial t} = \omega(c_m - c_{im}) \quad (16)$$

$$\frac{\partial(\theta_m c_m)}{\partial t} + \rho\frac{\partial S}{\partial t} = \frac{\partial}{\partial x}\left(\theta_m D\frac{\partial c_m}{\partial x}\right) - \frac{\partial(q c_m)}{\partial x} - \omega(c_m - c_{im}) \quad (17)$$

$$\rho\frac{\partial S}{\partial t} = \theta_m k_a c_m - k_d \rho S \quad (18)$$

where c_m is the cell (Nc L^{-3}) concentration in the mobile region, c_{im} is the cell (Nc L^{-3}) concentration in the immobile region, ω (T^{-1}) is the first-order mass transfer rate between the mobile and immobile regions, ρ (M L^{-3}) is soil bulk density, S (Nc M^{-1}) is the quantity of immobilized *E. coli* cells in the solid phase, D (L^2T^{-1}) is the dispersion coefficient, k_a is the first-order attachment rate coefficient (T^{-1}), and k_d is the first-order detachment rate coefficient (T^{-1}). In this study the attachment rate, k_a, represents the total removal rate that includes the effects of the air-water interface and straining.

The values of θ_{m}, θ_{im}, ω, D, k_a and k_d were estimated by inversely solving equations (16) to (18) using HYDRUS-1D. In other words, the HYDRUS-1D solutions were fitted to the breakthrough data using the least-squares algorithm to obtain the best-fit values. For bacterial transport simulations the upper and lower boundary condition was set to concentration flux and zero concentration gradient.

4.2.4. E.coli transport under transient flow

The ionic strength of the soil solution may drop and this change in pore water chemistry could lead to the release of previously retained bacterial cells in unsaturated soil [Jensen et al., 1998]. Such release of the bacterial cells was previously identified as a major mechanism that can lead to groundwater contamination. For this purpose, the transport experiments were initially carried out using 10 mM NaCl. A 1mM NaCl solution was then introduced to the columns. Once a new steady state was reached (i.e., effluent bacterial cell concentration returned to zero), the experiments were ended.

Soil moisture content constantly changes as a result of rainfall, snowmelt, irrigation and evapotranspiration. It was previously reported that the wetting (imbibition) fronts can mobilize substantial quantities of colloid-sized particles in unsaturated soil [Cheng and Saiers, 2009]. To study the mobilization of retained bacterial cells during imbibition, a saturated column was initially drained to a moisture content of ~12% using a flow rate of 0.3 mL/min. A bacterial cell suspension was injected into the column under steady flow conditions. Following the flushing step under the same flow rate (i.e., 0.3 mL/min), the inflow rate was increased to 1 mL/min. Once the wetting front reached the bottom of the column and the soil moisture content rose to 25%(±2%), the outflow rate was equalized with inflow rate set at 1 mL/min to maintain steady flow condition. As the moisture content inside the column increased, a fraction of the previously retained bacterial cells were mobilized. The experiment was terminated following the pulse-type release of bacterial cells.

4.3 Results and Discussions

From the saturated sand columns, the soil moisture content was lowered to ~12% and ~25% by controlling the inflow and outflow rates (Figure 6). Figure 6 also showed that once the target soil moisture content was reached, it can be maintained steady during the *E. coli* transport experiments.

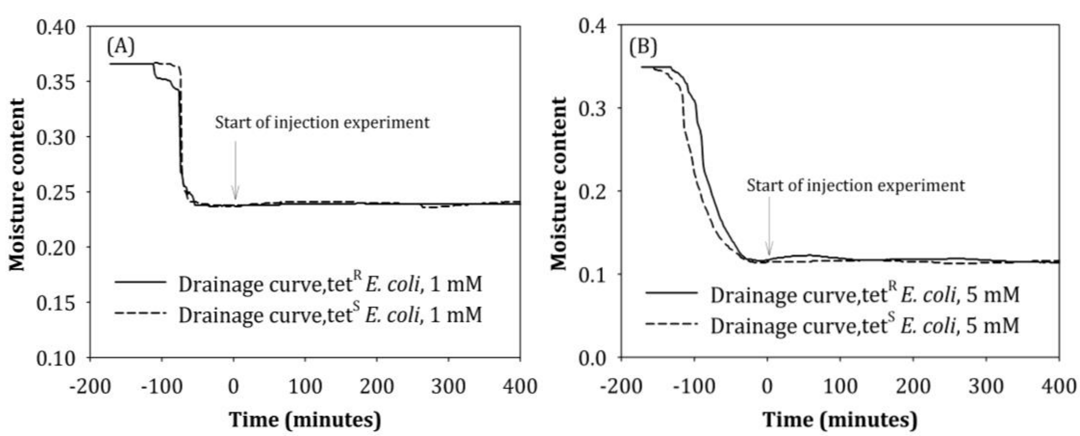

Figure 6. Representative soil drainage curve (soil moisture content vs. time) for the steady-state (i.e., constant soil moisture content) experiments. (A) drainage to ~25% of soil moisture content; (B) drainage to ~12% of soil moisture content. The injection of cell suspensions started at time 0.

The breakthrough curves of the tet^R and tet^S *E. coli* strains under high soil moisture content conditions (i.e., ~25%) are shown in Figure 7. When the ionic strength was 1 mM, the breakthrough concentrations of the tet^S *E. coli* strain were slightly higher than those of the tet^R *E. coli* strain. When the ionic strength was either 5 mM or 10 mM, the tet^R *E. coli* strain consistently displayed higher mobility than the tet^S *E. coli* strain (i.e., higher breakthrough concentrations for the tet^R *E. coli* strain). The mobility of the tet^S *E. coli* strain also decreased more rapidly with increasing ionic strength than the tet^R *E. coli* strain. Overall, the results suggested that, consistent to the findings obtained under saturated conditions, the manure-derived tet^R *E. coli* strain could spread more easily than the corresponding tet^S *E. coli* strain that was isolated from the same source. A mathematical model using equations (16) to (18) was fitted to the breakthrough data using the computer program HYDRUS-1D [Pang et al., 2008]. Overall, the dual porosity model could satisfactorily describe the transport behavior of the tracer under both soil moisture conditions with R^2 values greater than 0.95 (Figure 7).

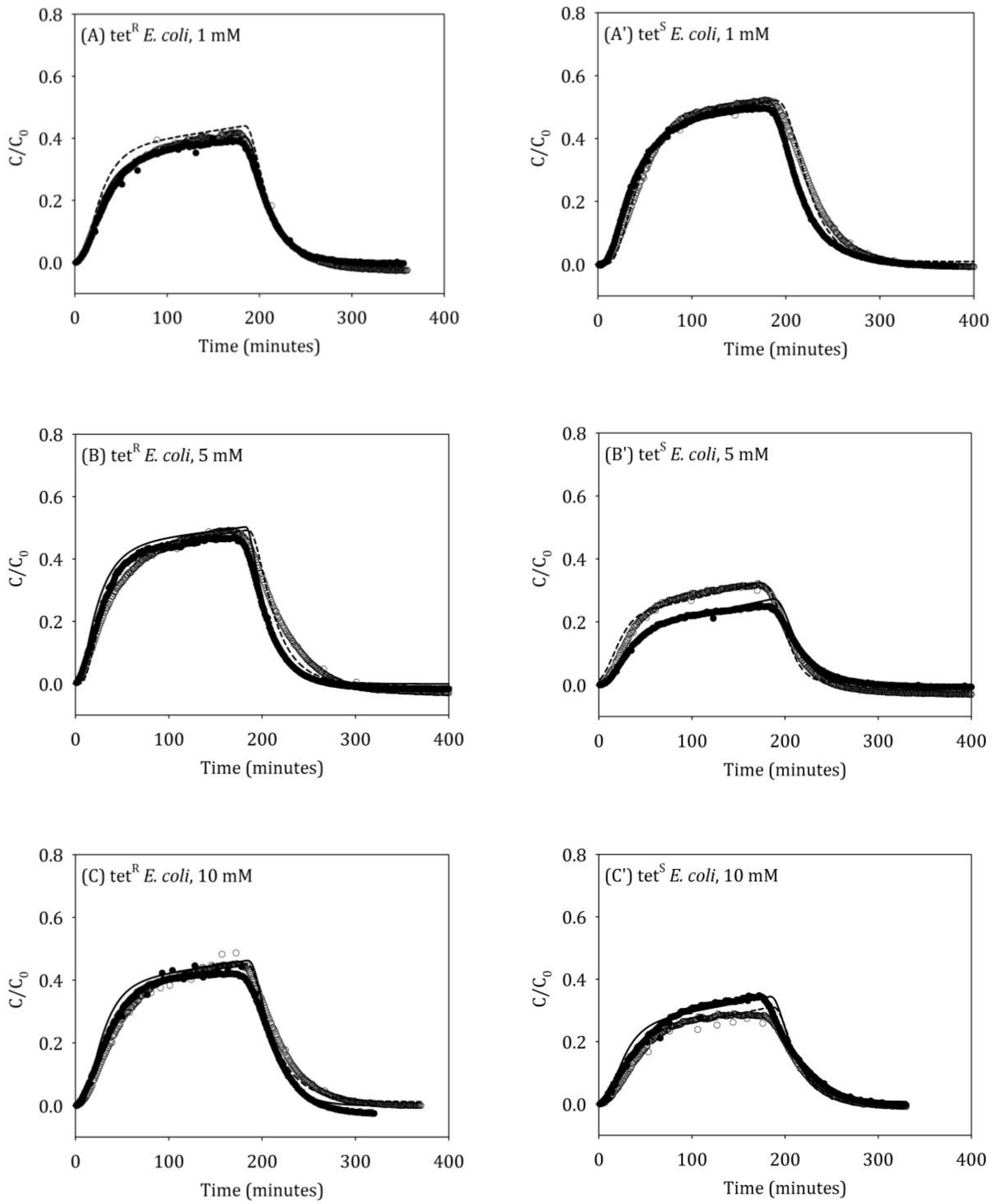

Figure 7. Breakthrough concentrations of the tet[R] (A-C) and tet[S] (A'-C') *E. coli* strains under ~25% of soil moisture content. Symbols represent experimental observations and lines represent model simulation results.

The best-fit values of θ_{im}, *D*, k_a and k_d were shown in Table 2. The model-derived k_a rates were generally one order of magnitude larger for both strains in comparison to other studies [Pang et al., 2008; Garciulo et al., 2008]. The explanation for high k_a rates is that the sand used in this study was coated with Fe and Mn oxides, which promoted attachment of bacterial cells. The simulation results indicated that the immobile fraction of the aqueous phase is usually less than 3%, suggesting that the aqueous phase was predominantly mobile. Because the values of θ_{im} are relatively small compared to θ, the effects of the immobile zone on *E. coli* transport was negligible. Additionally, it was found that the values of k_d were usually two orders of magnitude or more lower than k_a, suggesting that cell detachment was negligible. The very low k_d rates were also reported in Pang et al. study [2008].

Table 2. The best-fit values of θ_{im}, ω, *D*, k_a and k_d that were estimated from the *E. coli* breakthrough curves using HYDRUS-1D. Note that $\theta = \theta_{\text{m}} + \theta_{\text{im}}$. Because the values of θ_{im} is relatively small compared to θ, the effects of immobile zone on *E. coli* transport was negligible.

Moisture content (θ)	*E. coli* strain	Ionic strength (mM)	θ_{im}	*D* (cm^2/min)	k_a (min^{-1})	k_d (min^{-1})
25%	tet^R	1	2.85(±0.93)%	3.39(±1.67)	0.0273(±0.0014)	<10^{-4}
		5	3.99(±1.24)%		0.0222(±0.0020)	<10^{-4}
		10	2.03(±2.87)%		0.0234(±0.0015)	<10^{-4}
	tet^S	1	<1%	2.79(±1.65)	0.0166(±0.0016)	<10^{-4}
		5	<1%		0.0346(±0.0087)	<10^{-4}
		10	<1%		0.0347(±0.0017)	<10^{-4}
12%	tet^R	1	<1%	5.05(±4.25)	0.0175(±0.0055)	<10^{-4}
		5	<1%		0.0169(±0.0084)	<10^{-4}
		10	<1%		0.0228(±0.0020)	<10^{-4}
	tet^S	1	<1%	2.27(±1.38)	0.0200(±0.0022)	<10^{-4}
		5	<1%		0.0319(±0.0076)	<10^{-4}
		10	<1%		0.0300(±0.0097)	<10^{-4}

Figure 8 shows breakthrough concentrations of the tet^R and tet^S *E. coli* strains under low soil moisture content conditions (i.e., θ = ~12%). In general, the breakthrough concentrations of both *E. coli* strains were lower than those measured under the high soil moisture content conditions. Within partially saturated porous media, the water-air interface provides an important adsorption site for the immobilization of colloidal sized particles such as *E. coli* cells and the area of the water-air interface usually increases when soil moisture content decreases [DeNovio et al., 2004].The decrease in *E. coli* mobility under lower soil moisture content thus reflected the increased adsorption of *E. coli* cells at the water-air interface. Because the size of *E. coli* cells was found to be 1 µm or greater [Walczak et al., 2011b], *E. coli* cells could also be immobilized as a result of straining within the thin water films that coat the surface of the solid matrix [Wan and Tokunaga, 1997]. It is also expected that the thin-film straining of *E. coli* cells would increase as soil moisture content was lowered.

Consistent to the observations from the high soil moisture content conditions, the mobility of the tet^R *E. coli* strain was higher than the mobility of the tet^S *E. coli* strain under all three ionic strength conditions, suggesting that the tet^R *E. coli* strain tend to spread more easily within the partially saturated soil. The values of θ_{im}, *D*, k_a and k_d estimated using HYDRUS-1D showed that, even under the low soil moisture conditions, the fraction of immobile aqueous phase was small and the cell detachment from the solid matrix was slow and negligible (Table 2).

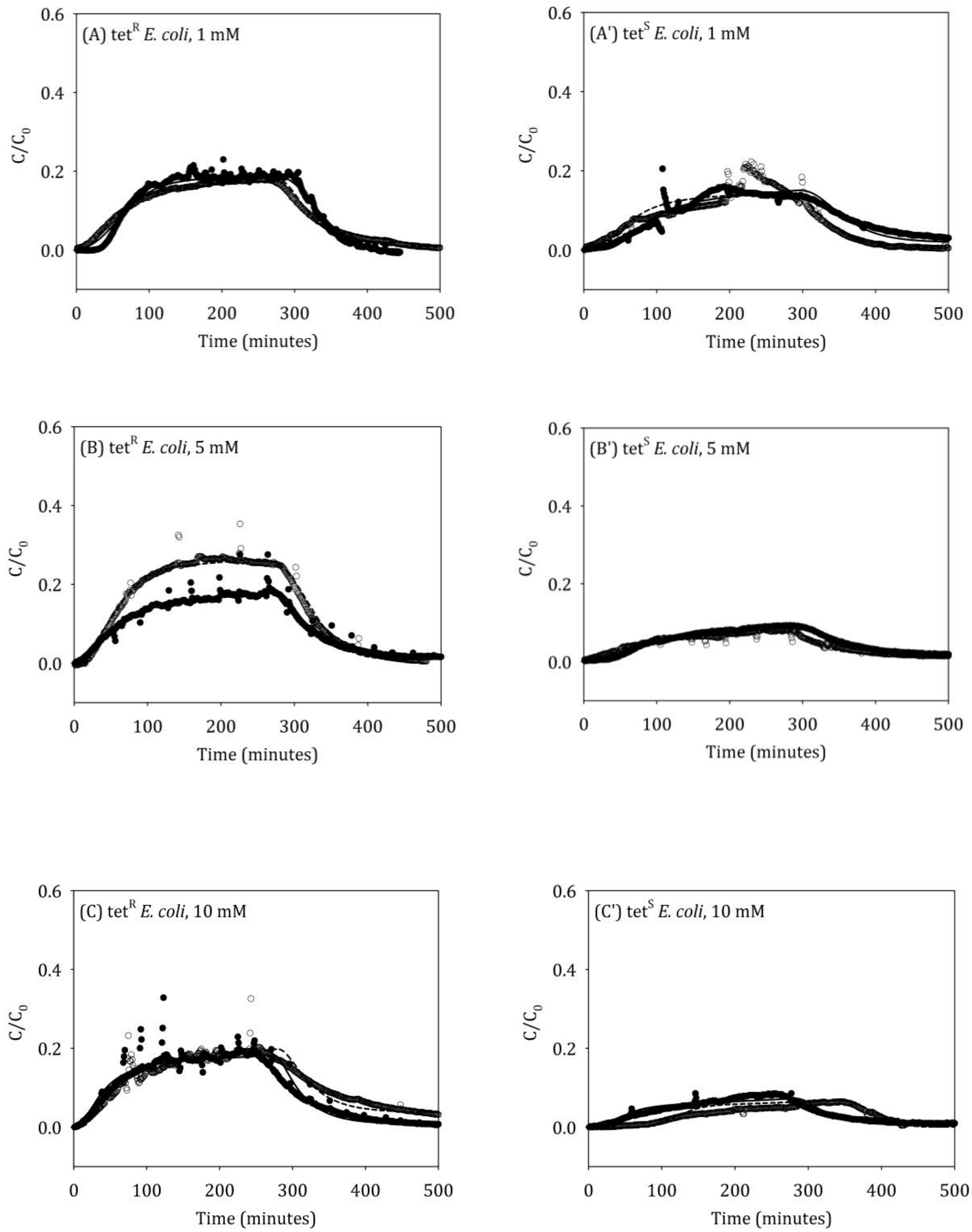

Figure 8. Breakthrough concentrations of the tet^R (A-C) and tet^S (A'-C') *E. coli* strains under 12% of soil moisture content. Symbols represent experimental observations and lines represent model simulation results.

Results from previous studies suggested that change in water chemistry conditions (e.g., a drop in ionic strength) could release the previously immobilized colloid sized particles and this process represents a major mechanism that can transport large quantities of colloids to the underlying groundwater [DeNovio et al., 2004]. In this research, following a few selected experiments performed using 10 mM NaCl, the ionic strength was lowered to 1 mM NaCl while the soil moisture content was maintained constant. The effects of chemical perturbation on the transport of *E. coli* cells within partially saturated soil could thus be evaluated.

In general, our results suggested that a small fraction of the immobilized *E. coli* cells under high ionic strength conditions could be remobilized as a result of the drop in NaCl concentration (Figure 9), suggesting that the immobilization of the *E. coli* cells within the unsaturated cells was largely irreversible.

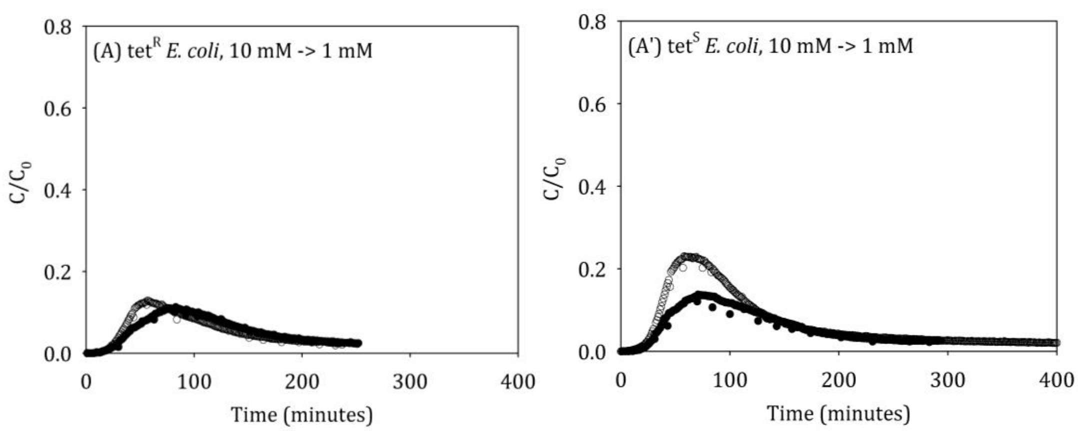

Figure 9. Typical results of the release of tet^R (A) and tet^S (A') *E. coli* cells when the ionic strength was lowered from 10 mM NaCl to 1 mM NaCl. The soil moisture content was maintained at 25%. Time 0 represents the start of the injection of the 1 mM NaCl solution. Lower effluent *E. coli* concentrations were observed during chemical perturbation experiments performed under other ionic strength and/or soil moisture conditions.

It was also suggested that changes in soil moisture contents (i.e., transient flow conditions) could lead to the release of previously immobilized colloid-sized particles [DeNovio et al., 2004; Cheng and Saiers, 2009]. To evaluate the potential effects of transient flow on the transport of manure-derived *E. coli*, the soil moisture content was raised from 12% to 25% following selected steady-state transport experiments. Similar to the observations from the chemical perturbation experiments, our results indicated that only a small fraction of the *E. coli* cells could be remobilized as a result of imbibition (i.e., increase in soil moisture content) (Figure 10). The effluent concentration of the *E. coli* cells during the imbibition experiments was generally less than 4% of the *E. coli* concentration that was used for the transport experiments (Figure 10).

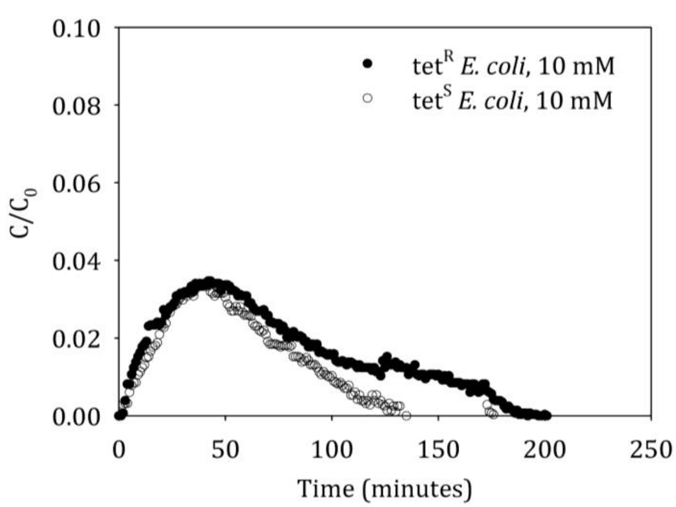

Figure 10. Typical results for the release of tet[R] and tet[S] *E. coli* cells when the soil moisture content was raised from ~12% to ~25% while the ionic strength was maintained at 10 mM NaCl. Time 0 represents the time when the initiation of the soil moisture content increase and start of the injection of 1 mM NaCl solution.

4.4. Conclusions

In this research, the transport behavior of manure-derived tetracycline resistant and susceptible *E.coli* within partially saturated sand packs were investigated with the focus on the effects of moisture content and pore-water chemistry (change in ionic strength) on the *E.coli* mobility. The remobilization of previously retained *E.coli* cells was examined through chemical and physical perturbation. The transport of the *E.coli* cells within partially saturated sands was described by the two-region, dual porosity model. Overall, the results suggested that:

1. The tet^R *E. coli* strain isolated from dairy manure exhibited higher mobility than then tet^S *E. coli* strain isolated from the same source.
2. The mobility of manure-derived *E. coli* was lower when the ionic strength increased or when the soil moisture content decreased.
3. Only a small fraction of the previously immobilized *E. coli* cells were re-mobilized due to chemical perturbation or transient flow.
4. The simulation of tet^R and tet^S *E.coli* cells transport within partially saturated sand packs using a two-region, dual porosity model indicated that the aqueous phase was predominantly in mobile region and the cell detachment was negligible.

4.5 References

Alekshun, M.N. and Levy, S.B. Molecular mechanisms of antibacterial multidrug resistance. *Cell* **2007**, 128, 6, 1037-1050.

Cheng, T. and Saiers, J.E. Mobilization and transport of in situ colloids during drainage and imbibition of partially saturated sediments. *Water Resources Research* **2009**, 45, W08414, doi:08410.01029/02008WR007494.

de Cristobal, R.E., Vincent, P.A. and Salomon, R.A.Multidrug resistance pump AcrAB-TolC is required for high-level, Tet(A)-mediated tetracycline resistance in *Escherichia coli*. *Journal of Antimicrobial Chemotherapy* **2006**, 58, 1, 31-36.

DeNovio, N.M.; Saiers, J.E.; Ryan, J.N. Colloid movement in unsaturated porous media: recent advances and future directions. *Vadose Zone J.* **2004**, *3*, 338–351.

Gargiulo, G.; Bradford, S.A.; Simunek, J.; Ustohal, P.; Vereecken, H.; and Klumpp, E. Bacteria transport and deposition under unsaturated flow conditions: the role of water content and bacteria surface hydrophobicity. *Vadose Zone J.* **2008**, 7, 406 – 419.

Jensen, M.B., Hansen, H.C.B., Hansen, S., Jorgensen, P.R., Magid, J. and Nielsen, N.E. Phosphate and tritium transport through undisturbed subsoil as affected by ionic strength. *Journal of Environmental Quality* **1998**, 27, 1, 139-145.

Lenhart, J.J.; and Saiers, J.E. Transport of silica colloids through unsaturated porous media: Experimental results and model comparisons. *Environ. Sci. Technol*. **2002**, 36, 769 – 777.

Mualem, Y. A new model for predicting the hydraulic conductivity of unsaturated porous media. *Water Resources Research* **1976**, 12, 3, 513 – 522.

Pang, L., McLeod, M., Aislabie, J., Simunek, J., Close, M. and Hector, R. Modeling Transport of Microbes in Ten Undisturbed Soils under Effluent Irrigation. *Vadose Zone Journal* **2008**, 7, 1, 97-111.

Richards, L.A. Capillary conduction of fl uid through porous mediums. *Physics* **1931**, 1, 318 – 333.

Saiers, J.E., Hornberger, G.M., Gower, D.B. and Herman, J.S. The role of moving air-water interfaces in colloid mobilization within the vadose zone. *Geophysical Research Letters* **2003**, 30, 21, 2083.

Van Genuchten, M.Th. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. *Soil Sci. Soc. Am. J.* **1980**, 44, 892 – 898.

Walczak, J.J. and Xu, S.P. Manure as a Source of Antibiotic-Resistant *Escherichia coli* and *Enterococci*: a Case Study of a Wisconsin, USA Family Dairy Farm. *Water Air and Soil Pollution* **2011**, 219(1-4), 579-589.

Walczak, J.J., Bardy, S.L., Feriancikova, L. and Xu, S. Comparison of the Transport of Tetracycline-Resistant and Tetracycline-Susceptible *Escherichia coli* Isolated from Lake Michigan. *Water Air and Soil Pollution* **2011a**, 222(1-4), 305-314.

Walczak, J.J., Bardy, S.L., Feriancikova, L. and Xu, S.P. Influence of tetracycline resistance on the transport of manure-derived *Escherichia coli* in saturated porous media. *Water Research* **2011b**, 45, 4, 1681-1690.

Wan, J.M. and Tokunaga, T.K. Film straining of colloids in unsaturated porous media: Conceptual model and experimental testing. *Environmental Science & Technology* **1997**, 31, 8, 2413-2420

World Health Organization (**2003**) 1st Joint FAO/OIE/WHO Expert Workshop on Non-human Antimicrobial Usage and Antimicrobial Resistance: Scientific assessment, http://www.who.int/foodsafety/publications/micro/en/amr.pdf, Geneva.

Xu, C.X., Lin, X.M., Ren, H.X., Zhang, Y.L., Wang, S.Y. and Peng, X.X. Analysis of outer membrane proteome of *Escherichia coli* related to resistance to ampicillin and tetracycline. *Proteomics* **2006**, 6, 2, 462-473.

CHAPTER 5

Deposition and Remobilization of Graphene Oxide within Saturated Sand Packs

5.1 Introduction

Graphene oxide (GO) is a layered carbon-based nano-material that contains graphene sheets and oxygen-bearing functional groups [Dreyer et al., 2010]. For the past decade, there has been exploding interests in the industrial use (e.g. drug delivery, biosensing, nano- and micro-electronics) of this group of materials due to their unique electronic, thermal and mechanical properties [Hu et al., 2011; Dinikn et al., 2007; Zhang et al., 2011; Berlin et al., 2011; Chen et al., 2010; Eda et al., 2008; Fan et al., 2008; Fugetsu et al., 2011; Mkhoyan et al., 2009; Polichetti et al., 2010]. As the production and use of this group of nano-materials are predicted to grow rapidly in the future, it is expected that substantial quantities of GO particles could be released into the natural environment throughout its industrial life cycle [Salas et al., 2010].

Thanks to the hydrophilic oxygen-bearing functional groups, GO has high solubility in water [Mkhoyan et al., 2009]. Several recent studies examined the biocompatibility and potential toxicity of GO particles suspended in aqueous solutions. The results suggested that GO particles can be toxic to human, animal (e.g., mice) and bacterial cells Akhavan and Ghaderi, 2010; Wang et al., 2011; Vallabani et al., 2011; Singh et al., 2011]. Akhavan and Ghaderi, for instance, reported that the GO particles could significantly reduce the viability of *Escherichia coli* and *Staphylococcus aureus* because the sharp edges of GO particles could damage cell membranes. Wang et al. documented that the ingestion of small quantities (~0.4 mg) of graphene oxide by mice could cause death and lung granuloma formation. Vallabani et al. observed that GO particles could significantly increase the apoptosis of normal human lung cells.

The findings from the toxicity studies raised serious concerns about the potential environmental and health impacts of GO particles that could be released into the natural system. As an integral part of the water cycle, the soil-groundwater system represents an important pathway for the potential spread of GO particles within the natural environment. For this subsurface system, which supplies ~40% of drinking water in the United States [Kenny et al., 2009], the fate and environmental impacts of GO particles will strongly depend on its mobility within the soil and aquifer materials. To our knowledge, no study has examined the remobilization of previously retained GO particles as a result of chemical perturbation (e.g., when the ionic strength is lowered). Finally, the transport behavior of GO within the sand packs was related to the energy interaction profiles between GO particles and quartz sands, which were calculated using extended Derjaguin-Landay-Verwey-Overbeek (XDLVO) theory.

5.2 Materials and Methods

5.2.1 Graphene oxide

GO particles manufactured using the Hummers method was purchased from Cheaptubes Inc. (Brattleboro, VT). Atomic force microscopy (AFM) measurements performed by the manufacturer showed that the GO particles were generally single-layered and their horizontal sizes were between 300 to 800 nm. The GO particles received from the manufacturer were sonically (Branson Ultrasonic Bath) dispersed in electrolyte solutions that contained 1, 5, 20 and 100 mM NaCl, respectively [Dreyer et al., 2010; Becerril et al., 2008]. All the electrolyte solutions were prepared using Nanopure water (Barnstead) that had a specific resistivity of ~18.2 MΩcm. The pH of the GO suspensions was ~6.0. Scans of absorbance as a function of wavelength using a Shimadzu UV-1700 spectrophotometer for each of the sonicated suspensions showed that the optimal wavelength for GO concentration measurement was 220 nm. Calibration curves were then prepared to establish the relationship between absorbance and GO concentrations (up to 70mg/L) (R^2>0.99). Dynamic light scattering (DLS) measurement performed using a Brookhaven ZetaPALS showed that the average hydrodynamic radius of the GO particles was 329$\pm$79 nm, which was consistent to the AFM measurements, and did not vary with NaCl concentration.

5.2.2 Preparation of sand columns

The transport experiments were performed in duplicate using a pair of glass chromatography columns measuring 2.5 cm in diameter and 15 cm in length (Kontes, Vineland, NJ). The silica sands received from the manufacturer (US Silica, Ottawa, IL) were sieved for the 0.211 – 0.297 mm fraction. The sieved sands were then alternately cleaned using concentrated nitric acid to remove metal hydroxides and diluted NaOH solution to remove natural clay particles [Xu et al., 2008], rinsed with deionized water and dried at 80^{o}C. The porosity (*n*) of the sand was determined using the bulk density method and equaled 0.37 [Weight, 2008]. The vertically oriented columns were wet-packed with the clean silica sands and care was taken to eliminate the possibility of trapped air bubbles. The packed saturated sand columns were equilibrated by pumping >30 pore volumes (PV) of appropriate background electrolyte (i.e., 1, 5, 20 or 100 mM NaCl) using peristaltic pumps (MasterFlex, Vernon Hills, IL). The Darcy velocity was maintained using peristaltic pumps at 0.31 cm/min. Following the equilibrium step, the packed sand columns were ready for the tracer or GO transport experiments.

5.2.3 Tracer tests

The primary goal of the tracer tests was to estimate the hydraulic dispersion coefficient [Xu et al., 2006]. Briefly, a tracer solution (9.75 mM NaCl and 0.25 mM KNO_3 with NO_3^- being the tracer) was injected to the top of the pre-equilibrated columns and the concentrations of nitrate in the effluent was determined through measuring the absorbance at a wavelength of 220 nm using a Shimadzu UV-1700 spectrophotometer [Abudalo et al., 2005]. After 60 min of injection of the tracer solution (~3.5 PV), the columns were flushed with the background NaCl solution that did not contain KNO_3 until the absorbance of effluent returned to the background values. The transport of the conservative tracer within the saturated sand packs can be described by the advection-dispersion equation:

$$\frac{\partial C_T}{\partial t} = -v\frac{\partial C_T}{\partial x} + D\frac{\partial^2 C_T}{\partial x^2} \qquad (16)$$

where C_T is the concentration of the tracer (NO_3^-) in the pore water; t is the time; v is the average linear pore water velocity; which equaled Darcy velocity divided by porosity; x is the coordinate parallel to flow; and D is the hydrodynamic dispersion coefficient.

Eq. (16) was approximated by a second-order, finite-difference scheme with a first-type boundary condition at the column inlet, and the resulting system of linear equations was solved iteratively to obtain effluent tracer concentrations as a function of time. The solutions of Eq. (16) were fitted to the tracer breakthrough data using the Levenberg-Marquardt least-squares algorithm to obtain the best-fit values of the hydrodynamic dispersion coefficient, D [Xu et al., 2006; Press, 1989].

5.2.4 Transport of GO particles within the saturated sand packs

Similar to the tracer tests, the GO transport experiments were initiated by injecting GO suspensions (5 mg/L of GO, NaCl concentration: 1, 5, 20 and 100 mM NaCl) into the columns from the top. The outflow from the columns were connected to quartz flow-through cuvettes (NSG Precision, Farmingdale, NY) and the concentrations of the GO particles in the effluent were monitored using a Shimadzu UV-1700 spectrophotometer at 30 seconds intervals at a wavelength of 220 nm. The injection of the GO suspension lasted for 60 min (~3.5 PV). The columns were then flushed with background electrolyte solution until the absorbance of effluent returned to the background values.

The potential remobilization of previously deposited GO particles due to chemical perturbation were performed after GO injection experiments using 100 mM

NaCl, when the 1 mM NaCl solution free of GO particles was injected to the columns at 6 PV. The quantity of the remobilized GO particles in the column effluent was similarly monitored using the spectrophotometer until the absorbance returned to background values. The remobilization experiments lasted for ~8 PV.

The transport of GO particles within the saturated sand packs was described using a second-order deposition model which assumed that the number of GO deposition sites was limited and the deposition rate decreased as the GO deposition sites were progressively occupied by the retained GO particles. The mathematical form of this Langmuir-type model was:

$$\frac{\partial C}{\partial t} = -v\frac{\partial C}{\partial x} + D\frac{\partial^2 C}{\partial x^2} - k_d\left(1 - \frac{S}{S_0}\right)C + k_r\frac{\rho}{n}S \quad (17)$$

$$\frac{\rho}{n}\frac{\partial S}{\partial t} = k_d\left(1 - \frac{S}{S_0}\right)C - k_r\frac{\rho}{n}S \quad (18)$$

where C is the pore water concentration of GO particles; k_d is the deposition rate coefficient; k_r is the release rate coefficient; S is the concentration of retained GO particles; S_0 is the maximum concentration of retained GO particles; ρ is the bulk density of quartz sand; n is the porosity of the silica sands (0.37) and other parameters were previously defined.

Similar to Eq. (16), the coupled Eqs. (17) and (18) were also approximated by a second-order, finite-difference scheme with a first-type boundary condition at the column inlet and then numerically solved iteratively to obtain effluent GO concentrations as a function of time. The solutions were fitted to the GO breakthrough data using the Levenberg-Marquardt least-squares algorithm to obtain the best-fit values of k_d and S_0 for the deposition experiments and k_r for the remobilization experiments [Xu et al., 2006; Press, 1989].

5.3. Energy interactions between GO particles and quartz sands

The mobility of the GO particles within the saturated sand packs is determined by the energy interactions between the GO particles and the surface of sands. According to the extended Derjaguin-Landau-Verwye-Overbeek (XDLVO) theory, the energy interactions between the GO particles and the quartz sands (a plate-plate system) include the Lifshitz-van der Waals (LW) interactions, the electrostatic double layer (EDL) interactions and the Lewis acid-base (AB) interactions, which can be calculated using the following equations [Redman et al., 2004; Huang et al., 2010]:

$$\phi^{\mathrm{LW}} = -\frac{A}{12\pi h^2} \tag{5}$$

$$\phi^{\mathrm{EDL}} = \frac{\varepsilon_0 \varepsilon_w \kappa}{2}\left\{2\psi_p\psi_s \frac{1}{\sinh(\kappa h)} + \left(\psi_p^2 + \psi_s^2\right)[1 - \coth(\kappa h)]\right\} \tag{6}$$

$$\phi^{\mathrm{AB}} = \Delta G_{h_0}^{AB} exp\left(\frac{h_0 - h}{\lambda_w}\right) \tag{7}$$

where A represents the Hamaker constant, which determines the magnitude of the LW force; h is the separation distance between the GO particles and sand surface; ε_0 is the dielectric permittivity of vacuum (8.854 x 10^{-12} CV^{-1} m^{-1}); ε_w is the dielectric constant of water (78.5); κ is the inverse of Debye length, which represents the thickness of the

EDL; ψ_p and ψ_s are the surface potentials of GO particles and sand, respectively; $\Delta G_{h_0}^{AB}$ is the acid-base free energy per unit area at the minimum separation, λ_w (-0.6nm); h_0 represents the minimum equilibrium distance between the GO particle and sand surface and equals to 0.157 nm [van Oss, 1993].

The values of the Debye length vary with ionic strength and were calculated using the following equation:

$$\kappa^{-1} = \sqrt{\frac{\varepsilon_0 \varepsilon_w kT}{2N_A I e^2}} \quad (9)$$

where ε_0 and ε_w were previously defined, k is Boltzmann's constant, T is absolute temperature, N_A is the Avogadro number, I is ionic strength and e is the electron charge.

For Eqs. (5)-(7), the values of A, $\Delta G_{h_0}^{AB}$, κ, ψ_{GO}, ψ_s were required for the interaction energy calculations. In this research, the zeta potential values were used in the place of surface potential values for the EDL interaction calculation. The zeta potential of the GO particles suspended in the NaCl solutions were measured (≥ 5 measurements) using a Brookhaven ZetaPALS analyzer. Silica sands were firstly pulverized and the colloid-sized particles thus produced were suspended in various NaCl solutions to determine their zeta potential values in a similar fashion [Porubcan and Xu, 2011; Johnson, 1999].

To obtain the values of A and $\Delta G_{h_0}^{AB}$, the contact angles (θ) of three probing liquids (water glycerol and diiodomethane) were acquired with a Rame-Hart goniometer using thin GO films produced by drying concentrated GO suspensions on clean glass slides [Ong et al., 1999]. As the surface interfacial tension parameters of the selected probing liquids were known [van Oss, 1993; Morrow et al., 2005], the LW (γ_{GO}^{LW}), electron-accepting (γ_{GO}^{+}) and electron-donating (γ_{GO}^{-}) interfacial tension values for GO could be determined through the following equations [van Oss, 1993]:

$$\gamma_i^L(1 + cos\theta) = 2\sqrt{\gamma_i^{LW}\gamma^{LW}} + 2\sqrt{\gamma_i^{+}\gamma^{-}} + 2\sqrt{\gamma_i^{-}\gamma^{+}} \qquad (11)$$

where the subscripts i represents water (γ_i^L = 72.8, γ_i^{LW}= 21.8, $\gamma^{+} = \gamma^{-} = 25.5$ mJ m^{-2}) glycerol (γ_i^L = 64.0, γ^{LW} = 34.0, γ^{+} = 3.92 γ^{-}= 57.4 mJ m^{-2}) and diiodomethane (γ_i^L = 50.8, γ^{LW} = 50.8, $\gamma^{+} = \gamma^{-} =$ 0 mJ m^{-2}), respectively [van Oss, 1993].

The values of A and $\Delta G_{h_0}^{AB}$ were then calculated from the interfacial tension parameters [van Oss, 1993]:

$$A = 24\pi h_0^2\left(\sqrt{\gamma_b^{LW}} - \sqrt{\gamma_w^{LW}}\right)\left(\sqrt{\gamma_s^{LW}} - \sqrt{\gamma_w^{LW}}\right) \qquad (8)$$

$$\Delta G_{h_0}^{AB} = 2\left[\sqrt{\gamma_w^{+}}\left(\sqrt{\gamma_b^{-}} + \sqrt{\gamma_s^{-}} - \sqrt{\gamma_w^{-}}\right) + \sqrt{\gamma_w^{-}}\left(\sqrt{\gamma_b^{+}} + \sqrt{\gamma_s^{+}} - \sqrt{\gamma_w^{+}}\right) - \sqrt{\gamma_b^{-}\gamma_s^{+}} - \sqrt{\gamma_b^{+}\gamma_s^{-}}\right] \qquad (10)$$

where the subscripts of b, w and s represent GO particles, water and sand, respectively. For quartz sands, the previously published interfacial tension values of γ_s^{LW}(39.2 mJ m^{-2}) γ_s^{+} (1.4 mJ m^{-2}) and γ_s^{-} (47.8 mJ m^{-2}) were used in this research [Morrow et al., 2005].

5.3 Results and Discussion

5.3.1 Results of tracer test

The results of the tracer tests are shown in Figure 11. The effluent tracer solutions obtained by numerically solving Eq. (16) were fitted to the experimental breakthrough data and the hydrodynamic dispersion coefficient (D) was estimated as 3.58 ($\pm$0.63) cm^2/h. This best-fit value of dispersion coefficient was then used to model the transport of GO particles within the saturated quartz sands.

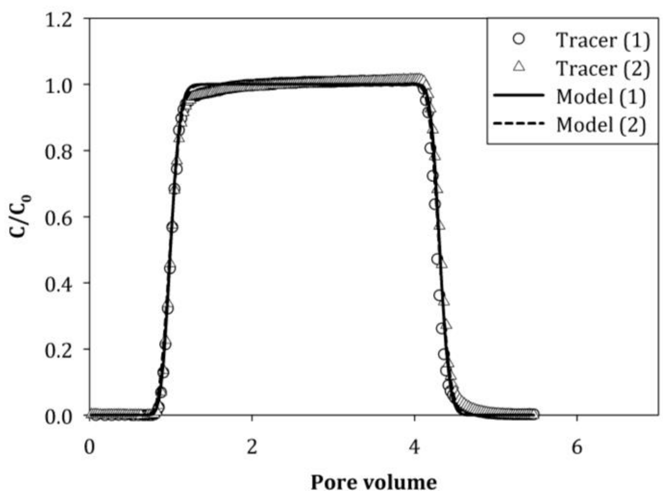

Figure 11. Breakthrough curves of a conservative tracer (NO^{3-}). Symbols represent measured concentrations and lines represent model-predicted results. The best-fit value of the dispersion coefficient (*D*) was 3.58 ($\pm$0.63) cm^2/h.

5.3.2 Deposition of GO particles within saturated sand packs

The breakthrough concentrations of GO particles (GO concentrations in the effluent normalized by its concentration in the influent) under various ionic strength conditions (1-100 mM NaCl) are shown in Fig. 12. Little retention of GO particles occurred under the 1 mM NaCl condition and the breakthrough concentrations approached 100% toward the end of the injection experiments (Fig. 12A). There was noticeable drop in early GO breakthrough concentrations when the ionic strength was increased to 5 mM (Fig. 12B). Further increase in ionic strength to 20 mM led to significant decrease in GO breakthrough concentrations (Fig. 12C). Under the 100 mM NaCl condition, the breakthrough concentrations of GO remained below 10% of its influent concentration throughout the transport experiments. Under all ionic strength conditions, the breakthrough concentrations of the GO particles increased with time (Fig. 12A – D), suggesting that as the available deposition sites for GO particles were progressively occupied, the effective deposition rates became lower. Integration of the breakthrough curve showed that 93.5% ($\pm$1.0%), 90.0% ($\pm$2.7%), 34.8% ($\pm$0.4%) and 3.4% ($\pm$1.4%) of GO particles traveled through the columns under 1, 5, 20 and 100 mM NaCl conditions, respectively. Overall, our results showed that the transport and retention of GO within saturated sand packs was strongly dependent on ionic strength and GO particles could display high mobility (i.e., low retention) under low ionic strength conditions.

When the columns were flushed using the background solution of identical ionic strength following the injection of GO suspensions, the GO breakthrough curves were similar to those of the conservative tracer. This suggested that when the same ionic strength was maintained, the release of the immobilized GO particles was negligible. The mathematical model represented by Eqs. (17) and (18) were thus simplified by assuming that $k_r = 0$. The simplified model was then solved and inversely fitted to the GO breakthrough concentrations. Comparison of the measured and model-predicted GO breakthrough concentrations suggested that the Langmuir-type mathematical model was adequate to describe the transport of GO particles under all ionic strength conditions (Fig. 12). The R^2 values for all the model predictions were greater than 0.98. In particular, the model was successful at describing the temporal increase in GO breakthrough concentration during the injection experiments.

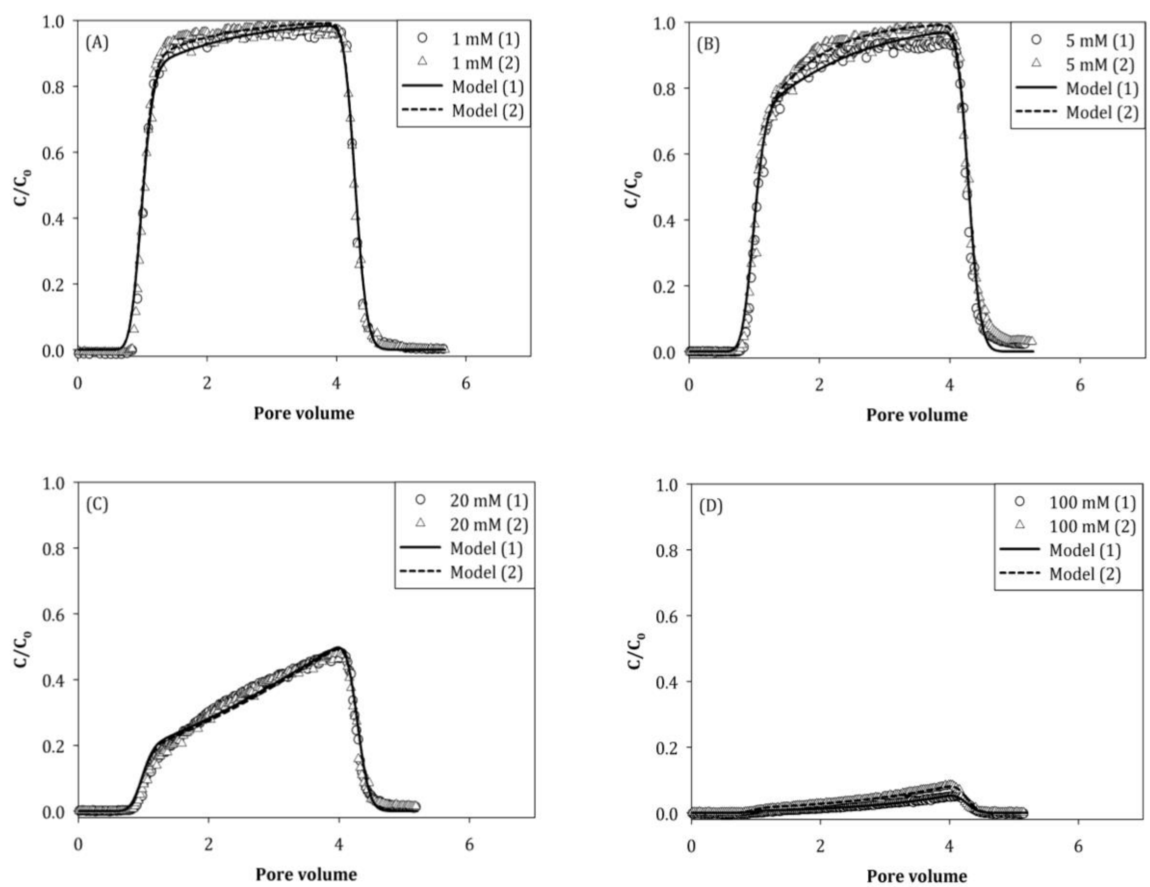

Figure 12. Breakthrough curves of GO particles suspended in (A) 1 mM NaCl, (B) 5 mM NaCl, (C) 20 mM NaCl, and (D) 100 mM NaCl, respectively. (C) represents aqueous GO concentrations in the effluent and C_0 represents influent GO concentrations. Symbols represent measured concentrations and lines represent model-predicted results. The R^2 value for all model predictions were greater than 0.98.

The best-fit values of GO deposition rate coefficient (k_d) and deposition capacity (S_0) were obtained from the inverse simulations (Fig. 13). The deposition rate coefficient increased from 0.50 h^{-1} to 15.9 h^{-1} as the water ionic strength increased from 1 to 100 mM NaCl (Fig. 13A). Similarly, the values of S_0 increased from 0.19 µg/g (1 mM NaCl) to 7.89 µg/g (100 mM NaCl) (Fig. 13B). The estimated values of S_0 were on the order of µg/g and indicated that the maximum quantity of GO that could be removed by silica sand was limited. As a result, if large quantities of GO particles would be released into the subsurface environment, they could potentially spread widely within the groundwater system.

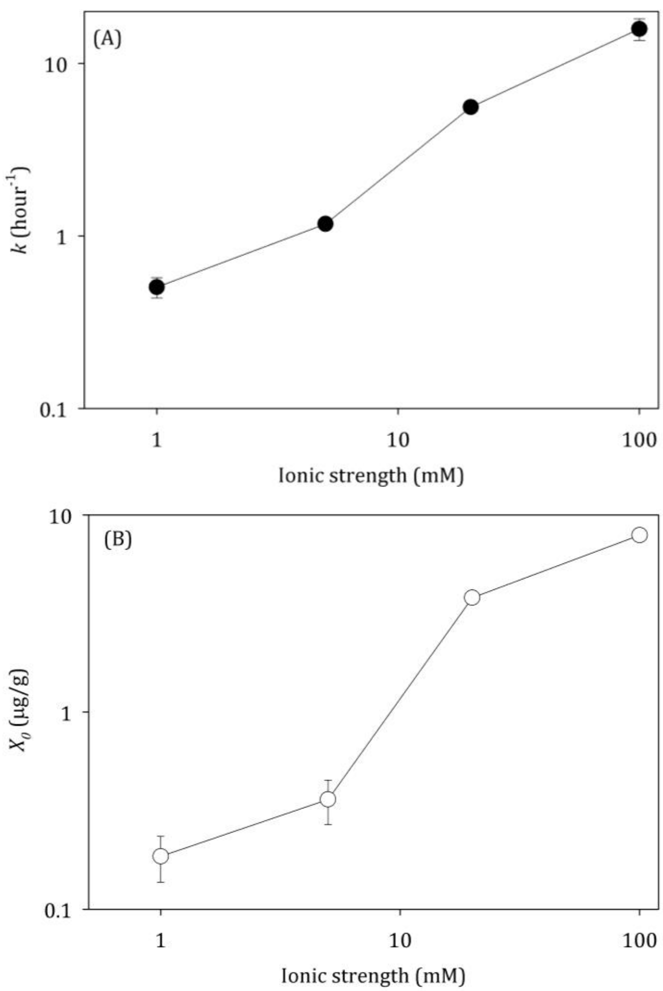

Figure 13. The best-fit values of (A) GO deposition rate coefficient (k_d), and (B) deposition capacity (S_0) estimated from inverse simulation.

With the simplifying assumptions that the average diameter of the sand grain was 0.254 mm and the sand grains were spherical, we calculated the surface area of the sand as $8.91 \times 10^{-3}\ m^2/g$. Given a density of $1.8\ g/cm^3$ [Dikin et al., 2007] and average thickness of 0.95 nm for the GO particles, 1 μg of GO could cover an area of $5.85 \times 10^{-4}\ m^2$. The estimate S_0 values were thus equivalent to 1.2%, 2.4%, 25.0% and 51.8% coverage of the sand surface area for 1, 5, 20 and 100 mM NaCl, respectively. These coverage calculations suggested that, particularly under high ionic strength conditions, a significant portion of the surface of the quartz sands could be covered by GO particles when the adsorption capacities were reached. As a result, the surface properties of the sands could be substantially altered. For instance, because the zeta potential of the GO particles was less negative than the quartz sands (see Section: Interaction energy profiles between GO particles and sand surfaces), the surface of the GO-covered sands could become less negatively charged. This alteration could have important implications for the transport of other chemicals and particulate matters within the sand packs.

5.3.3 Remobilization of previously retained GO particles

Following the injection of GO suspensions under the 100 mM NaCl condition, the 1 mM NaCl solution was introduced into the columns to examine the potential remobilization of previously retained GO particles when the ionic strength was reduced. The results showed that the maximum GO concentrations in the effluent were ~ 5 – 7 times greater than the original influent concentrations (Fig. 14). Integration of GO concentrations during the remobilization experiments showed that 114 ($\pm$12)% of the retained GO particles were remobilized. Practically speaking, the reduction of ionic strength from 100 mM to 1 mM led to the release of all retained GO particles.

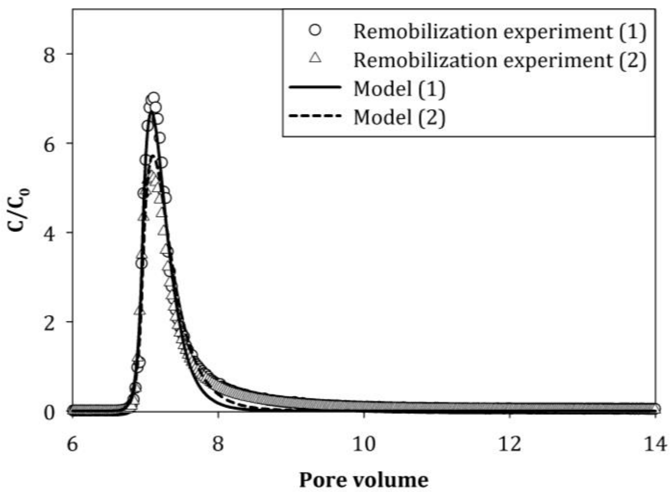

Figure 14. The remobilization of previously retained GO particles as a result of chemical perturbation. Following the transport experiment of 100 mM NaCl (Fig. 20D), the 1 mM NaCl solution was introduced to the columns at 6 PV. The symbols represent the experimentally determined GO particle concentrations in the effluent and the lines represent the model simulation results. The best-fit value of the release rate coefficient was 13.75 ($\pm$2.85) h^{-1}.

The mathematical model of Eqs. (17) and (18) were fitted to the effluent GO concentrations during the remobilization experiments. For these simulations, it was assumed that, when the 100 mM NaCl solution was displaced by the 1 mM NaCl solution, the deposition of GO particles was still occurring and the deposition kinetics parameters (i.e., k_d = 0.50 h^{-1}, S_0 = 0.19 μg/g) that were determined independently from the deposition experiments were used. The values of k_r were estimated from the remobilized GO concentrations through inverse simulation. The simulation results showed that the mathematical model could satisfactorily ($R^2 > 0.98$) describe the release kinetics of the GO particles (Fig. 14). The best-fit value of k_r was 13.75 ($\pm$2.85) h^{-1}.

5.3.4 Interaction energy profiles between GO particles and sand surfaces

The measured zeta potential values for GO particles and quartz sand are shown in Fig. 15. Both the GO particles and the quartz sands were negatively charged, suggesting repulsive EDL interactions. The negative charges of the GO particles arose from the deprotonation of the oxygen-containing functional groups (e.g., -OH) under the experimental pH condition (~6.0) [Dreyer et al., 2010; Si and Samulski, 2008]. For the surface of the silica sands, the negative charges were acquired through the dissociation of proton from the silanol (i.e., SiOH) group [Iler, 1979]. In general, the zeta potential of both the GO particles and quartz sands increased and became less negative with the increase in ionic strength due to the suppression of the electric double layer. Under the same ionic strength conditions, the zeta potential of the GO particles was less negative than that of the quartz sand.

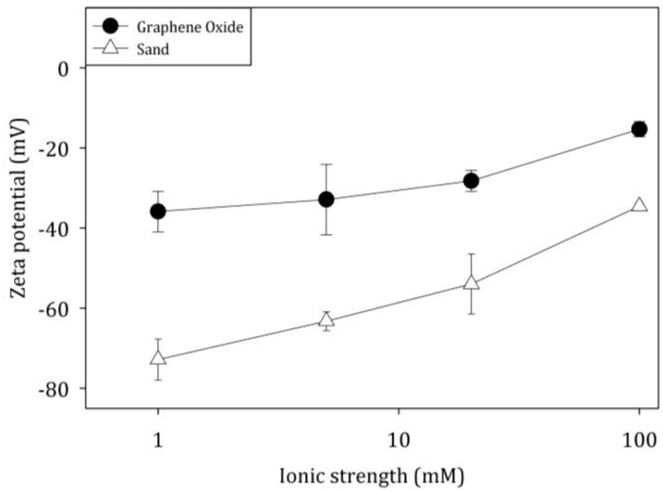

Figure 15. Zeta potential of the GO particles and silica sand under various ionic strength conditions. The error bars represent the standard deviation of a minimum of 3 measurements.

The measured contact angles (n ≥ 4) of water, glycerol and diiodomethane on GO film were 29.7^o ($\pm$7.1^o), 17.4^o ($\pm$2.8^o), and 25.4^o ($\pm$3.6^o), respectively. Using Eq. (11), the values of γ_{GO}^{LW}, γ_{GO}^{-}, and γ_{GO}^{+} were calculated as 46.01, 31.78 and 2.44 mJ m^{-2}, respectively. Combined with the surface tension values (γ_S^{LW}=39.2 mJ m^{-2}, γ_S^{+}=1.4mJ m^{-2} and γ_S^{-}=47.8mJ m^{-2}) of quartz sands that were previously reported [Morrow et al., 2005], the Hamaker constant (Eq.(8)), for the GO-water-quartz system equaled to 6.26 x 10^{-21}J. The estimated value of $\Delta G_{h_0}^{AB}$ was 17.55 mJ/m^2 (Eq. (10)). The AB interaction between the GO particles and quartz sand surfaces was thus repulsive.

Using the values of A, $\Delta G_{h_0}^{AB}$, κ, ψ_{GO}, ψ_S, the XDLVO interaction energy profiles between the GO particles and the quartz sands were calculated (Fig. 16). For all the ionic strength conditions, the energy barrier between the GO particles and the sand surfaces was greater than 10 mJ/m^2 (Fig. 16A). Inspection of the LW, EDL and AB forces indicated that the strong repulsive AB force between GO particles and the surface of quartz sands was significantly higher than the generally repulsive EDL force and was primarily responsible for the magnitude of the energy barrier (Fig. 16B). The calculated interaction energy profiles also indicated the presence of the secondary energy minimum for ionic strength conditions greater than 1 mM and the depth of the secondary energy minimum increased with ionic strength (Fig. 16C). While the presence of the substantial energy barriers would prevent the deposition of GO particles into the primary energy minimum, the GO particles could be immobilized within the secondary energy minimum [Redman et al., 2004]. With the increase in ionic strength, the magnitude of the secondary energy minimum increased and it became more likely for the GO particles to be retained. This was consistent to the observation that the deposition of GO particles increased with ionic strength (Fig. 12). In the meantime, for the GO particles that were immobilized within the secondary energy minimum under the ionic strength condition of 100 mM NaCl, the reduction of ionic strength to 1 mM NaCl would effectively eliminate the secondary energy minimum and the previously retained GO particles could be released. This was consistent to the results of the chemical perturbation experiments which suggested that ~100% of the GO particles retained under 100 mM NaCl were remobilized when the ionic strength was reduced to 1 mM NaCl. Overall, it was found that the XDLVO theory could explain the retention and remobilization of GO particles within saturated quartz sands under the tested chemical conditions (i.e., 1 – 100 mM NaCl).

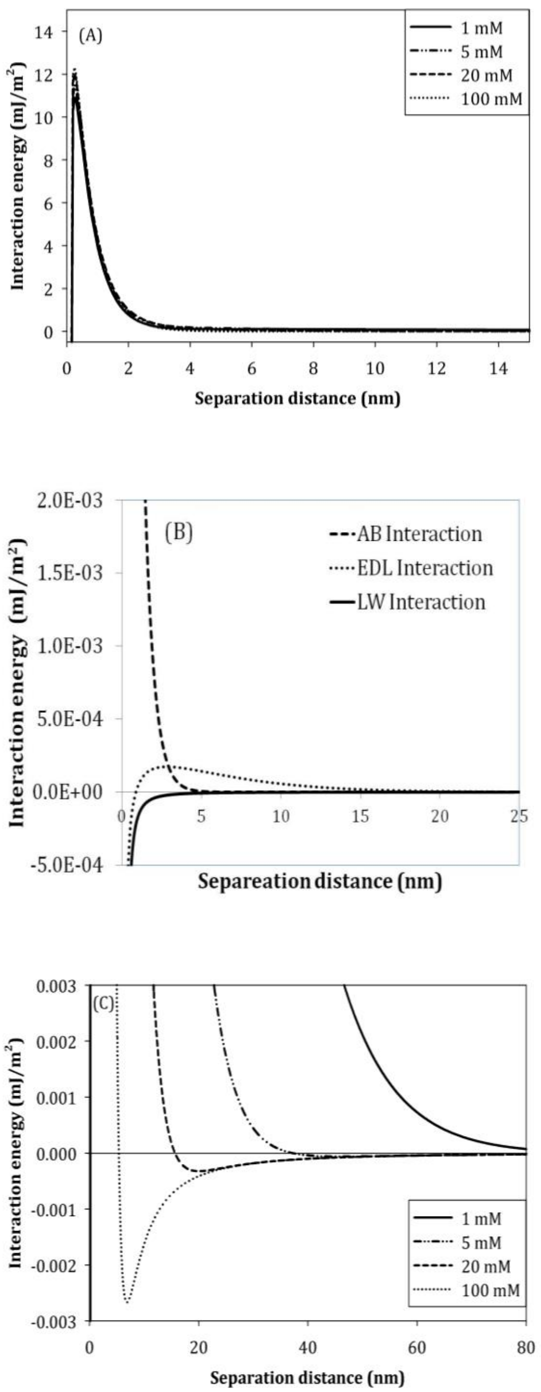

Figure 16. (A) Calculated XDLVO interaction energy between GO particles and silica sands as a function of separation distance and ionic strength. (B) Comparison of the LW, EDL and AB interactions for the ionic strength of 5 mM. Please note the log scale for the interaction energy values. (C) The secondary energy minimum of the XDLVO interaction energy profiles.

In this research, uniform and clean quartz sands were used as the porous media. It is recognized that sediments in the natural subsurface system usually display a broad range of size distribution and are coated with materials such as iron oxide and iron hydroxide which, due to the positive charges they create, could facilitate the attachment of negatively charged particles such as GO on the surface of the solid matrix [Abudalo et al., 2005]. Additional studies will be required to quantify the mobility of GO particles within natural soil and sediments under a wide range of chemical and flow conditions, and to test the effectiveness of XDLVO theory in explaining the observed transport behavior of GO particles.

5.4 Conclusions

In this research, the transport behavior of GO particles within saturated sand packs under various ionic strength conditions was investigated through a series laboratory column experiments. The remobilization kinetics of the previously retained GO particles due to chemical perturbation was determined. A Langmuir-type transport model was applied to describe the transport behavior of GO particles and the XDLVO theory was employed to interpret the observed trend in the mobility of GO particles. Overall, our findings suggested that GO particles will have high mobility within sandy groundwater aquifers and the best practice to limit its impact on the subsurface system is to minimize its release into the environment. More specifically, the major findings from this research include:

- Under low ionic strength conditions, the GO particles displayed high mobility within the saturated quartz sands.

- Although significant immobilization of GO particles was observed under high ionic strength conditions, the immobilization process would eventually be limited by the deposition capacities of GO particles, which were found to be quite small (~8 μg/g).

- The GO particles that were retained within the sand packs could be remobilized as a result of the decrease in ionic strength.

- The transport behavior of the GO particles within the saturated sand packs could be described by a Langmuir-type model.

- The XDLVO theory could explain the observed trend in the mobility of GO particles within saturated sand packs under the chemical conditions (ionic strength: 1 – 100 mM NaCl) that were tested in this research.

5.5 References

Abudalo, R.A.; Bogatsu, Y.G.; Ryan, J.N.; Harvey, R.W., Metge, D.W.; Elimelech M. Effect of ferric oxyhydroxide grain coatings on the transport of bacteriophage PRD1 and *Cryptosporidium parvum* oocysts in saturated porous media. *Environ. Sci. Technol*. **2005**, 39, 6412 – 6419.

Akhavan, O.; and Ghaderi, E. Toxicity of graphene and graphene oxide nanowalls against bacteria, ACS Nano 2010, 4, 5731 – 5736.

Becerril, H.A.; Mao, J.; Liu, Z.; Stoltenberg, R.M., Bao, Z.; Chen, Y. Evaluation of solution-processed reduced graphene oxide films as transparent conductors, *ACS Nano* **2008**, 2, 463 – 470.

Berlin, J.M.; Yu, J.; Lu, W.; Walsh, E.E.; Zhang, L.L.; Zhang, P.; Chen, W. Kan, A.T.; Wong, M.S., Tomson, M.B.; Tour, J.M. Engineered nanoparticles for hydrocarbon detection in oil-field rocks, *Energy Environ. Sci.* **2001**, 4, 505 – 509.

Chen, W.F.; Yan, L.F.; Bangal, P.R. Chemical reduction of graphene oxide to graphene by sulfur-containing compounds. *J. Phys. Chem. C* **2010**, 114, 19885 – 19890.

Dikin, D.A.; Stankowich, S.; Zimney, E.J.; Piner, R.D.; Dommett, G.H.B.; Evmenenko, G.; Nguyen, S.T.; Ruoff, R.S. Preparation and characterization of graphene oxide paper, *Nature* **2007**, 448, 457 – 460.

Dreyer, D.R.; Park, S.; Bielawski, C.W.; Ruoff, R.S. The chemistry of graphene oxide. *Chem. Soc. Rev*. **2010**, 39, 228 – 240.

Eda, G.; Fanchini, G.; Chhowalla, M. Large-area ultrathin films of reduced graphene oxide as a transparent and flexible electronic material, *Nat. Nanotechnol*. **2008**, 3, 270 – 274.

Fan, X.B.; Peng, W.C.; Li, Y.; Li, X.Y.; Wang, S.L.; Zhang, G.L.; Zhang, F.B. Deoxygenation of exfoliated graphite oxide under alkaline conditions: a green route to graphene preparation. *Adv. Mater*. **2008**, 20, 4490 – 4493.

Fugetsu, B.; Sano, E.; Yu, H.W.; Mori, K.; Tanaka, T. Graphene oxide as dyestuffs for the creation of electrically conductive fabrics. Carbon 2010, 48, 3340 – 3345.

Hu, W.B.; Fan, C.H.; Peng, C.; Lv, M.; Li, X.M.; Zhang, Y.J.; Chen, N.; Huang, Q. Protein corona-mediated mitigation of cytotoxicity of graphene oxide, *ACS Nano* **2011**, 5, 3693 – 3700.

Huang, X.F.; Bhattacharjee, S.; Hoek, E.M.V. Is surface roughness a ‘scapecoat” or a primary factor when defining particle-substrate interactions? Langmuir 2010, 26, 2528 – 2537.

Iler, R.K. The Chemistry of Silica: Solubility, Polymerization, Colloid and Surface Properties, and Biochemistry, Wiley, New York, **1979**.

Johnson, P.R. A comparison of streaming and microelectrophoresis methods for obtaining the zeta potential of granular porous media surfaces. *J. Colloid Interface Sci.* **1999**, 209, 264 – 267.

Kenny, J.F.; Barber, N.L., Hutson, S.S.; Linsey, K.S.; Lovelace, J.K.; Maupin, M.A. Estimated Use of Water in the United States in 2005, **2009**.

Liu, Z.A.; Feng, L.Z.; Zhang, S.A. Graphene based gene transfection, *Nanoscale* 2011, 3, 1252 – 1257.

Mkhoyan, K.A.; Contryman, A.W.; Silcox, J.; Stewart, D.A.; Eda, G.; Mattevi, C.; Miller, S.; Chhowalla, M. Atomic and electronic structure of graphene-oxide, *Nano Lett*. **2009**, 9, 1058 – 1063.

Morrow, J.B.; Stratton, R.; Yang, H.H.; Smets, B.F.; Grasso, D. Macro- and nanoscale observations of adhesive behavior for several E.coli strains (O157:H7 and environmental isolates) on mineral surfaces. *Environ. Sci. Technol*. **2005**, 39, 6395 – 6404.

Ong, Y.L.; Razatos, A.; Georgiou, G.; Sharma, M.M. Adhesion forces between *E.coli* bacteria and biomaterial surfaces. *Langmuir* **1999**, 15, 2719 – 2725.

Polichetti, T.; Miglietta, M.L.; Di Francia, G. Overview on graphene: properties, fabrication and applications. *Chim. Oggi* **2010**, 28, 6 – 9.

Porubcan, A.A.; and Xu, S.P. Colloid straining within saturated heterogeneous porous media. *Water Res*. **2011**, 45, 1796 – 1806.

Press, W.H. Numerical Recipes: the Art of Scientific Computing. Cambridge University Press, New York, NY, 1989.

Redman, J.A.; Walker, S.L.; Elimelech, M. Bacterial adhesion and transport in porous media: role of the secondary energy minimum, *Environ. Sci. Technol*. **2004**, 38, 1777 – 1785.

Salas, E.C.; Sun, Z.Z.; Luttge, A.; Tour, J.M. Reduction of graphene oxide via bacterial respiration, *ACS Nano* **2010**, 4, 4852 – 4856.

Si, Y.; Samulski, E.T. Synthesis of water soluble graphene. *Nano Lett*. **2008**, 8, 1679 – 1682.

Singh, S.K.; Singh, M.K.; Nayak, M.K.; Kumari, S.; Gracio, J.J.A.; Dash, D. Characterization of graphene oxide by flow cytometry and assessment of its cellular toxicity. J. Biomed. Nanotechnol. 2011, 7, 30 – 31.

Vallabani, N.V.S.; Mittal, S.; Shukla, R.K.; Pandey, A.K.; Dhakate, S.R.; Pasricha, R.; Dhawan, A. Toxicity of graphene in normal human lung cells (BEAS-2B). J. Biomed. Nanotechnol. 2011, 7, 106 – 107.

Van Oss, C.J. Acid-base interfacial interactions in aqueous media, *Colloids Surf. A*. **1993**, 78, 1 – 49.

Van Oss, C.J. The properties of water and their role in colloidal and biological systems, *Elsevier/Academic Press*. **2008**, Amsterdam/Boston.

Wang, K.; Ruan, J.; Song, H.; Zhang, J.L.; Wo, Y.; Guo, S.W.; Cui, D.X. Biocampatibility of graphene oxide. *Nanoscale Res. Lett*. **2011**, 6.

Weight, W.D. Hydrogeology Field Manual, 2nd ed., McGraw-Hill, New York, 2008.Xu, S.P.; Liao, Q.; Saiers, J.E. Straining of nonspherical colloids in saturated porous media. *Environ. Sci. Technol*. **2008**, 42, 771 – 778.

Xu, S.P.; Gao, B.; Saiers, J.E. Straining of colloidal particles in saturated porous media, *Water Resour. Re*. **2006**, 42, W12S16, (http://dx.doi.org/10.1029/2006WR004948).

Xu, S.P.; Liao, Q.; Saiers, J.E. Straining of nonspherical colloids in saturated porous media. *Environ. Sci. Technol*. **2008**, 42, 771 – 778.

Zhang, R.Y.; Hummelgard, M.; Lv, G.; Olin, H. Real time monitoring of the drug release of rhodamine B on graphene oxide, *Carbon* **2011**, 49, 1126 – 1132.

APPENDIX

Transport of tetracycline-resistant and tetracycline-susceptible *Escherichia coli* within unsaturated porous media

Table A1. Breakthrough concentrations of the tet^R and tet^S *E.coli* strains at 12% of soil moisture content and under ionic strength condition of 1 mM NaCl. Where, PV is the pore volume of the sand packed column at 12% of soil moisture content and C/Co is the normalized breakthrough concentrations.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.000	0.000	0.000	-0.006	0.000	0.007	0.000	0.000
0.007	0.000	0.007	-0.007	0.007	0.003	0.007	0.000
0.014	0.001	0.014	-0.007	0.014	0.003	0.015	0.001
0.022	0.001	0.022	-0.006	0.022	0.003	0.022	0.000
0.029	0.000	0.029	-0.007	0.029	0.004	0.030	0.000
0.036	0.001	0.036	-0.008	0.036	0.003	0.037	0.000
0.043	0.000	0.043	-0.007	0.043	0.010	0.045	0.000
0.050	0.003	0.050	-0.007	0.050	0.010	0.052	0.000
0.058	0.004	0.058	-0.006	0.058	0.010	0.060	0.000
0.065	0.003	0.065	-0.007	0.065	0.010	0.067	-0.001
0.072	0.004	0.072	-0.006	0.072	0.010	0.075	-0.001
0.079	0.004	0.079	-0.004	0.079	0.010	0.082	-0.001
0.086	0.003	0.086	-0.004	0.086	0.010	0.090	0.000
0.093	0.004	0.093	-0.004	0.093	0.010	0.097	0.001
0.101	0.002	0.101	-0.004	0.101	0.010	0.105	0.000
0.108	0.003	0.108	-0.003	0.108	0.010	0.112	0.000
0.115	0.004	0.115	-0.004	0.115	0.010	0.120	0.001
0.122	0.002	0.122	-0.004	0.122	0.009	0.127	0.002
0.129	0.003	0.129	-0.003	0.129	0.010	0.135	0.004
0.137	0.003	0.137	-0.004	0.137	0.010	0.142	-0.002
0.144	0.004	0.144	-0.003	0.144	0.010	0.150	-0.002

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.151	0.004	0.151	-0.003	0.151	0.010	0.157	-0.003
0.158	0.004	0.158	-0.003	0.158	0.009	0.165	-0.003
0.165	0.004	0.165	-0.003	0.165	0.009	0.172	-0.003
0.173	0.005	0.173	-0.003	0.173	0.009	0.180	-0.003
0.180	0.004	0.180	-0.003	0.180	0.009	0.187	-0.003
0.187	0.004	0.187	-0.001	0.187	0.009	0.195	-0.003
0.194	0.005	0.194	-0.002	0.194	0.009	0.202	-0.003
0.201	0.004	0.201	-0.002	0.201	0.010	0.210	-0.002
0.208	0.004	0.208	-0.002	0.208	0.010	0.217	-0.001
0.216	0.004	0.216	-0.001	0.216	0.011	0.225	-0.002
0.223	0.005	0.223	-0.002	0.223	0.009	0.232	-0.002
0.230	0.004	0.230	-0.002	0.230	0.010	0.240	-0.001
0.237	0.004	0.237	-0.001	0.237	0.011	0.247	0.000
0.244	0.004	0.244	-0.001	0.244	0.010	0.255	-0.001
0.252	0.006	0.252	-0.001	0.252	0.010	0.262	-0.001
0.259	0.004	0.259	-0.001	0.259	0.011	0.270	-0.001
0.266	0.004	0.266	0.000	0.266	0.010	0.277	-0.001
0.273	0.004	0.273	-0.001	0.273	0.010	0.285	-0.001
0.280	0.005	0.280	0.000	0.280	0.011	0.292	-0.003
0.288	0.006	0.288	-0.001	0.288	0.010	0.300	-0.002
0.295	0.005	0.295	0.000	0.295	0.011	0.307	-0.001

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.302	0.005	0.302	0.000	0.302	0.011	0.315	-0.001
0.309	0.005	0.309	-0.001	0.309	0.011	0.322	-0.001
0.316	0.005	0.316	0.000	0.316	0.016	0.330	-0.001
0.324	0.004	0.324	0.000	0.324	0.014	0.337	-0.001
0.331	0.005	0.331	-0.001	0.331	0.013	0.345	-0.001
0.338	0.004	0.338	-0.001	0.338	0.013	0.352	0.000
0.345	0.005	0.345	0.000	0.345	0.012	0.360	0.000
0.352	0.005	0.352	0.000	0.352	0.013	0.367	0.001
0.359	0.004	0.359	-0.001	0.359	0.012	0.375	-0.001
0.367	0.005	0.367	0.000	0.367	0.012	0.382	0.000
0.374	0.004	0.374	0.000	0.374	0.012	0.390	0.001
0.381	0.004	0.381	0.000	0.381	0.012	0.397	0.000
0.388	0.005	0.388	0.000	0.388	0.012	0.405	0.000
0.395	0.006	0.395	0.000	0.395	0.011	0.412	-0.001
0.403	0.006	0.403	-0.001	0.403	0.012	0.420	0.000
0.410	0.005	0.410	0.000	0.410	0.012	0.427	-0.001
0.417	0.004	0.417	-0.001	0.417	0.011	0.435	-0.001
0.424	0.005	0.424	0.000	0.424	0.011	0.442	0.000
0.431	0.005	0.431	0.000	0.431	0.011	0.450	-0.001
0.439	0.004	0.439	-0.001	0.439	0.011	0.457	-0.001
0.446	0.005	0.446	-0.001	0.446	0.012	0.465	0.001
0.453	0.004	0.453	-0.001	0.453	0.012	0.472	-0.001

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.460	0.005	0.460	-0.001	0.460	0.011	0.480	0.001
0.467	0.005	0.467	-0.001	0.467	0.011	0.487	0.001
0.474	0.004	0.474	-0.001	0.474	0.010	0.495	0.000
0.482	0.005	0.482	-0.001	0.482	0.012	0.502	0.001
0.489	0.005	0.489	-0.001	0.489	0.011	0.510	0.001
0.496	0.005	0.496	-0.001	0.496	0.010	0.517	0.001
0.503	0.005	0.503	0.000	0.503	0.010	0.525	0.001
0.510	0.005	0.510	-0.001	0.510	0.010	0.532	0.001
0.518	0.005	0.518	-0.001	0.518	0.010	0.540	0.000
0.525	0.004	0.525	-0.001	0.525	0.008	0.547	0.001
0.532	0.006	0.532	-0.001	0.532	0.009	0.555	0.001
0.539	0.004	0.539	-0.001	0.539	0.008	0.562	0.002
0.546	0.004	0.546	-0.001	0.546	0.008	0.570	0.002
0.554	0.005	0.554	0.000	0.554	0.007	0.577	0.006
0.561	0.005	0.561	-0.001	0.561	0.007	0.585	0.003
0.568	0.005	0.568	0.000	0.568	0.007	0.592	0.002
0.575	0.005	0.575	0.001	0.575	0.007	0.600	0.001
0.582	0.005	0.582	0.001	0.582	0.007	0.607	0.000
0.589	0.005	0.589	0.001	0.589	0.007	0.615	0.002
0.597	0.004	0.597	0.001	0.597	0.006	0.622	0.001
0.604	0.006	0.604	0.002	0.604	0.005	0.630	0.002
0.611	0.005	0.611	0.003	0.611	0.005	0.637	0.001

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.618	0.006	0.618	0.004	0.618	0.005	0.645	0.001
0.625	0.005	0.625	0.005	0.625	0.005	0.652	0.001
0.633	0.005	0.633	0.006	0.633	0.005	0.660	0.000
0.640	0.006	0.640	0.007	0.640	0.004	0.667	0.003
0.647	0.006	0.647	0.009	0.647	0.005	0.675	0.003
0.654	0.006	0.654	0.010	0.654	0.004	0.682	0.004
0.661	0.007	0.661	0.012	0.661	0.004	0.690	0.004
0.669	0.008	0.669	0.014	0.669	0.004	0.697	0.002
0.676	0.008	0.676	0.016	0.676	0.004	0.705	0.004
0.683	0.009	0.683	0.019	0.683	0.003	0.712	0.004
0.690	0.009	0.690	0.021	0.690	0.003	0.720	0.003
0.697	0.011	0.697	0.022	0.697	0.003	0.727	0.004
0.705	0.012	0.705	0.025	0.705	0.004	0.735	0.004
0.712	0.013	0.712	0.028	0.712	0.003	0.742	0.004
0.719	0.015	0.719	0.032	0.719	0.003	0.750	0.004
0.726	0.016	0.726	0.035	0.726	0.003	0.757	0.004
0.733	0.016	0.733	0.038	0.733	0.003	0.765	0.004
0.740	0.018	0.740	0.041	0.740	0.003	0.772	0.005
0.748	0.019	0.748	0.044	0.748	0.003	0.780	0.005
0.755	0.021	0.755	0.048	0.755	0.003	0.787	0.006
0.762	0.022	0.762	0.053	0.762	0.003	0.795	0.006
0.769	0.026	0.769	0.056	0.769	0.001	0.802	0.006

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.776	0.027	0.776	0.060	0.776	0.001	0.810	0.007
0.784	0.028	0.784	0.062	0.784	0.002	0.817	0.007
0.791	0.030	0.791	0.066	0.791	0.003	0.825	0.007
0.798	0.031	0.798	0.069	0.798	0.001	0.832	0.008
0.805	0.035	0.805	0.074	0.805	0.001	0.840	0.008
0.812	0.036	0.812	0.077	0.812	0.001	0.847	0.008
0.820	0.038	0.820	0.079	0.820	0.001	0.855	0.010
0.827	0.039	0.827	0.084	0.827	0.000	0.862	0.010
0.834	0.042	0.834	0.087	0.834	-0.001	0.870	0.010
0.841	0.044	0.841	0.089	0.841	0.001	0.877	0.011
0.848	0.046	0.848	0.092	0.848	0.001	0.885	0.010
0.855	0.047	0.855	0.094	0.855	-0.001	0.892	0.011
0.863	0.049	0.863	0.097	0.863	-0.001	0.900	0.010
0.870	0.052	0.870	0.099	0.870	0.001	0.907	0.010
0.877	0.054	0.877	0.102	0.877	0.001	0.915	0.012
0.884	0.055	0.884	0.105	0.884	-0.001	0.922	0.012
0.891	0.057	0.891	0.107	0.891	-0.001	0.930	0.014
0.899	0.058	0.899	0.112	0.899	-0.001	0.937	0.014
0.906	0.059	0.906	0.113	0.906	-0.001	0.945	0.016
0.913	0.060	0.913	0.115	0.913	-0.001	0.952	0.016
0.920	0.063	0.920	0.118	0.920	-0.001	0.960	0.017
0.927	0.067	0.927	0.120	0.927	0.000	0.967	0.018

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.935	0.067	0.935	0.120	0.935	-0.001	0.975	0.019
0.942	0.069	0.942	0.123	0.942	-0.001	0.982	0.021
0.949	0.070	0.949	0.126	0.949	0.001	0.990	0.021
0.956	0.073	0.956	0.128	0.956	-0.001	0.997	0.022
0.963	0.075	0.963	0.128	0.963	0.001	1.005	0.023
0.971	0.076	0.971	0.132	0.971	0.000	1.012	0.025
0.978	0.077	0.978	0.134	0.978	0.001	1.020	0.026
0.985	0.079	0.985	0.139	0.985	0.001	1.027	0.025
0.992	0.081	0.992	0.138	0.992	0.001	1.035	0.026
0.999	0.084	0.999	0.141	0.999	0.001	1.042	0.027
1.006	0.085	1.006	0.143	1.006	0.001	1.050	0.028
1.014	0.087	1.014	0.145	1.014	0.002	1.057	0.029
1.021	0.089	1.021	0.145	1.021	-0.001	1.065	0.030
1.028	0.089	1.028	0.148	1.028	-0.004	1.072	0.032
1.035	0.091	1.035	0.148	1.035	-0.004	1.080	0.035
1.042	0.092	1.042	0.148	1.042	-0.003	1.087	0.035
1.050	0.092	1.050	0.151	1.050	-0.002	1.095	0.033
1.057	0.095	1.057	0.152	1.057	-0.003	1.102	0.026
1.064	0.095	1.064	0.154	1.064	0.001	1.110	0.024
1.071	0.097	1.071	0.155	1.071	-0.001	1.117	0.035
1.078	0.099	1.078	0.158	1.078	0.001	1.125	0.039
1.086	0.100	1.086	0.159	1.086	0.001	1.132	0.040

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.093	0.101	1.093	0.163	1.093	0.008	1.140	0.042
1.100	0.102	1.100	0.169	1.100	0.009	1.147	0.042
1.107	0.104	1.107	0.163	1.107	0.010	1.155	0.043
1.114	0.106	1.114	0.166	1.114	0.010	1.162	0.043
1.121	0.107	1.121	0.166	1.121	0.010	1.170	0.045
1.129	0.108	1.129	0.166	1.129	0.011	1.177	0.045
1.136	0.110	1.136	0.166	1.136	0.012	1.185	0.046
1.143	0.111	1.143	0.166	1.143	0.012	1.192	0.047
1.150	0.111	1.150	0.166	1.150	0.013	1.200	0.048
1.157	0.112	1.157	0.166	1.157	0.013	1.207	0.049
1.165	0.115	1.165	0.168	1.165	0.014	1.215	0.049
1.172	0.115	1.172	0.166	1.172	0.015	1.222	0.051
1.179	0.116	1.179	0.166	1.179	0.015	1.230	0.052
1.186	0.118	1.186	0.164	1.186	0.016	1.237	0.052
1.193	0.118	1.193	0.164	1.193	0.017	1.245	0.054
1.201	0.120	1.201	0.164	1.201	0.018	1.252	0.055
1.208	0.121	1.208	0.163	1.208	0.018	1.260	0.057
1.215	0.122	1.215	0.161	1.215	0.018	1.267	0.058
1.222	0.125	1.222	0.162	1.222	0.022	1.275	0.059
1.229	0.126	1.229	0.163	1.229	0.022	1.282	0.059
1.236	0.127	1.236	0.165	1.236	0.023	1.290	0.059
1.244	0.128	1.244	0.166	1.244	0.024	1.297	0.059

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.251	0.128	1.251	0.168	1.251	0.024	1.305	0.061
1.258	0.129	1.258	0.170	1.258	0.026	1.312	0.058
1.265	0.128	1.265	0.171	1.265	0.026	1.320	0.059
1.272	0.129	1.272	0.172	1.272	0.027	1.327	0.059
1.280	0.132	1.280	0.174	1.280	0.029	1.335	0.063
1.287	0.132	1.287	0.174	1.287	0.029	1.342	0.064
1.294	0.133	1.294	0.175	1.294	0.029	1.350	0.065
1.301	0.133	1.301	0.176	1.301	0.029	1.357	0.065
1.308	0.133	1.308	0.177	1.308	0.030	1.365	0.066
1.316	0.134	1.316	0.180	1.316	0.031	1.372	0.066
1.323	0.136	1.323	0.181	1.323	0.034	1.380	0.067
1.330	0.133	1.330	0.181	1.330	0.037	1.387	0.068
1.337	0.134	1.337	0.184	1.337	0.038	1.395	0.070
1.344	0.136	1.344	0.186	1.344	0.038	1.402	0.071
1.352	0.137	1.352	0.184	1.352	0.039	1.410	0.067
1.359	0.139	1.359	0.185	1.359	0.039	1.417	0.065
1.366	0.141	1.366	0.185	1.366	0.041	1.425	0.058
1.373	0.141	1.373	0.186	1.373	0.041	1.432	0.055
1.380	0.141	1.380	0.186	1.380	0.041	1.440	0.051
1.387	0.141	1.387	0.190	1.387	0.042	1.447	0.054
1.395	0.142	1.395	0.190	1.395	0.043	1.455	0.046
1.402	0.143	1.402	0.186	1.402	0.044	1.462	0.205

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.409	0.142	1.409	0.187	1.409	0.045	1.470	0.152
1.416	0.144	1.416	0.186	1.416	0.046	1.477	0.143
1.423	0.144	1.423	0.186	1.423	0.048	1.485	0.134
1.431	0.145	1.431	0.185	1.431	0.051	1.492	0.130
1.438	0.145	1.438	0.183	1.438	0.053	1.500	0.120
1.445	0.147	1.445	0.183	1.445	0.054	1.507	0.113
1.452	0.146	1.452	0.183	1.452	0.056	1.514	0.106
1.459	0.147	1.459	0.184	1.459	0.058	1.522	0.103
1.467	0.147	1.467	0.184	1.467	0.059	1.529	0.100
1.474	0.148	1.474	0.186	1.474	0.061	1.537	0.098
1.481	0.148	1.481	0.186	1.481	0.063	1.544	0.098
1.488	0.149	1.488	0.182	1.488	0.063	1.552	0.098
1.495	0.149	1.495	0.187	1.495	0.063	1.559	0.098
1.502	0.150	1.502	0.198	1.502	0.064	1.567	0.098
1.510	0.152	1.510	0.205	1.510	0.066	1.574	0.098
1.517	0.152	1.517	0.210	1.517	0.066	1.582	0.101
1.524	0.152	1.524	0.204	1.524	0.067	1.589	0.100
1.531	0.154	1.531	0.202	1.531	0.064	1.597	0.101
1.538	0.153	1.538	0.200	1.538	0.058	1.604	0.103
1.546	0.154	1.546	0.215	1.546	0.073	1.612	0.101
1.553	0.156	1.553	0.206	1.553	0.077	1.619	0.111
1.560	0.155	1.560	0.204	1.560	0.078	1.627	0.122

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.567	0.156	1.567	0.195	1.567	0.079	1.634	0.105
1.574	0.156	1.574	0.190	1.574	0.078	1.642	0.098
1.582	0.157	1.582	0.191	1.582	0.078	1.649	0.098
1.589	0.157	1.589	0.185	1.589	0.079	1.657	0.098
1.596	0.157	1.596	0.186	1.596	0.079	1.664	0.098
1.603	0.158	1.603	0.187	1.603	0.079	1.672	0.101
1.610	0.157	1.610	0.184	1.610	0.078	1.679	0.103
1.618	0.154	1.618	0.184	1.618	0.077	1.687	0.104
1.625	0.156	1.625	0.183	1.625	0.079	1.694	0.104
1.632	0.156	1.632	0.188	1.632	0.079	1.702	0.106
1.639	0.156	1.639	0.186	1.639	0.077	1.709	0.108
1.646	0.156	1.646	0.184	1.646	0.078	1.717	0.108
1.653	0.158	1.653	0.176	1.653	0.078	1.724	0.106
1.661	0.157	1.661	0.196	1.661	0.078	1.732	0.107
1.668	0.158	1.668	0.196	1.668	0.079	1.739	0.109
1.675	0.158	1.675	0.190	1.675	0.078	1.747	0.109
1.682	0.158	1.682	0.188	1.682	0.078	1.754	0.112
1.689	0.159	1.689	0.182	1.689	0.079	1.762	0.113
1.697	0.158	1.697	0.177	1.697	0.080	1.769	0.117
1.704	0.160	1.704	0.174	1.704	0.081	1.777	0.115
1.711	0.160	1.711	0.174	1.711	0.081	1.784	0.117
1.718	0.160	1.718	0.176	1.718	0.083	1.792	0.119

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.725	0.160	1.725	0.204	1.725	0.081	1.799	0.122
1.733	0.160	1.733	0.185	1.733	0.083	1.807	0.123
1.740	0.160	1.740	0.187	1.740	0.083	1.814	0.126
1.747	0.162	1.747	0.183	1.747	0.083	1.822	0.127
1.754	0.161	1.754	0.186	1.754	0.085	1.829	0.128
1.761	0.160	1.761	0.182	1.761	0.086	1.837	0.130
1.768	0.162	1.768	0.182	1.768	0.086	1.844	0.131
1.776	0.162	1.776	0.181	1.776	0.086	1.852	0.132
1.783	0.162	1.783	0.180	1.783	0.087	1.859	0.133
1.790	0.161	1.790	0.180	1.790	0.088	1.867	0.135
1.797	0.162	1.797	0.179	1.797	0.088	1.874	0.137
1.804	0.162	1.804	0.180	1.804	0.089	1.882	0.137
1.812	0.164	1.812	0.185	1.812	0.089	1.889	0.139
1.819	0.164	1.819	0.182	1.819	0.090	1.897	0.139
1.826	0.166	1.826	0.182	1.826	0.091	1.904	0.141
1.833	0.167	1.833	0.170	1.833	0.092	1.912	0.142
1.840	0.165	1.840	0.230	1.840	0.091	1.919	0.143
1.848	0.166	1.848	0.197	1.848	0.092	1.927	0.143
1.855	0.166	1.855	0.195	1.855	0.091	1.934	0.146
1.862	0.166	1.862	0.193	1.862	0.092	1.942	0.146
1.869	0.166	1.869	0.189	1.869	0.092	1.949	0.149
1.876	0.167	1.876	0.184	1.876	0.092	1.957	0.149

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.883	0.168	1.883	0.182	1.883	0.093	1.964	0.150
1.891	0.168	1.891	0.173	1.891	0.092	1.972	0.151
1.898	0.169	1.898	0.173	1.898	0.088	1.979	0.151
1.905	0.169	1.905	0.175	1.905	0.087	1.987	0.151
1.912	0.169	1.912	0.192	1.912	0.088	1.994	0.152
1.919	0.167	1.919	0.186	1.919	0.088	2.002	0.152
1.927	0.167	1.927	0.183	1.927	0.089	2.009	0.152
1.934	0.167	1.934	0.182	1.934	0.089	2.017	0.152
1.941	0.168	1.941	0.180	1.941	0.090	2.024	0.153
1.948	0.171	1.948	0.180	1.948	0.090	2.032	0.153
1.955	0.172	1.955	0.180	1.955	0.091	2.039	0.158
1.963	0.172	1.963	0.182	1.963	0.098	2.047	0.158
1.970	0.172	1.970	0.181	1.970	0.097	2.054	0.158
1.977	0.171	1.977	0.180	1.977	0.099	2.062	0.157
1.984	0.173	1.984	0.180	1.984	0.098	2.069	0.158
1.991	0.173	1.991	0.183	1.991	0.099	2.077	0.159
1.999	0.174	1.999	0.186	1.999	0.100	2.084	0.159
2.006	0.172	2.006	0.186	2.006	0.099	2.092	0.160
2.013	0.174	2.013	0.181	2.013	0.100	2.099	0.160
2.020	0.174	2.020	0.206	2.020	0.101	2.107	0.159
2.027	0.174	2.027	0.197	2.027	0.101	2.114	0.158
2.034	0.174	2.034	0.198	2.034	0.101	2.122	0.158

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.042	0.171	2.042	0.196	2.042	0.101	2.129	0.149
2.049	0.172	2.049	0.192	2.049	0.102	2.137	0.145
2.056	0.173	2.056	0.190	2.056	0.103	2.144	0.138
2.063	0.174	2.063	0.187	2.063	0.102	2.152	0.158
2.070	0.172	2.070	0.186	2.070	0.103	2.159	0.155
2.078	0.174	2.078	0.181	2.078	0.103	2.167	0.155
2.085	0.174	2.085	0.178	2.085	0.105	2.174	0.154
2.092	0.174	2.092	0.176	2.092	0.106	2.182	0.155
2.099	0.175	2.099	0.173	2.099	0.105	2.189	0.154
2.106	0.174	2.106	0.190	2.106	0.105	2.197	0.155
2.114	0.175	2.114	0.185	2.114	0.106	2.204	0.153
2.121	0.175	2.121	0.184	2.121	0.107	2.212	0.152
2.128	0.175	2.128	0.186	2.128	0.106	2.219	0.150
2.135	0.175	2.135	0.186	2.135	0.107	2.227	0.149
2.142	0.175	2.142	0.186	2.142	0.107	2.234	0.149
2.149	0.174	2.149	0.185	2.149	0.109	2.242	0.149
2.157	0.174	2.157	0.185	2.157	0.107	2.249	0.149
2.164	0.177	2.164	0.186	2.164	0.107	2.257	0.148
2.171	0.175	2.171	0.191	2.171	0.108	2.264	0.149
2.178	0.174	2.178	0.190	2.178	0.109	2.272	0.150
2.185	0.175	2.185	0.192	2.185	0.109	2.279	0.148
2.193	0.175	2.193	0.202	2.193	0.109	2.287	0.147

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.200	0.174	2.200	0.194	2.200	0.108	2.294	0.146
2.207	0.175	2.207	0.195	2.207	0.109	2.302	0.144
2.214	0.175	2.214	0.195	2.214	0.110	2.309	0.143
2.221	0.177	2.221	0.194	2.221	0.111	2.317	0.144
2.229	0.177	2.229	0.193	2.229	0.111	2.324	0.143
2.236	0.177	2.236	0.194	2.236	0.111	2.332	0.143
2.243	0.176	2.243	0.189	2.243	0.110	2.339	0.144
2.250	0.175	2.250	0.190	2.250	0.110	2.347	0.144
2.257	0.175	2.257	0.189	2.257	0.110	2.354	0.144
2.265	0.175	2.265	0.187	2.265	0.112	2.362	0.143
2.272	0.175	2.272	0.186	2.272	0.112	2.369	0.144
2.279	0.175	2.279	0.186	2.279	0.112	2.377	0.143
2.286	0.177	2.286	0.181	2.286	0.112	2.384	0.144
2.293	0.178	2.293	0.179	2.293	0.113	2.392	0.142
2.300	0.175	2.300	0.184	2.300	0.114	2.399	0.142
2.308	0.177	2.308	0.185	2.308	0.114	2.407	0.143
2.315	0.177	2.315	0.177	2.315	0.112	2.414	0.143
2.322	0.177	2.322	0.176	2.322	0.114	2.422	0.144
2.329	0.178	2.329	0.193	2.329	0.114	2.429	0.143
2.336	0.177	2.336	0.199	2.336	0.114	2.437	0.142
2.344	0.177	2.344	0.195	2.344	0.114	2.444	0.141
2.351	0.178	2.351	0.188	2.351	0.115	2.452	0.142

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.358	0.178	2.358	0.186	2.358	0.115	2.459	0.142
2.365	0.178	2.365	0.187	2.365	0.116	2.467	0.140
2.372	0.179	2.372	0.186	2.372	0.115	2.474	0.138
2.380	0.178	2.380	0.181	2.380	0.116	2.482	0.140
2.387	0.179	2.387	0.194	2.387	0.116	2.489	0.139
2.394	0.180	2.394	0.188	2.394	0.116	2.497	0.139
2.401	0.178	2.401	0.188	2.401	0.117	2.504	0.138
2.408	0.178	2.408	0.187	2.408	0.117	2.512	0.140
2.415	0.177	2.415	0.186	2.415	0.119	2.519	0.139
2.423	0.178	2.423	0.186	2.423	0.121	2.527	0.138
2.430	0.179	2.430	0.186	2.430	0.121	2.534	0.140
2.437	0.179	2.437	0.186	2.437	0.121	2.542	0.139
2.444	0.180	2.444	0.183	2.444	0.121	2.549	0.137
2.451	0.179	2.451	0.186	2.451	0.121	2.557	0.139
2.459	0.179	2.459	0.187	2.459	0.119	2.564	0.140
2.466	0.178	2.466	0.188	2.466	0.121	2.572	0.140
2.473	0.178	2.473	0.191	2.473	0.121	2.579	0.140
2.480	0.178	2.480	0.198	2.480	0.162	2.587	0.140
2.487	0.177	2.487	0.198	2.487	0.198	2.594	0.139
2.495	0.178	2.495	0.196	2.495	0.191	2.602	0.137
2.502	0.178	2.502	0.194	2.502	0.172	2.609	0.138
2.509	0.178	2.509	0.192	2.509	0.157	2.617	0.139

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.516	0.178	2.516	0.190	2.516	0.153	2.624	0.138
2.523	0.179	2.523	0.188	2.523	0.133	2.632	0.138
2.530	0.177	2.530	0.187	2.530	0.155	2.639	0.137
2.538	0.178	2.538	0.184	2.538	0.153	2.647	0.125
2.545	0.178	2.545	0.181	2.545	0.150	2.654	0.120
2.552	0.177	2.552	0.176	2.552	0.147	2.662	0.126
2.559	0.176	2.559	0.174	2.559	0.146	2.669	0.139
2.566	0.177	2.566	0.179	2.566	0.144	2.677	0.137
2.574	0.174	2.574	0.195	2.574	0.141	2.684	0.137
2.581	0.174	2.581	0.197	2.581	0.140	2.692	0.136
2.588	0.173	2.588	0.176	2.588	0.147	2.699	0.136
2.595	0.170	2.595	0.171	2.595	0.148	2.707	0.136
2.602	0.170	2.602	0.165	2.602	0.164	2.714	0.135
2.610	0.170	2.610	0.158	2.610	0.160	2.722	0.136
2.617	0.171	2.617	0.153	2.617	0.159	2.729	0.138
2.624	0.167	2.624	0.149	2.624	0.162	2.737	0.137
2.631	0.166	2.631	0.146	2.631	0.160	2.744	0.137
2.638	0.166	2.638	0.144	2.638	0.173	2.752	0.136
2.646	0.163	2.646	0.140	2.646	0.204	2.759	0.137
2.653	0.162	2.653	0.135	2.653	0.208	2.767	0.136
2.660	0.161	2.660	0.133	2.660	0.208	2.774	0.136
2.667	0.159	2.667	0.130	2.667	0.217	2.782	0.135

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.674	0.157	2.674	0.127	2.674	0.209	2.789	0.135
2.681	0.155	2.681	0.125	2.681	0.206	2.797	0.135
2.689	0.154	2.689	0.125	2.689	0.212	2.804	0.136
2.696	0.150	2.696	0.125	2.696	0.212	2.812	0.136
2.703	0.148	2.703	0.131	2.703	0.200	2.819	0.137
2.710	0.148	2.710	0.135	2.710	0.206	2.827	0.136
2.717	0.145	2.717	0.130	2.717	0.195	2.834	0.136
2.725	0.143	2.725	0.123	2.725	0.223	2.842	0.135
2.732	0.141	2.732	0.118	2.732	0.202	2.849	0.136
2.739	0.139	2.739	0.109	2.739	0.199	2.857	0.135
2.746	0.134	2.746	0.104	2.746	0.217	2.864	0.136
2.753	0.134	2.753	0.099	2.753	0.200	2.872	0.138
2.761	0.132	2.761	0.095	2.761	0.192	2.879	0.137
2.768	0.129	2.768	0.092	2.768	0.190	2.887	0.138
2.775	0.128	2.775	0.089	2.775	0.192	2.894	0.136
2.782	0.126	2.782	0.087	2.782	0.190	2.902	0.136
2.789	0.124	2.789	0.087	2.789	0.188	2.909	0.134
2.796	0.120	2.796	0.083	2.796	0.184	2.917	0.133
2.804	0.120	2.804	0.082	2.804	0.184	2.924	0.133
2.811	0.118	2.811	0.083	2.811	0.189	2.932	0.133
2.818	0.116	2.818	0.083	2.818	0.210	2.939	0.134
2.825	0.114	2.825	0.086	2.825	0.199	2.947	0.133

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.832	0.112	2.832	0.085	2.832	0.186	2.954	0.131
2.840	0.110	2.840	0.073	2.840	0.178	2.962	0.131
2.847	0.109	2.847	0.071	2.847	0.176	2.969	0.130
2.854	0.105	2.854	0.069	2.854	0.173	2.977	0.129
2.861	0.104	2.861	0.064	2.861	0.176	2.984	0.129
2.868	0.103	2.868	0.062	2.868	0.175	2.992	0.127
2.876	0.101	2.876	0.056	2.876	0.174	2.999	0.127
2.883	0.099	2.883	0.053	2.883	0.172	3.006	0.128
2.890	0.097	2.890	0.051	2.890	0.172	3.014	0.127
2.897	0.096	2.897	0.049	2.897	0.172	3.021	0.126
2.904	0.095	2.904	0.048	2.904	0.173	3.029	0.125
2.912	0.093	2.912	0.046	2.912	0.172	3.036	0.124
2.919	0.090	2.919	0.045	2.919	0.171	3.044	0.122
2.926	0.089	2.926	0.046	2.926	0.170	3.051	0.122
2.933	0.088	2.933	0.046	2.933	0.169	3.059	0.120
2.940	0.087	2.940	0.048	2.940	0.169	3.066	0.119
2.947	0.085	2.947	0.042	2.947	0.167	3.074	0.117
2.955	0.084	2.955	0.053	2.955	0.165	3.081	0.117
2.962	0.082	2.962	0.046	2.962	0.165	3.089	0.116
2.969	0.080	2.969	0.040	2.969	0.164	3.096	0.117
2.976	0.080	2.976	0.036	2.976	0.162	3.104	0.115
2.983	0.078	2.983	0.033	2.983	0.161	3.111	0.114

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.991	0.076	2.991	0.031	2.991	0.160	3.119	0.113
2.998	0.075	2.998	0.030	2.998	0.158	3.126	0.112
3.005	0.073	3.005	0.028	3.005	0.158	3.134	0.111
3.012	0.075	3.012	0.027	3.012	0.157	3.141	0.110
3.019	0.072	3.019	0.026	3.019	0.157	3.149	0.109
3.027	0.071	3.027	0.024	3.027	0.153	3.156	0.108
3.034	0.069	3.034	0.024	3.034	0.153	3.164	0.109
3.041	0.069	3.041	0.022	3.041	0.152	3.171	0.106
3.048	0.067	3.048	0.021	3.048	0.151	3.179	0.104
3.055	0.065	3.055	0.022	3.055	0.150	3.186	0.103
3.062	0.065	3.062	0.020	3.062	0.149	3.194	0.101
3.070	0.063	3.070	0.020	3.070	0.147	3.201	0.099
3.077	0.062	3.077	0.018	3.077	0.146	3.209	0.098
3.084	0.060	3.084	0.017	3.084	0.145	3.216	0.097
3.091	0.060	3.091	0.017	3.091	0.143	3.224	0.098
3.098	0.059	3.098	0.016	3.098	0.142	3.231	0.096
3.106	0.060	3.106	0.018	3.106	0.141	3.239	0.095
3.113	0.057	3.113	0.018	3.113	0.139	3.246	0.094
3.120	0.058	3.120	0.022	3.120	0.138	3.254	0.094
3.127	0.055	3.127	0.025	3.127	0.137	3.261	0.094
3.134	0.055	3.134	0.022	3.134	0.135	3.269	0.092
3.142	0.054	3.142	0.025	3.142	0.134	3.276	0.092

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.149	0.054	3.149	0.016	3.149	0.132	3.284	0.090
3.156	0.052	3.156	0.014	3.156	0.130	3.291	0.088
3.163	0.052	3.163	0.011	3.163	0.129	3.299	0.088
3.170	0.051	3.170	0.009	3.170	0.127	3.306	0.087
3.177	0.051	3.177	0.011	3.177	0.127	3.314	0.085
3.185	0.050	3.185	0.009	3.185	0.120	3.321	0.084
3.192	0.049	3.192	0.009	3.192	0.119	3.329	0.082
3.199	0.048	3.199	0.010	3.199	0.118	3.336	0.082
3.206	0.047	3.206	0.009	3.206	0.123	3.344	0.081
3.213	0.046	3.213	0.009	3.213	0.137	3.351	0.082
3.221	0.046	3.221	0.007	3.221	0.184	3.359	0.080
3.228	0.045	3.228	0.007	3.228	0.171	3.366	0.078
3.235	0.044	3.235	0.009	3.235	0.147	3.374	0.078
3.242	0.042	3.242	0.009	3.242	0.134	3.381	0.077
3.249	0.043	3.249	0.009	3.249	0.124	3.389	0.077
3.257	0.042	3.257	0.010	3.257	0.119	3.396	0.076
3.264	0.041	3.264	0.010	3.264	0.116	3.404	0.074
3.271	0.042	3.271	0.014	3.271	0.112	3.411	0.075
3.278	0.041	3.278	0.007	3.278	0.109	3.419	0.074
3.285	0.040	3.285	0.006	3.285	0.106	3.426	0.073
3.293	0.039	3.293	0.004	3.293	0.104	3.434	0.072
3.300	0.039	3.300	0.002	3.300	0.102	3.441	0.071

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.307	0.039	3.307	0.002	3.307	0.100	3.449	0.071
3.314	0.038	3.314	0.004	3.314	0.097	3.456	0.070
3.321	0.038	3.321	0.004	3.321	0.097	3.464	0.071
3.328	0.037	3.328	0.004	3.328	0.093	3.471	0.069
3.336	0.036	3.336	0.003	3.336	0.092	3.479	0.067
3.343	0.036	3.343	0.014	3.343	0.091	3.486	0.067
3.350	0.036	3.350	0.002	3.350	0.090	3.494	0.066
3.357	0.035	3.357	0.002	3.357	0.088	3.501	0.065
3.364	0.034	3.364	0.001	3.364	0.086	3.509	0.065
3.372	0.034	3.372	-0.001	3.372	0.084	3.516	0.059
3.379	0.034	3.379	-0.001	3.379	0.082	3.524	0.057
3.386	0.033	3.386	-0.002	3.386	0.090	3.531	0.056
3.393	0.034	3.393	-0.003	3.393	0.107	3.539	0.065
3.400	0.032	3.400	-0.003	3.400	0.083	3.546	0.065
3.408	0.032	3.408	-0.004	3.408	0.076	3.554	0.064
3.415	0.031	3.415	-0.001	3.415	0.076	3.561	0.064
3.422	0.031	3.422	-0.001	3.422	0.075	3.569	0.064
3.429	0.031	3.429	0.000	3.429	0.075	3.576	0.063
3.436	0.031	3.436	-0.001	3.436	0.073	3.584	0.063
3.443	0.029	3.443	0.012	3.443	0.072	3.591	0.061
3.451	0.030	3.451	-0.001	3.451	0.069	3.599	0.061
3.458	0.029	3.458	-0.003	3.458	0.068	3.606	0.059

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.465	0.028	3.465	-0.003	3.465	0.066	3.614	0.059
3.472	0.028	3.472	-0.005	3.472	0.066	3.621	0.058
3.479	0.029	3.479	-0.005	3.479	0.064	3.629	0.057
3.487	0.028	3.487	-0.005	3.487	0.062	3.636	0.057
3.494	0.028	3.494	-0.005	3.494	0.062	3.644	0.056
3.501	0.028	3.501	-0.005	3.501	0.060	3.651	0.056
3.508	0.027	3.508	-0.006	3.508	0.058	3.659	0.055
3.515	0.027	3.515	-0.006	3.515	0.058	3.666	0.055
3.523	0.027	3.523	-0.006	3.523	0.056	3.674	0.055
3.530	0.026	3.530	-0.006	3.530	0.055	3.681	0.055
3.537	0.026	3.537	-0.006	3.537	0.053	3.689	0.054
3.544	0.026	3.544	-0.006	3.544	0.053	3.696	0.054
3.551	0.026	3.551	-0.006	3.551	0.052	3.704	0.053
3.559	0.026	3.559	-0.007	3.559	0.051	3.711	0.053
3.566	0.027	3.566	-0.007	3.566	0.051	3.719	0.052
3.573	0.026	3.573	-0.006	3.573	0.049	3.726	0.053
3.580	0.025	3.580	-0.007	3.580	0.049	3.734	0.052
3.587	0.026	3.587	-0.005	3.587	0.047	3.741	0.050
3.594	0.026	3.594	-0.005	3.594	0.045	3.749	0.049
3.602	0.025	3.602	-0.004	3.602	0.044	3.756	0.050
3.609	0.024	3.609	-0.003	3.609	0.044	3.764	0.048
3.616	0.024	3.616	-0.003	3.616	0.044	3.771	0.049

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.623	0.024	3.623	-0.005	3.623	0.042	3.779	0.048
3.630	0.024	3.630	-0.004	3.630	0.039	3.786	0.048
3.638	0.024	3.638	-0.007	3.638	0.040	3.794	0.047
3.645	0.024	3.645	-0.005	3.645	0.038	3.801	0.047
3.652	0.024	3.652	-0.007	3.652	0.038	3.809	0.048
3.659	0.024	3.659	-0.009	3.659	0.037	3.816	0.047
3.666	0.025	3.666	-0.008	3.666	0.035	3.824	0.047
3.674	0.023	3.674	-0.009	3.674	0.035	3.831	0.047
3.681	0.024	3.681	-0.009	3.681	0.034	3.839	0.047
3.688	0.024	3.688	-0.009	3.688	0.033	3.846	0.046
3.695	0.024	3.695	-0.009	3.695	0.032	3.854	0.045
3.702	0.022	3.702	-0.009	3.702	0.031	3.861	0.046
3.709	0.023	3.709	-0.009	3.709	0.031	3.869	0.045
3.717	0.022	3.717	-0.009	3.717	0.030	3.876	0.045
3.724	0.021	3.724	-0.009	3.724	0.029	3.884	0.044
3.731	0.021	3.731	-0.007	3.731	0.029	3.891	0.043
3.738	0.020	3.738	-0.005	3.738	0.029	3.899	0.041
3.745	0.020	3.745	-0.005	3.745	0.028	3.906	0.042
3.753	0.019	3.753	-0.007	3.753	0.027	3.914	0.043
3.760	0.019	3.760	-0.002	3.760	0.027	3.921	0.041
3.767	0.018	3.767	-0.007	3.767	0.027	3.929	0.041
3.774	0.018	3.774	-0.007	3.774	0.026	3.936	0.041

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.781	0.016	3.781	-0.009	3.781	0.025	3.944	0.041
3.789	0.016	3.789	-0.008	3.789	0.025	3.951	0.041
3.796	0.016	3.796	-0.009	3.796	0.024	3.959	0.041
3.803	0.016	3.803	-0.010	3.803	0.024	3.966	0.042
3.810	0.016	3.810	-0.009	3.810	0.023	3.974	0.042
3.817	0.015	3.817	-0.009	3.817	0.023	3.981	0.041
3.824	0.015	3.824	-0.009	3.824	0.023	3.989	0.040
3.832	0.014	3.832	-0.009	3.832	0.022	3.996	0.039
3.839	0.014	3.839	-0.009	3.839	0.020	4.004	0.040
3.846	0.014	3.846	-0.010	3.846	0.020	4.011	0.039
3.853	0.014	3.853	-0.009	3.853	0.020	4.019	0.039
3.860	0.014	3.860	-0.009	3.860	0.018	4.026	0.037
3.868	0.014	3.868	-0.009	3.868	0.019	4.034	0.037
3.875	0.013	3.875	-0.007	3.875	0.018	4.041	0.037
3.882	0.013	3.882	-0.007	3.882	0.018	4.049	0.038
3.889	0.012	3.889	-0.007	3.889	0.018	4.056	0.037
3.896	0.012	3.896	-0.007	3.896	0.017	4.064	0.038
3.904	0.012	3.904	0.009	3.904	0.016	4.071	0.037
3.911	0.011	3.911	-0.006	3.911	0.017	4.079	0.037
3.918	0.011	3.918	-0.008	3.918	0.016	4.086	0.038
3.925	0.011	3.925	-0.006	3.925	0.016	4.094	0.038
3.932	0.012	3.932	-0.008	3.932	0.014	4.101	0.038

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.940	0.011	3.940	-0.008	3.940	0.014	4.109	0.037
3.947	0.011	3.947	-0.007	3.947	0.015	4.116	0.037
3.954	0.011	3.954	-0.007	3.954	0.014	4.124	0.037
3.961	0.011	3.961	-0.008	3.961	0.015	4.131	0.036
3.968	0.011	3.968	-0.009	3.968	0.015	4.139	0.036
3.975	0.010	3.975	-0.011	3.975	0.015	4.146	0.035
3.983	0.009	3.983	-0.010	3.983	0.015	4.154	0.035
3.990	0.009	3.990	-0.011	3.990	0.014	4.161	0.035
3.997	0.010	3.997	-0.012	3.997	0.015	4.169	0.036
4.004	0.009	4.004	-0.013	4.004	0.014	4.176	0.037
4.011	0.009	4.011	-0.012	4.011	0.014	4.184	0.036
4.019	0.009	4.019	-0.013	4.019	0.014	4.191	0.036
4.026	0.009	4.026	-0.013	4.026	0.013	4.199	0.036
4.033	0.009	4.033	-0.013	4.033	0.012	4.206	0.035
4.040	0.008	4.040	-0.013	4.040	0.011	4.214	0.035
4.047	0.009	4.047	-0.013	4.047	0.011	4.221	0.035
4.055	0.008	4.055	-0.011	4.055	0.010	4.229	0.035
4.062	0.008	4.062	-0.011	4.062	0.010	4.236	0.034
4.069	0.008	4.069	-0.011	4.069	0.010	4.244	0.033
4.076	0.008	4.076	-0.010	4.076	0.008	4.251	0.033
4.083	0.008	4.083	-0.009	4.083	0.008	4.259	0.032
4.090	0.007	4.090	-0.010	4.090	0.009	4.266	0.031

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.098	0.008	4.098	-0.009	4.098	0.008	4.274	0.032
4.105	0.007	4.105	-0.011	4.105	0.008	4.281	0.032
4.112	0.007	4.112	-0.011	4.112	0.008	4.289	0.033
4.119	0.006	4.119	-0.014	4.119	0.008	4.296	0.033
4.126	0.006	4.126	-0.013	4.126	0.008	4.304	0.032
4.134	0.006	4.134	-0.011	4.134	0.008	4.311	0.032
4.141	0.006	4.141	-0.012	4.141	0.009	4.319	0.033
4.148	0.006	4.148	-0.011	4.148	0.008	4.326	0.032
4.155	0.006	4.155	-0.010	4.155	0.008	4.334	0.032
4.162	0.006	4.162	-0.013	4.162	0.010	4.341	0.032
4.170	0.006	4.170	-0.011	4.170	0.010	4.349	0.032
4.177	0.006	4.177	-0.013	4.177	0.010	4.356	0.032
4.184	0.005	4.184	-0.013	4.184	0.010	4.364	0.031
4.191	0.006	4.191	-0.014	4.191	0.010	4.371	0.031
4.198	0.006	4.198	-0.013	4.198	0.010	4.379	0.030
4.206	0.006	4.206	-0.011	4.206	0.010	4.386	0.031
4.213	0.006	4.213	-0.009	4.213	0.009	4.394	0.030
4.220	0.005	4.220	-0.007	4.220	0.010	4.401	0.030
4.227	0.005	4.227	-0.004	4.227	0.009	4.409	0.030
4.234	0.005	4.234	-0.001	4.234	0.008	4.416	0.030
4.241	0.005	4.241	0.009	4.241	0.007	4.424	0.030
4.249	0.005	4.249	0.000	4.249	0.007	4.431	0.030

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.256	0.005	4.256	-0.003	4.256	0.007	4.439	0.030
4.263	0.005	4.263	-0.005	4.263	0.007	4.446	0.031
4.270	0.005	4.270	-0.008	4.270	0.006	4.454	0.030
4.277	0.005	4.277	-0.011	4.277	0.007	4.461	0.029
4.285	0.006	4.285	-0.012	4.285	0.007	4.469	0.029
4.292	0.004	4.292	-0.013	4.292	0.007	4.476	0.029
4.299	0.004	4.299	-0.012	4.299	0.006	4.484	0.029
4.306	0.005	4.306	-0.013	4.306	0.007	4.491	0.028
4.313	0.005	4.313	-0.013	4.313	0.007	4.499	0.027
4.321	0.004	4.321	-0.007	4.321	0.007	4.506	0.027
4.328	0.004	4.328	-0.014	4.328	0.006	4.513	0.028
4.335	0.004	4.335	-0.015	4.335	0.007	4.521	0.027
4.342	0.004	4.342	-0.015	4.342	0.008	4.528	0.026
4.349	0.003	4.349	-0.016	4.349	0.008	4.536	0.026
4.356	0.004	4.356	-0.015	4.356	0.007	4.543	0.026
4.364	0.004	4.364	-0.015	4.364	0.008	4.551	0.026
4.371	0.003	4.371	-0.015	4.371	0.007	4.558	0.026
4.378	0.004	4.378	-0.015	4.378	0.006	4.566	0.026
4.385	0.003	4.385	-0.015	4.385	0.007	4.573	0.026
4.392	0.002	4.392	-0.014	4.392	0.006	4.581	0.026
4.400	0.002	4.400	-0.014	4.400	0.006	4.588	0.026
4.407	0.002	4.407	-0.013	4.407	0.006	4.596	0.026

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.414	0.002	4.414	-0.013	4.414	0.005	4.603	0.024
4.421	0.002	4.421	-0.011	4.421	0.006	4.611	0.025
4.428	0.002	4.428	-0.011	4.428	0.006	4.618	0.025
4.436	0.002	4.436	-0.012	4.436	0.005	4.626	0.023
4.443	0.002	4.443	-0.011	4.443	0.006	4.633	0.024
4.450	0.001	4.450	-0.011	4.450	0.005	4.641	0.024
4.457	0.002	4.457	-0.013	4.457	0.006	4.648	0.024
4.464	0.001	4.464	-0.013	4.464	0.005	4.656	0.023
4.471	0.002	4.471	-0.015	4.471	0.006	4.663	0.024
4.479	0.002	4.479	-0.015	4.479	0.005	4.671	0.023
4.486	0.002	4.486	-0.015	4.486	0.005	4.678	0.022
4.493	0.002	4.493	-0.015	4.493	0.005	4.686	0.023
4.500	0.001	4.500	-0.015	4.500	0.005	4.693	0.022
4.507	0.001	4.507	-0.014	4.507	0.005	4.701	0.022
4.515	0.001	4.515	-0.013	4.515	0.005	4.708	0.023
4.522	0.000	4.522	-0.013	4.522	0.005	4.716	0.023
4.529	0.001	4.529	-0.012	4.529	0.005	4.723	0.022
4.536	0.001	4.536	-0.013	4.536	0.005	4.731	0.022
4.543	0.001	4.543	-0.012	4.543	0.005	4.738	0.022
4.551	0.001	4.551	-0.015	4.551	0.005	4.746	0.022
4.558	0.000	4.558	-0.015	4.558	0.004	4.753	0.022
4.565	0.001	4.565	-0.016	4.565	0.005	4.761	0.022

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.572	0.000	4.572	-0.016	4.572	0.005	4.768	0.022
4.579	0.001	4.579	-0.015	4.579	0.004	4.776	0.022
4.587	0.001	4.587	-0.014	4.587	0.005	4.783	0.021
4.594	0.000	4.594	-0.015	4.594	0.004	4.791	0.021
4.601	0.000	4.601	-0.014	4.601	0.005	4.798	0.021
4.608	0.000	4.608	-0.013	4.608	0.004	4.806	0.021
4.615	0.001	4.615	-0.013	4.615	0.004	4.813	0.021
4.622	0.000	4.622	-0.011	4.622	0.005	4.821	0.021
4.630	0.000	4.630	-0.014	4.630	0.010	4.828	0.021
4.637	0.000	4.637	-0.015	4.637	0.015	4.836	0.021
4.644	0.000	4.644	-0.015	4.644	0.006	4.843	0.020
4.651	-0.001	4.651	-0.016	4.651	0.005	4.851	0.021
4.658	0.000	4.658	-0.015	4.658	0.005	4.858	0.022
4.666	0.000	4.666	-0.014	4.666	0.005	4.866	0.021
4.673	-0.001	4.673	-0.014	4.673	0.005	4.873	0.020
4.680	0.000	4.680	-0.014	4.680	0.005	4.881	0.020
4.687	0.000	4.687	-0.013	4.687	0.004	4.888	0.020
4.694	0.000	4.694	-0.014	4.694	0.004	4.896	0.021
4.702	0.000	4.702	-0.013	4.702	0.004	4.903	0.022
4.709	0.000	4.709	-0.014	4.709	0.003	4.911	0.020
4.716	0.000	4.716	-0.015	4.716	0.004	4.918	0.021
4.723	0.000	4.723	-0.015	4.723	0.004	4.926	0.020

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.730	-0.001	4.730	-0.016	4.730	0.004	4.933	0.020
4.737	0.000	4.737	-0.016	4.737	0.004	4.941	0.019
4.745	0.000	4.745	-0.016	4.745	0.003	4.948	0.020
4.752	0.000	4.752	-0.016	4.752	0.003	4.956	0.020
4.759	0.000	4.759	-0.016	4.759	0.004	4.963	0.019
4.766	0.000	4.766	-0.016	4.766	0.003	4.971	0.020
4.773	0.000	4.773	-0.015	4.773	0.003	4.978	0.019
4.781	-0.001	4.781	-0.015	4.781	0.003	4.986	0.018
4.788	-0.002	4.788	-0.014	4.788	0.004	4.993	0.020
4.795	-0.001	4.795	-0.015	4.795	0.003	5.001	0.020
4.802	-0.001	4.802	-0.015	4.802	0.003	5.008	0.020
4.809	-0.001	4.809	-0.011	4.809	0.003	5.016	0.020
4.817	-0.001	4.817	-0.013	4.817	0.003	5.023	0.019
4.824	0.000	4.824	-0.014	4.824	0.003	5.031	0.020
4.831	-0.001	4.831	-0.015	4.831	0.003	5.038	0.018
4.838	-0.002	4.838	-0.015	4.838	0.003	5.046	0.019
4.845	-0.001	4.845	-0.016	4.845	0.003	5.053	0.018
4.853	-0.002	4.853	-0.016	4.853	0.005	5.061	0.018
4.860	-0.002	4.860	-0.017	4.860	0.003	5.068	0.018
4.867	0.000	4.867	-0.015	4.867	0.003	5.076	0.018
4.874	-0.002	4.874	-0.016	4.874	0.003	5.083	0.019
4.881	-0.002	4.881	-0.015	4.881	0.003	5.091	0.018

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.888	-0.001	4.888	-0.014	4.888	0.003	5.098	0.018
4.896	-0.002	4.896	-0.014	4.896	0.003	5.106	0.018
4.903	-0.002	4.903	-0.014	4.903	0.003	5.113	0.018
4.910	-0.002	4.910	-0.013	4.910	0.003	5.121	0.018
4.917	-0.002	4.917	-0.014	4.917	0.003	5.128	0.018
4.924	-0.002	4.924	-0.015	4.924	0.003	5.136	0.018
4.932	-0.001	4.932	-0.015	4.932	0.003	5.143	0.018
4.939	-0.002	4.939	-0.015	4.939	0.003	5.151	0.018
4.946	-0.002	4.946	-0.016	4.946	0.004	5.158	0.018
4.953	0.000	4.953	-0.016	4.953	0.004	5.166	0.017
4.960	-0.002	4.960	-0.016	4.960	0.003	5.173	0.018
4.968	-0.002	4.968	-0.016	4.968	0.003	5.181	0.019
4.975	-0.002	4.975	-0.016	4.975	0.003	5.188	0.017
4.982	-0.002	4.982	-0.017	4.982	0.003	5.196	0.017
4.989	-0.002	4.989	-0.016	4.989	0.003	5.203	0.018
4.996	-0.002	4.996	-0.016	4.996	0.003	5.211	0.017
5.003	-0.003	5.003	-0.015	5.003	0.003	5.218	0.017
5.011	-0.002	5.011	-0.015	5.011	0.003	5.226	0.018
5.018	-0.002	5.018	-0.015	5.018	0.003	5.233	0.017
5.025	-0.003	5.025	-0.014	5.025	0.003	5.241	0.017
5.032	-0.003	5.032	-0.015	5.032	0.003	5.248	0.018
5.039	-0.002	5.039	-0.013	5.039	0.003	5.256	0.017

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.047	-0.003	5.047	-0.013	5.047	0.003	5.263	0.017
5.054	-0.004	5.054	-0.012	5.054	0.003	5.271	0.016
5.061	-0.002	5.061	-0.015	5.061	0.003	5.278	0.016
5.068	-0.003	5.068	-0.014	5.068	0.003	5.286	0.017
5.075	-0.003	5.075	-0.014	5.075	0.003	5.293	0.017
5.083	-0.003	5.083	-0.014	5.083	0.003	5.301	0.017
5.090	-0.004	5.090	-0.015	5.090	0.003	5.308	0.016
5.097	-0.003	5.097	-0.015	5.097	0.003	5.316	0.017
5.104	-0.003	5.104	-0.015	5.104	0.003	5.323	0.016
5.111	-0.003	5.111	-0.015	5.111	0.003	5.331	0.016
5.118	-0.003	5.118	-0.017	5.118	0.003	5.338	0.017
5.126	-0.003	5.126	-0.016	5.126	0.003	5.346	0.017
5.133	-0.003	5.133	-0.017	5.133	0.002	5.353	0.016
5.140	-0.003	5.140	-0.017	5.140	0.002	5.361	0.016
5.147	-0.003	5.147	-0.018	5.147	0.003	5.368	0.016
5.154	-0.003	5.154	-0.019	5.154	0.003	5.376	0.016
5.162	-0.004	5.162	-0.017	5.162	0.002	5.383	0.016
5.169	-0.003	5.169	-0.017	5.169	0.002	5.391	0.016
5.176	-0.003	5.176	-0.017	5.176	0.003	5.398	0.016
5.183	-0.004	5.183	-0.016	5.183	0.003	5.406	0.016
5.190	-0.004	5.190	-0.015	5.190	0.003	5.413	0.017
5.198	-0.004	5.198	-0.016	5.198	0.003	5.421	0.016

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.205	-0.003	5.205	-0.015	5.205	0.003	5.428	0.016
5.212	-0.003	5.212	-0.016	5.212	0.001	5.436	0.016
5.219	-0.004	5.219	-0.016	5.219	-0.003	5.443	0.016
5.226	-0.004	5.226	-0.017	5.226	-0.004	5.451	0.015
5.234	-0.005	5.234	-0.017	5.234	-0.006	5.458	0.015
5.241	-0.003	5.241	-0.019	5.241	-0.004	5.466	0.016
5.248	-0.003	5.248	-0.018	5.248	-0.006	5.473	0.014
5.255	-0.005	5.255	-0.019	5.255	-0.006	5.481	0.015
5.262	-0.003	5.262	-0.017	5.262	-0.006	5.488	0.017
5.269	-0.004	5.269	-0.019	5.269	-0.005	5.496	0.015
5.277	-0.004	5.277	-0.018	5.277	-0.005	5.503	0.015
5.284	-0.004	5.284	-0.019	5.284	-0.004	5.511	0.015
5.291	-0.004	5.291	-0.019	5.291	-0.004	5.518	0.015
5.298	-0.005	5.298	-0.017	5.298	-0.004	5.526	0.015
5.305	-0.004	5.305	-0.016	5.305	-0.004	5.533	0.016
5.313	-0.005	5.313	-0.016	5.313	-0.004	5.541	0.015
5.320	-0.004	5.320	-0.015	5.320	-0.012	5.548	0.015
5.327	-0.005	5.327	-0.016	5.327	-0.008	5.556	0.014
5.334	-0.004	5.334	-0.015	5.334	-0.006	5.563	0.015
5.341	-0.004	5.341	-0.012	5.341	-0.005	5.571	0.015
5.349	-0.005	5.349	-0.017	5.349	-0.005	5.578	0.014
5.356	-0.005	5.356	-0.017	5.356	-0.004	5.586	0.014

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.363	-0.003	5.363	-0.016	5.363	-0.004	5.593	0.014
5.370	-0.004	5.370	-0.016	5.370	-0.005	5.601	0.014
5.377	-0.005	5.377	-0.015	5.377	-0.005	5.608	0.014
5.384	-0.005	5.384	-0.016	5.384	-0.004	5.616	0.014
5.392	-0.005	5.392	-0.009	5.392	-0.006	5.623	0.015
5.399	-0.004	5.399	-0.016	5.399	-0.006	5.631	0.013
5.406	-0.005	5.406	-0.016	5.406	-0.006	5.638	0.014
5.413	-0.005	5.413	-0.018	5.413	-0.006	5.646	0.014
5.420	-0.005	5.420	-0.019	5.420	-0.006	5.653	0.013
5.428	-0.005	5.428	-0.019	5.428	-0.006	5.661	0.014
5.435	-0.005	5.435	-0.019	5.435	-0.005	5.668	0.014
5.442	-0.005	5.442	-0.019	5.442	-0.006	5.676	0.013
5.449	-0.006	5.449	-0.019	5.449	-0.006	5.683	0.013
5.456	-0.005	5.456	-0.019	5.456	-0.006	5.691	0.013
5.464	-0.005	5.464	-0.019	5.464	-0.004	5.698	0.013
5.471	-0.006	5.471	-0.019	5.471	-0.004	5.706	0.013
5.478	-0.005	5.478	-0.019	5.478	-0.003	5.713	0.014
5.485	-0.004	5.485	-0.019	5.485	-0.003	5.721	0.013
5.492	-0.005	5.492	-0.019	5.492	-0.003	5.728	0.014
5.500	-0.006	5.500	-0.018	5.500	-0.004	5.736	0.013
5.507	-0.006	5.507	-0.017	5.507	-0.004	5.743	0.013
5.514	-0.006	5.514	-0.016	5.514	-0.004	5.751	0.013

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.521	-0.005	5.521	-0.016	5.521	-0.004	5.758	0.012
5.528	-0.006	5.528	-0.016	5.528	-0.003	5.766	0.014
5.535	-0.007	5.535	-0.016	5.535	0.001	5.773	0.012
5.543	-0.006	5.543	-0.017	5.543	0.005	5.781	0.013
5.550	-0.006	5.550	-0.017	5.550	0.001	5.788	0.013
5.557	-0.006	5.557	-0.019	5.557	-0.003	5.796	0.012
5.564	-0.006	5.564	-0.020	5.564	-0.003	5.803	0.013
5.571	-0.006	5.571	-0.019	5.571	-0.004	5.811	0.013
5.579	-0.005	5.579	-0.019	5.579	-0.002	5.818	0.013
5.586	-0.005	5.586	-0.019	5.586	-0.002	5.826	0.013
5.593	-0.005	5.593	-0.019	5.593	-0.003	5.833	0.013
5.600	-0.006	5.600	-0.020	5.600	-0.003	5.841	0.013
5.607	-0.006	5.607	-0.020	5.607	-0.002	5.848	0.013
5.615	-0.006	5.615	-0.019	5.615	-0.003	5.856	0.012
5.622	-0.005	5.622	-0.019	5.622	-0.002	5.863	0.012
5.629	-0.005	5.629	-0.019	5.629	-0.002	5.871	0.013
5.636	-0.005	5.636	-0.017	5.636	-0.001	5.878	0.013
5.643	-0.005	5.643	-0.016	5.643	-0.002	5.886	0.012
5.650	-0.005	5.650	-0.017	5.650	-0.001	5.893	0.013
5.658	-0.005	5.658	-0.015	5.658	-0.003	5.901	0.012
5.665	-0.005	5.665	-0.016	5.665	-0.003	5.908	0.012
5.672	-0.005	5.672	-0.015	5.672	-0.003	5.916	0.012

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.679	-0.005	5.679	-0.019	5.679	-0.003	5.923	0.012
5.686	-0.005	5.686	-0.019	5.686	-0.001	5.931	0.012
5.694	-0.005	5.694	-0.020	5.694	-0.002	5.938	0.012
5.701	-0.005	5.701	-0.019	5.701	-0.001	5.946	0.012
5.708	-0.005	5.708	-0.019	5.708	-0.001	5.953	0.012
5.715	-0.004	5.715	-0.021	5.715	-0.001	5.961	0.012
5.722	-0.004	5.722	-0.020	5.722	0.000	5.968	0.012
5.730	-0.004	5.730	-0.020	5.730	-0.001	5.976	0.012
5.737	-0.004	5.737	-0.020	5.737	0.000	5.983	0.012
5.744	-0.004	5.744	-0.020	5.744	-0.001	5.991	0.011
5.751	-0.004	5.751	-0.020	5.751	-0.001	5.998	0.012
5.758	-0.003	5.758	-0.020	5.758	0.000	6.006	0.012
5.765	-0.002	5.765	-0.019	5.765	-0.001	6.013	0.011
5.773	-0.003	5.773	-0.017	5.773	0.000	6.020	0.011
5.780	-0.002	5.780	-0.017	5.780	-0.001	6.028	0.012
5.787	-0.004	5.787	-0.017	5.787	-0.001	6.035	0.011
5.794	-0.003	5.794	-0.017	5.794	0.001	6.043	0.012
5.801	-0.003	5.801	-0.007	5.801	0.002	6.050	0.012
5.809	-0.002	5.809	-0.016	5.809	0.001	6.058	0.012
5.816	-0.003	5.816	-0.018	5.816	0.001	6.065	0.013
5.823	-0.001	5.823	-0.018	5.823	0.001	6.073	0.012
5.830	0.001	5.830	-0.019	5.830	0.001	6.080	0.012

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.837	0.000	5.837	-0.019	5.837	0.001	6.088	0.011
5.845	-0.003	5.845	-0.019	5.845	0.001	6.095	0.012
5.852	-0.002	5.852	-0.020	5.852	0.001	6.103	0.012
5.859	-0.003	5.859	-0.021	5.859	0.001	6.110	0.011
5.866	-0.003	5.866	-0.021	5.866	0.001	6.118	0.011
5.873	-0.002	5.873	-0.021	5.873	0.003	6.125	0.010
5.881	-0.002	5.881	-0.019	5.881	0.002	6.133	0.010
5.888	-0.002	5.888	-0.018	5.888	0.003	6.140	0.010
5.895	-0.002	5.895	-0.019	5.895	0.001	6.148	0.011
5.902	-0.003	5.902	-0.017	5.902	0.002	6.155	0.012
5.909	-0.002	5.909	-0.017	5.909	0.002	6.163	0.010
5.916	-0.003	5.916	-0.016	5.916	0.002	6.170	0.011
5.924	-0.003	5.924	-0.016	5.924	0.002	6.178	0.010
5.931	-0.003	5.931	-0.016	5.931	0.002	6.185	0.011
5.938	-0.001	5.938	-0.019	5.938	0.002	6.193	0.011
5.945	-0.002	5.945	-0.019	5.945	0.002	6.200	0.011
5.952	-0.003	5.952	-0.019	5.952	0.002	6.208	0.011
5.960	-0.002	5.960	-0.019	5.960	0.003	6.215	0.010
5.967	-0.003	5.967	-0.019	5.967	0.001	6.223	0.010
5.974	-0.003	5.974	-0.017	5.974	0.002	6.230	0.010
5.981	-0.002	5.981	-0.019	5.981	0.001	6.238	0.010
5.988	-0.002	5.988	-0.017	5.988	0.003	6.245	0.011

Table A1. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.996	-0.002	5.996	-0.016	5.996	0.001	6.253	0.010
6.003	-0.002	6.003	-0.017	6.003	0.001	6.260	0.010

Table A2. Breakthrough concentrations of the tet^R and tet^S *E.coli* strains at 12% of soil moisture content and under ionic strength condition of 5 mM NaCl. Where, PV is the pore volume of the sand packed column at 12% of soil moisture content and C/Co is the normalized breakthrough concentrations.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.000	-0.031	0.000	-0.004	0.000	0.000	0.000	-0.005
0.007	-0.031	0.008	-0.004	0.007	-0.001	0.007	-0.005
0.015	-0.031	0.015	-0.003	0.015	-0.001	0.015	-0.006
0.022	-0.031	0.023	-0.004	0.022	-0.001	0.022	-0.003
0.030	-0.031	0.031	-0.005	0.030	0.000	0.030	-0.003
0.037	-0.030	0.038	-0.008	0.037	-0.001	0.037	-0.003
0.045	-0.028	0.046	-0.008	0.045	0.000	0.044	-0.004
0.052	-0.028	0.054	-0.007	0.052	-0.001	0.052	-0.004
0.060	-0.028	0.061	-0.006	0.059	-0.002	0.059	-0.004
0.067	-0.028	0.069	-0.003	0.067	-0.002	0.066	-0.004
0.075	-0.028	0.076	-0.003	0.074	-0.001	0.074	-0.004
0.082	-0.027	0.084	-0.003	0.082	-0.002	0.081	-0.004
0.090	-0.028	0.092	-0.004	0.089	-0.003	0.089	-0.005
0.097	-0.028	0.099	-0.004	0.097	-0.002	0.096	-0.004

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.105	-0.028	0.107	-0.002	0.104	-0.002	0.103	-0.004
0.112	-0.027	0.115	-0.004	0.111	-0.002	0.111	-0.004
0.120	-0.027	0.122	-0.002	0.119	-0.002	0.118	-0.004
0.127	-0.025	0.130	-0.002	0.126	-0.002	0.126	-0.004
0.134	-0.027	0.138	-0.002	0.134	-0.002	0.133	-0.004
0.142	-0.026	0.145	-0.003	0.141	-0.002	0.140	-0.004
0.149	-0.025	0.153	-0.003	0.148	0.000	0.148	-0.004
0.157	-0.025	0.161	-0.002	0.156	-0.002	0.155	-0.004
0.164	-0.024	0.168	-0.001	0.163	-0.002	0.163	-0.004
0.172	-0.025	0.176	-0.002	0.171	-0.001	0.170	-0.004
0.179	-0.024	0.184	-0.002	0.178	-0.001	0.177	-0.004
0.187	-0.024	0.191	-0.003	0.186	-0.002	0.185	-0.004
0.194	-0.025	0.199	-0.002	0.193	-0.002	0.192	-0.005
0.202	-0.025	0.207	-0.004	0.200	-0.001	0.199	-0.004
0.209	-0.023	0.214	-0.004	0.208	-0.001	0.207	-0.004
0.217	-0.024	0.222	-0.002	0.215	-0.002	0.214	-0.004
0.224	-0.022	0.229	-0.003	0.223	-0.001	0.222	-0.005
0.232	-0.022	0.237	-0.005	0.230	0.000	0.229	-0.004
0.239	-0.021	0.245	-0.004	0.238	-0.002	0.236	-0.004
0.247	-0.021	0.252	-0.002	0.245	0.000	0.244	-0.004
0.254	-0.019	0.260	-0.003	0.252	-0.002	0.251	-0.004
0.262	-0.020	0.268	-0.003	0.260	-0.001	0.259	-0.004

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.269	-0.021	0.275	-0.004	0.267	0.000	0.266	-0.004
0.276	-0.019	0.283	-0.002	0.275	0.000	0.273	-0.004
0.284	-0.019	0.291	-0.002	0.282	0.000	0.281	-0.004
0.291	-0.019	0.298	-0.002	0.290	0.000	0.288	-0.003
0.299	-0.018	0.306	-0.002	0.297	0.000	0.296	-0.002
0.306	-0.018	0.314	-0.004	0.304	0.000	0.303	-0.004
0.314	-0.018	0.321	-0.004	0.312	0.000	0.310	-0.003
0.321	-0.017	0.329	-0.004	0.319	0.001	0.318	-0.004
0.329	-0.017	0.337	-0.002	0.327	0.000	0.325	-0.004
0.336	-0.015	0.344	-0.002	0.334	0.000	0.332	-0.003
0.344	-0.016	0.352	-0.001	0.342	0.000	0.340	-0.003
0.351	-0.016	0.360	-0.002	0.349	0.000	0.347	-0.003
0.359	-0.015	0.367	-0.003	0.356	0.000	0.355	-0.004
0.366	-0.015	0.375	-0.002	0.364	-0.001	0.362	-0.003
0.374	-0.015	0.382	-0.002	0.371	-0.002	0.369	-0.004
0.381	-0.015	0.390	-0.001	0.379	0.000	0.377	-0.004
0.389	-0.015	0.398	-0.003	0.386	0.000	0.384	-0.001
0.396	-0.013	0.405	-0.002	0.394	0.000	0.392	0.001
0.403	-0.013	0.413	-0.004	0.401	0.000	0.399	0.000
0.411	-0.013	0.421	-0.002	0.408	0.000	0.406	0.000
0.418	-0.013	0.428	-0.003	0.416	0.000	0.414	-0.001
0.426	-0.011	0.436	-0.002	0.423	0.000	0.421	-0.001

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.433	-0.012	0.444	-0.003	0.431	0.003	0.429	-0.001
0.441	-0.011	0.451	-0.001	0.438	0.002	0.436	0.000
0.448	-0.012	0.459	-0.001	0.445	0.002	0.443	-0.001
0.456	-0.011	0.467	-0.001	0.453	0.003	0.451	0.000
0.463	-0.011	0.474	-0.002	0.460	0.003	0.458	-0.002
0.471	-0.011	0.482	-0.001	0.468	0.003	0.465	0.000
0.478	-0.010	0.490	-0.001	0.475	0.003	0.473	-0.001
0.486	-0.011	0.497	-0.001	0.483	0.003	0.480	-0.001
0.493	-0.010	0.505	-0.001	0.490	0.003	0.488	-0.001
0.501	-0.010	0.513	0.000	0.497	0.004	0.495	-0.002
0.508	-0.009	0.520	0.000	0.505	0.003	0.502	-0.002
0.516	-0.010	0.528	-0.001	0.512	0.003	0.510	-0.001
0.523	-0.010	0.535	-0.001	0.520	0.003	0.517	-0.002
0.531	-0.010	0.543	-0.002	0.527	0.003	0.525	-0.001
0.538	-0.008	0.551	-0.001	0.535	0.004	0.532	-0.002
0.545	-0.009	0.558	-0.002	0.542	0.003	0.539	-0.001
0.553	-0.009	0.566	-0.002	0.549	0.004	0.547	-0.002
0.560	-0.009	0.574	-0.002	0.557	0.005	0.554	-0.001
0.568	-0.009	0.581	-0.002	0.564	0.004	0.561	0.000
0.575	-0.009	0.589	-0.001	0.572	0.005	0.569	-0.001
0.583	-0.009	0.597	-0.001	0.579	0.005	0.576	-0.001
0.590	-0.008	0.604	-0.001	0.587	0.005	0.584	-0.002

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.598	-0.009	0.612	-0.002	0.594	0.006	0.591	-0.001
0.605	-0.008	0.620	-0.002	0.601	0.005	0.598	0.000
0.613	-0.009	0.627	-0.002	0.609	0.005	0.606	0.000
0.620	-0.008	0.635	-0.002	0.616	0.006	0.613	-0.001
0.628	-0.007	0.643	-0.002	0.624	0.006	0.621	-0.001
0.635	-0.007	0.650	-0.002	0.631	0.006	0.628	-0.002
0.643	-0.007	0.658	-0.001	0.639	0.006	0.635	0.006
0.650	-0.006	0.666	0.000	0.646	0.006	0.643	0.006
0.658	-0.004	0.673	-0.001	0.653	0.006	0.650	0.006
0.665	-0.006	0.681	-0.001	0.661	0.006	0.658	0.006
0.672	-0.006	0.688	0.000	0.668	0.006	0.665	0.006
0.680	-0.006	0.696	0.000	0.676	0.006	0.672	0.006
0.687	-0.006	0.704	0.002	0.683	0.008	0.680	0.007
0.695	-0.004	0.711	0.002	0.691	0.007	0.687	0.009
0.702	-0.004	0.719	0.003	0.698	0.009	0.694	0.009
0.710	-0.004	0.727	0.003	0.705	0.008	0.702	0.010
0.717	-0.004	0.734	0.004	0.713	0.009	0.709	0.010
0.725	-0.003	0.742	0.004	0.720	0.009	0.717	0.010
0.732	-0.003	0.750	0.006	0.728	0.010	0.724	0.011
0.740	-0.002	0.757	0.007	0.735	0.010	0.731	0.012
0.747	-0.002	0.765	0.009	0.742	0.011	0.739	0.012
0.755	-0.001	0.773	0.010	0.750	0.012	0.746	0.012

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.762	-0.001	0.780	0.012	0.757	0.012	0.754	0.013
0.770	-0.001	0.788	0.010	0.765	0.013	0.761	0.013
0.777	0.001	0.796	0.006	0.772	0.013	0.768	0.014
0.785	0.001	0.803	0.004	0.780	0.014	0.776	0.014
0.792	0.000	0.811	0.017	0.787	0.015	0.783	0.016
0.800	-0.001	0.819	0.020	0.794	0.017	0.791	0.017
0.807	0.003	0.826	0.021	0.802	0.017	0.798	0.017
0.814	0.005	0.834	0.023	0.809	0.018	0.805	0.018
0.822	0.006	0.841	0.024	0.817	0.018	0.813	0.018
0.829	0.007	0.849	0.026	0.824	0.019	0.820	0.019
0.837	0.008	0.857	0.030	0.832	0.019	0.827	0.020
0.844	0.009	0.864	0.032	0.839	0.020	0.835	0.020
0.852	0.010	0.872	0.034	0.846	0.022	0.842	0.019
0.859	0.012	0.880	0.036	0.854	0.022	0.850	0.021
0.867	0.012	0.887	0.037	0.861	0.023	0.857	0.020
0.874	0.013	0.895	0.038	0.869	0.025	0.864	0.022
0.882	0.013	0.903	0.040	0.876	0.025	0.872	0.022
0.889	0.014	0.910	0.042	0.884	0.025	0.879	0.023
0.897	0.016	0.918	0.044	0.891	0.027	0.887	0.023
0.904	0.017	0.926	0.048	0.898	0.028	0.894	0.024
0.912	0.018	0.933	0.048	0.906	0.029	0.901	0.025
0.919	0.018	0.941	0.050	0.913	0.030	0.909	0.026

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.927	0.020	0.949	0.054	0.921	0.031	0.916	0.027
0.934	0.022	0.956	0.056	0.928	0.031	0.923	0.027
0.941	0.022	0.964	0.058	0.936	0.033	0.931	0.027
0.949	0.024	0.972	0.059	0.943	0.033	0.938	0.027
0.956	0.025	0.979	0.064	0.950	0.035	0.946	0.028
0.964	0.025	0.987	0.066	0.958	0.037	0.953	0.027
0.971	0.027	0.994	0.066	0.965	0.038	0.960	0.027
0.979	0.028	1.002	0.066	0.973	0.039	0.968	0.029
0.986	0.031	1.010	0.066	0.980	0.039	0.975	0.023
0.994	0.031	1.017	0.068	0.988	0.041	0.983	0.019
1.001	0.034	1.025	0.071	0.995	0.039	0.990	0.024
1.009	0.029	1.033	0.074	1.002	0.044	0.997	0.033
1.016	0.027	1.040	0.075	1.010	0.042	1.005	0.035
1.024	0.022	1.048	0.076	1.017	0.043	1.012	0.036
1.031	0.039	1.056	0.077	1.025	0.044	1.020	0.037
1.039	0.043	1.063	0.079	1.032	0.044	1.027	0.039
1.046	0.044	1.071	0.079	1.039	0.046	1.034	0.038
1.054	0.044	1.079	0.081	1.047	0.046	1.042	0.039
1.061	0.047	1.086	0.084	1.054	0.047	1.049	0.039
1.069	0.048	1.094	0.085	1.062	0.047	1.056	0.039
1.076	0.050	1.102	0.082	1.069	0.047	1.064	0.039
1.083	0.051	1.109	0.068	1.077	0.047	1.071	0.041

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.091	0.051	1.117	0.057	1.084	0.049	1.079	0.040
1.098	0.053	1.125	0.089	1.091	0.049	1.086	0.039
1.106	0.055	1.132	0.094	1.099	0.050	1.093	0.040
1.113	0.056	1.140	0.095	1.106	0.052	1.101	0.040
1.121	0.056	1.147	0.095	1.114	0.053	1.108	0.041
1.128	0.058	1.155	0.098	1.121	0.054	1.116	0.040
1.136	0.058	1.163	0.101	1.129	0.054	1.123	0.041
1.143	0.061	1.170	0.102	1.136	0.054	1.130	0.042
1.151	0.061	1.178	0.102	1.143	0.055	1.138	0.041
1.158	0.063	1.186	0.095	1.151	0.058	1.145	0.041
1.166	0.064	1.193	0.101	1.158	0.057	1.153	0.043
1.173	0.063	1.201	0.105	1.166	0.058	1.160	0.042
1.181	0.064	1.209	0.112	1.173	0.058	1.167	0.043
1.188	0.066	1.216	0.111	1.181	0.060	1.175	0.042
1.196	0.066	1.224	0.112	1.188	0.055	1.182	0.042
1.203	0.066	1.232	0.111	1.195	0.052	1.189	0.043
1.210	0.058	1.239	0.113	1.203	0.052	1.197	0.045
1.218	0.058	1.247	0.115	1.210	0.052	1.204	0.045
1.225	0.058	1.255	0.115	1.218	0.053	1.212	0.047
1.233	0.071	1.262	0.116	1.225	0.053	1.219	0.048
1.240	0.074	1.270	0.116	1.233	0.053	1.226	0.047
1.248	0.075	1.278	0.120	1.240	0.054	1.234	0.048

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.255	0.077	1.285	0.121	1.247	0.055	1.241	0.047
1.263	0.076	1.293	0.121	1.255	0.055	1.249	0.049
1.270	0.078	1.300	0.123	1.262	0.056	1.256	0.049
1.278	0.079	1.308	0.123	1.270	0.056	1.263	0.048
1.285	0.080	1.316	0.121	1.277	0.056	1.271	0.048
1.293	0.083	1.323	0.121	1.285	0.057	1.278	0.050
1.300	0.083	1.331	0.121	1.292	0.058	1.286	0.049
1.308	0.085	1.339	0.122	1.299	0.058	1.293	0.049
1.315	0.084	1.346	0.123	1.307	0.059	1.300	0.051
1.323	0.085	1.354	0.123	1.314	0.060	1.308	0.051
1.330	0.086	1.362	0.125	1.322	0.060	1.315	0.051
1.338	0.088	1.369	0.127	1.329	0.060	1.322	0.050
1.345	0.089	1.377	0.103	1.336	0.061	1.330	0.051
1.352	0.089	1.385	0.124	1.344	0.061	1.337	0.051
1.360	0.090	1.392	0.123	1.351	0.062	1.345	0.051
1.367	0.090	1.400	0.133	1.359	0.062	1.352	0.053
1.375	0.091	1.408	0.133	1.366	0.063	1.359	0.051
1.382	0.093	1.415	0.133	1.374	0.063	1.367	0.052
1.390	0.093	1.423	0.134	1.381	0.063	1.374	0.053
1.397	0.093	1.431	0.138	1.388	0.064	1.382	0.053
1.405	0.092	1.438	0.136	1.396	0.064	1.389	0.055
1.412	0.091	1.446	0.137	1.403	0.064	1.396	0.050

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.420	0.092	1.453	0.138	1.411	0.064	1.404	0.044
1.427	0.092	1.461	0.137	1.418	0.065	1.411	0.057
1.435	0.090	1.469	0.139	1.426	0.064	1.418	0.059
1.442	0.087	1.476	0.139	1.433	0.066	1.426	0.060
1.450	0.089	1.484	0.142	1.440	0.066	1.433	0.060
1.457	0.090	1.492	0.144	1.448	0.066	1.441	0.061
1.465	0.093	1.499	0.147	1.455	0.066	1.448	0.060
1.472	0.095	1.507	0.147	1.463	0.067	1.455	0.060
1.479	0.097	1.515	0.147	1.470	0.068	1.463	0.060
1.487	0.097	1.522	0.148	1.478	0.067	1.470	0.060
1.494	0.099	1.530	0.147	1.485	0.069	1.478	0.060
1.502	0.101	1.538	0.149	1.492	0.069	1.485	0.060
1.509	0.102	1.545	0.150	1.500	0.069	1.492	0.061
1.517	0.102	1.553	0.150	1.507	0.069	1.500	0.060
1.524	0.102	1.561	0.148	1.515	0.069	1.507	0.061
1.532	0.102	1.568	0.147	1.522	0.071	1.515	0.061
1.539	0.103	1.576	0.148	1.530	0.071	1.522	0.060
1.547	0.101	1.584	0.147	1.537	0.070	1.529	0.060
1.554	0.101	1.591	0.147	1.544	0.072	1.537	0.061
1.562	0.102	1.599	0.145	1.552	0.072	1.544	0.061
1.569	0.101	1.606	0.145	1.559	0.072	1.551	0.062
1.577	0.102	1.614	0.145	1.567	0.071	1.559	0.061

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.584	0.104	1.622	0.146	1.574	0.074	1.566	0.063
1.592	0.103	1.629	0.147	1.582	0.074	1.574	0.062
1.599	0.104	1.637	0.148	1.589	0.073	1.581	0.063
1.606	0.103	1.645	0.149	1.596	0.074	1.588	0.063
1.614	0.102	1.652	0.149	1.604	0.074	1.596	0.063
1.621	0.093	1.660	0.145	1.611	0.074	1.603	0.063
1.629	0.099	1.668	0.140	1.619	0.075	1.611	0.064
1.636	0.099	1.675	0.184	1.626	0.074	1.618	0.063
1.644	0.112	1.683	0.153	1.633	0.075	1.625	0.063
1.651	0.115	1.691	0.151	1.641	0.074	1.633	0.063
1.659	0.115	1.698	0.149	1.648	0.075	1.640	0.065
1.666	0.115	1.706	0.152	1.656	0.075	1.648	0.065
1.674	0.115	1.714	0.152	1.663	0.076	1.655	0.065
1.681	0.115	1.721	0.153	1.671	0.075	1.662	0.065
1.689	0.115	1.729	0.152	1.678	0.076	1.670	0.065
1.696	0.115	1.737	0.153	1.685	0.076	1.677	0.063
1.704	0.114	1.744	0.157	1.693	0.077	1.684	0.064
1.711	0.114	1.752	0.155	1.700	0.075	1.692	0.063
1.719	0.115	1.759	0.156	1.708	0.077	1.699	0.064
1.726	0.114	1.767	0.152	1.715	0.077	1.707	0.065
1.734	0.114	1.775	0.153	1.723	0.078	1.714	0.059
1.741	0.112	1.782	0.153	1.730	0.079	1.721	0.051

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.748	0.112	1.790	0.154	1.737	0.077	1.729	0.059
1.756	0.114	1.798	0.157	1.745	0.076	1.736	0.063
1.763	0.114	1.805	0.157	1.752	0.077	1.744	0.065
1.771	0.114	1.813	0.159	1.760	0.077	1.751	0.065
1.778	0.116	1.821	0.158	1.767	0.078	1.758	0.065
1.786	0.115	1.828	0.160	1.775	0.079	1.766	0.066
1.793	0.114	1.836	0.160	1.782	0.078	1.773	0.065
1.801	0.113	1.844	0.159	1.789	0.079	1.781	0.065
1.808	0.112	1.851	0.157	1.797	0.079	1.788	0.065
1.816	0.112	1.859	0.155	1.804	0.079	1.795	0.067
1.823	0.112	1.867	0.155	1.812	0.078	1.803	0.065
1.831	0.111	1.874	0.155	1.819	0.080	1.810	0.065
1.838	0.111	1.882	0.155	1.827	0.080	1.817	0.065
1.846	0.101	1.890	0.153	1.834	0.080	1.825	0.065
1.853	0.109	1.897	0.153	1.841	0.080	1.832	0.065
1.861	0.137	1.905	0.204	1.849	0.080	1.840	0.066
1.868	0.114	1.912	0.183	1.856	0.080	1.847	0.065
1.875	0.115	1.920	0.166	1.864	0.080	1.854	0.054
1.883	0.113	1.928	0.160	1.871	0.082	1.862	0.053
1.890	0.114	1.935	0.158	1.879	0.080	1.869	0.043
1.898	0.113	1.943	0.160	1.886	0.080	1.877	0.065
1.905	0.112	1.951	0.163	1.893	0.080	1.884	0.065

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.913	0.112	1.958	0.163	1.901	0.082	1.891	0.065
1.920	0.112	1.966	0.163	1.908	0.081	1.899	0.065
1.928	0.111	1.974	0.165	1.916	0.082	1.906	0.065
1.935	0.109	1.981	0.163	1.923	0.082	1.913	0.064
1.943	0.110	1.989	0.161	1.930	0.082	1.921	0.065
1.950	0.108	1.997	0.160	1.938	0.082	1.928	0.064
1.958	0.108	2.004	0.159	1.945	0.082	1.936	0.064
1.965	0.111	2.012	0.161	1.953	0.080	1.943	0.063
1.973	0.111	2.020	0.161	1.960	0.079	1.950	0.063
1.980	0.110	2.027	0.160	1.968	0.080	1.958	0.063
1.988	0.109	2.035	0.161	1.975	0.080	1.965	0.063
1.995	0.108	2.043	0.162	1.982	0.080	1.973	0.062
2.003	0.108	2.050	0.164	1.990	0.079	1.980	0.062
2.010	0.109	2.058	0.160	1.997	0.080	1.987	0.062
2.017	0.106	2.065	0.161	2.005	0.080	1.995	0.061
2.025	0.103	2.073	0.163	2.012	0.082	2.002	0.062
2.032	0.093	2.081	0.164	2.020	0.082	2.010	0.065
2.040	0.093	2.088	0.166	2.027	0.082	2.017	0.065
2.047	0.118	2.096	0.163	2.034	0.084	2.024	0.065
2.055	0.108	2.104	0.163	2.042	0.082	2.032	0.065
2.062	0.112	2.111	0.163	2.049	0.085	2.039	0.067
2.070	0.114	2.119	0.161	2.057	0.085	2.046	0.067

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.077	0.114	2.127	0.161	2.064	0.085	2.054	0.064
2.085	0.114	2.134	0.162	2.072	0.084	2.061	0.059
2.092	0.112	2.142	0.161	2.079	0.084	2.069	0.048
2.100	0.097	2.150	0.161	2.086	0.085	2.076	0.071
2.107	0.099	2.157	0.162	2.094	0.085	2.083	0.071
2.115	0.105	2.165	0.163	2.101	0.087	2.091	0.071
2.122	0.107	2.173	0.164	2.109	0.087	2.098	0.071
2.130	0.108	2.180	0.163	2.116	0.086	2.106	0.072
2.137	0.109	2.188	0.166	2.124	0.085	2.113	0.072
2.144	0.111	2.196	0.160	2.131	0.085	2.120	0.072
2.152	0.109	2.203	0.218	2.138	0.086	2.128	0.071
2.159	0.109	2.211	0.186	2.146	0.087	2.135	0.071
2.167	0.108	2.218	0.178	2.153	0.087	2.143	0.072
2.174	0.108	2.226	0.175	2.161	0.086	2.150	0.072
2.182	0.107	2.234	0.176	2.168	0.087	2.157	0.072
2.189	0.107	2.241	0.176	2.176	0.088	2.165	0.072
2.197	0.107	2.249	0.178	2.183	0.088	2.172	0.070
2.204	0.108	2.257	0.176	2.190	0.088	2.179	0.071
2.212	0.109	2.264	0.178	2.198	0.088	2.187	0.071
2.219	0.100	2.272	0.178	2.205	0.089	2.194	0.072
2.227	0.093	2.280	0.176	2.213	0.088	2.202	0.072
2.234	0.098	2.287	0.179	2.220	0.089	2.209	0.074

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.242	0.114	2.295	0.179	2.227	0.089	2.216	0.073
2.249	0.114	2.303	0.174	2.235	0.089	2.224	0.073
2.257	0.114	2.310	0.174	2.242	0.088	2.231	0.074
2.264	0.112	2.318	0.175	2.250	0.088	2.239	0.073
2.272	0.114	2.326	0.175	2.257	0.089	2.246	0.074
2.279	0.114	2.333	0.174	2.265	0.091	2.253	0.073
2.286	0.114	2.341	0.173	2.272	0.089	2.261	0.074
2.294	0.113	2.349	0.172	2.279	0.091	2.268	0.074
2.301	0.113	2.356	0.175	2.287	0.090	2.276	0.074
2.309	0.112	2.364	0.173	2.294	0.088	2.283	0.075
2.316	0.112	2.371	0.174	2.302	0.090	2.290	0.074
2.324	0.111	2.379	0.170	2.309	0.088	2.298	0.074
2.331	0.111	2.387	0.170	2.317	0.091	2.305	0.076
2.339	0.111	2.394	0.169	2.324	0.090	2.312	0.076
2.346	0.111	2.402	0.159	2.331	0.090	2.320	0.077
2.354	0.109	2.410	0.181	2.339	0.091	2.327	0.076
2.361	0.107	2.417	0.276	2.346	0.090	2.335	0.076
2.369	0.107	2.425	0.179	2.354	0.092	2.342	0.076
2.376	0.089	2.433	0.174	2.361	0.092	2.349	0.077
2.384	0.099	2.440	0.174	2.369	0.092	2.357	0.078
2.391	0.096	2.448	0.175	2.376	0.092	2.364	0.076
2.399	0.107	2.456	0.175	2.383	0.092	2.372	0.067

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.406	0.111	2.463	0.178	2.391	0.091	2.379	0.058
2.413	0.113	2.471	0.176	2.398	0.093	2.386	0.065
2.421	0.114	2.479	0.175	2.406	0.092	2.394	0.081
2.428	0.112	2.486	0.177	2.413	0.092	2.401	0.081
2.436	0.109	2.494	0.175	2.421	0.091	2.408	0.081
2.443	0.109	2.502	0.175	2.428	0.092	2.416	0.082
2.451	0.109	2.509	0.171	2.435	0.091	2.423	0.082
2.458	0.109	2.517	0.170	2.443	0.091	2.431	0.084
2.466	0.103	2.524	0.171	2.450	0.093	2.438	0.084
2.473	0.103	2.532	0.170	2.458	0.092	2.445	0.083
2.481	0.107	2.540	0.172	2.465	0.093	2.453	0.082
2.488	0.107	2.547	0.170	2.473	0.092	2.460	0.082
2.496	0.107	2.555	0.171	2.480	0.093	2.468	0.082
2.503	0.109	2.563	0.172	2.487	0.092	2.475	0.082
2.511	0.109	2.570	0.171	2.495	0.093	2.482	0.080
2.518	0.111	2.578	0.170	2.502	0.091	2.490	0.082
2.526	0.108	2.586	0.168	2.510	0.091	2.497	0.083
2.533	0.107	2.593	0.170	2.517	0.092	2.505	0.082
2.541	0.109	2.601	0.170	2.524	0.094	2.512	0.078
2.548	0.106	2.609	0.171	2.532	0.090	2.519	0.078
2.555	0.090	2.616	0.172	2.539	0.093	2.527	0.078
2.563	0.089	2.624	0.174	2.547	0.091	2.534	0.079

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.570	0.091	2.632	0.177	2.554	0.090	2.541	0.078
2.578	0.107	2.639	0.176	2.562	0.093	2.549	0.078
2.585	0.108	2.647	0.177	2.569	0.092	2.556	0.079
2.593	0.110	2.655	0.176	2.576	0.091	2.564	0.078
2.600	0.110	2.662	0.176	2.584	0.091	2.571	0.078
2.608	0.109	2.670	0.177	2.591	0.091	2.578	0.078
2.615	0.109	2.677	0.182	2.599	0.092	2.586	0.080
2.623	0.107	2.685	0.179	2.606	0.092	2.593	0.080
2.630	0.105	2.693	0.171	2.614	0.091	2.601	0.080
2.638	0.093	2.700	0.215	2.621	0.090	2.608	0.080
2.645	0.089	2.708	0.276	2.628	0.091	2.615	0.080
2.653	0.090	2.716	0.208	2.636	0.090	2.623	0.080
2.660	0.105	2.723	0.192	2.643	0.089	2.630	0.079
2.668	0.106	2.731	0.189	2.651	0.088	2.638	0.078
2.675	0.105	2.739	0.184	2.658	0.089	2.645	0.078
2.682	0.104	2.746	0.184	2.666	0.089	2.652	0.080
2.690	0.102	2.754	0.186	2.673	0.087	2.660	0.081
2.697	0.103	2.762	0.181	2.680	0.088	2.667	0.082
2.705	0.099	2.769	0.182	2.688	0.087	2.674	0.082
2.712	0.100	2.777	0.178	2.695	0.086	2.682	0.080
2.720	0.101	2.785	0.180	2.703	0.085	2.689	0.080
2.727	0.100	2.792	0.179	2.710	0.085	2.697	0.081

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.735	0.101	2.800	0.176	2.718	0.084	2.704	0.080
2.742	0.101	2.808	0.177	2.725	0.083	2.711	0.078
2.750	0.101	2.815	0.175	2.732	0.083	2.719	0.078
2.757	0.101	2.823	0.174	2.740	0.083	2.726	0.070
2.765	0.099	2.830	0.174	2.747	0.082	2.734	0.061
2.772	0.099	2.838	0.172	2.755	0.082	2.741	0.051
2.780	0.099	2.846	0.170	2.762	0.081	2.748	0.080
2.787	0.098	2.853	0.166	2.770	0.079	2.756	0.079
2.795	0.099	2.861	0.163	2.777	0.077	2.763	0.078
2.802	0.098	2.869	0.161	2.784	0.077	2.770	0.076
2.810	0.099	2.876	0.158	2.792	0.077	2.778	0.076
2.817	0.097	2.884	0.156	2.799	0.076	2.785	0.074
2.824	0.085	2.892	0.153	2.807	0.075	2.793	0.075
2.832	0.092	2.899	0.151	2.814	0.074	2.800	0.074
2.839	0.082	2.907	0.129	2.821	0.072	2.807	0.071
2.847	0.097	2.915	0.155	2.829	0.071	2.815	0.068
2.854	0.099	2.922	0.187	2.836	0.072	2.822	0.065
2.862	0.097	2.930	0.155	2.844	0.070	2.830	0.067
2.869	0.098	2.938	0.147	2.851	0.069	2.837	0.065
2.877	0.097	2.945	0.141	2.859	0.068	2.844	0.062
2.884	0.097	2.953	0.139	2.866	0.067	2.852	0.062
2.892	0.097	2.961	0.136	2.873	0.066	2.859	0.061

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.899	0.095	2.968	0.135	2.881	0.065	2.867	0.060
2.907	0.095	2.976	0.129	2.888	0.065	2.874	0.060
2.914	0.093	2.983	0.127	2.896	0.064	2.881	0.060
2.922	0.093	2.991	0.125	2.903	0.063	2.889	0.058
2.929	0.093	2.999	0.122	2.911	0.062	2.896	0.057
2.937	0.092	3.006	0.119	2.918	0.061	2.903	0.057
2.944	0.093	3.014	0.116	2.925	0.061	2.911	0.057
2.951	0.091	3.022	0.114	2.933	0.060	2.918	0.055
2.959	0.090	3.029	0.112	2.940	0.060	2.926	0.055
2.966	0.090	3.037	0.109	2.948	0.058	2.933	0.055
2.974	0.089	3.045	0.108	2.955	0.058	2.940	0.053
2.981	0.087	3.052	0.106	2.963	0.058	2.948	0.051
2.989	0.087	3.060	0.103	2.970	0.056	2.955	0.051
2.996	0.086	3.068	0.102	2.977	0.056	2.963	0.051
3.004	0.086	3.075	0.101	2.985	0.056	2.970	0.051
3.011	0.086	3.083	0.098	2.992	0.054	2.977	0.049
3.019	0.075	3.091	0.097	3.000	0.053	2.985	0.048
3.026	0.084	3.098	0.095	3.007	0.052	2.992	0.049
3.034	0.075	3.106	0.093	3.015	0.052	3.000	0.049
3.041	0.086	3.114	0.092	3.022	0.052	3.007	0.047
3.049	0.086	3.121	0.089	3.029	0.052	3.014	0.046
3.056	0.086	3.129	0.088	3.037	0.050	3.022	0.048

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.064	0.086	3.136	0.087	3.044	0.050	3.029	0.045
3.071	0.083	3.144	0.085	3.052	0.052	3.036	0.045
3.079	0.083	3.152	0.083	3.059	0.049	3.044	0.043
3.086	0.082	3.159	0.074	3.067	0.048	3.051	0.040
3.093	0.080	3.167	0.090	3.074	0.048	3.059	0.036
3.101	0.078	3.175	0.108	3.081	0.047	3.066	0.037
3.108	0.078	3.182	0.085	3.089	0.047	3.073	0.035
3.116	0.075	3.190	0.080	3.096	0.047	3.081	0.048
3.123	0.074	3.198	0.078	3.104	0.047	3.088	0.047
3.131	0.074	3.205	0.078	3.111	0.047	3.096	0.046
3.138	0.075	3.213	0.075	3.118	0.046	3.103	0.047
3.146	0.080	3.221	0.074	3.126	0.044	3.110	0.045
3.153	0.080	3.228	0.073	3.133	0.044	3.118	0.045
3.161	0.078	3.236	0.071	3.141	0.044	3.125	0.038
3.168	0.077	3.244	0.073	3.148	0.043	3.133	0.037
3.176	0.077	3.251	0.069	3.156	0.042	3.140	0.045
3.183	0.077	3.259	0.068	3.163	0.043	3.147	0.043
3.191	0.075	3.267	0.065	3.170	0.041	3.155	0.041
3.198	0.072	3.274	0.063	3.178	0.042	3.162	0.041
3.206	0.074	3.282	0.062	3.185	0.042	3.169	0.041
3.213	0.069	3.289	0.062	3.193	0.040	3.177	0.040
3.220	0.071	3.297	0.060	3.200	0.039	3.184	0.040

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.228	0.085	3.305	0.058	3.208	0.041	3.192	0.039
3.235	0.074	3.312	0.058	3.215	0.041	3.199	0.039
3.243	0.069	3.320	0.057	3.222	0.039	3.206	0.038
3.250	0.069	3.328	0.056	3.230	0.039	3.214	0.037
3.258	0.068	3.335	0.056	3.237	0.038	3.221	0.037
3.265	0.067	3.343	0.055	3.245	0.038	3.229	0.038
3.273	0.066	3.351	0.055	3.252	0.039	3.236	0.036
3.280	0.067	3.358	0.053	3.260	0.037	3.243	0.036
3.288	0.066	3.366	0.063	3.267	0.036	3.251	0.036
3.295	0.064	3.374	0.096	3.274	0.037	3.258	0.035
3.303	0.064	3.381	0.056	3.282	0.037	3.265	0.034
3.310	0.064	3.389	0.051	3.289	0.036	3.273	0.033
3.318	0.064	3.397	0.051	3.297	0.035	3.280	0.033
3.325	0.061	3.404	0.050	3.304	0.035	3.288	0.033
3.333	0.059	3.412	0.048	3.312	0.035	3.295	0.032
3.340	0.059	3.420	0.048	3.319	0.034	3.302	0.032
3.347	0.058	3.427	0.047	3.326	0.034	3.310	0.031
3.355	0.058	3.435	0.046	3.334	0.034	3.317	0.033
3.362	0.058	3.442	0.045	3.341	0.034	3.325	0.031
3.370	0.056	3.450	0.044	3.349	0.033	3.332	0.031
3.377	0.055	3.458	0.044	3.356	0.031	3.339	0.031
3.385	0.055	3.465	0.042	3.364	0.033	3.347	0.029

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.392	0.053	3.473	0.044	3.371	0.033	3.354	0.029
3.400	0.053	3.481	0.042	3.378	0.031	3.362	0.030
3.407	0.053	3.488	0.042	3.386	0.031	3.369	0.029
3.415	0.052	3.496	0.040	3.393	0.031	3.376	0.030
3.422	0.051	3.504	0.039	3.401	0.031	3.384	0.029
3.430	0.051	3.511	0.040	3.408	0.031	3.391	0.028
3.437	0.050	3.519	0.038	3.415	0.031	3.398	0.027
3.445	0.050	3.527	0.038	3.423	0.030	3.406	0.027
3.452	0.048	3.534	0.038	3.430	0.030	3.413	0.027
3.460	0.049	3.542	0.037	3.438	0.029	3.421	0.027
3.467	0.064	3.550	0.036	3.445	0.029	3.428	0.027
3.475	0.053	3.557	0.036	3.453	0.028	3.435	0.026
3.482	0.045	3.565	0.036	3.460	0.029	3.443	0.022
3.489	0.045	3.573	0.042	3.467	0.029	3.450	0.027
3.497	0.046	3.580	0.070	3.475	0.028	3.458	0.026
3.504	0.045	3.588	0.042	3.482	0.028	3.465	0.027
3.512	0.045	3.595	0.036	3.490	0.027	3.472	0.027
3.519	0.045	3.603	0.036	3.497	0.028	3.480	0.027
3.527	0.044	3.611	0.034	3.505	0.027	3.487	0.025
3.534	0.043	3.618	0.034	3.512	0.027	3.495	0.025
3.542	0.042	3.626	0.034	3.519	0.027	3.502	0.025
3.549	0.041	3.634	0.033	3.527	0.027	3.509	0.025

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.557	0.043	3.641	0.033	3.534	0.026	3.517	0.024
3.564	0.041	3.649	0.033	3.542	0.026	3.524	0.024
3.572	0.041	3.657	0.033	3.549	0.025	3.531	0.023
3.579	0.040	3.664	0.032	3.557	0.026	3.539	0.024
3.587	0.039	3.672	0.031	3.564	0.025	3.546	0.023
3.594	0.038	3.680	0.030	3.571	0.026	3.554	0.023
3.602	0.039	3.687	0.032	3.579	0.026	3.561	0.022
3.609	0.037	3.695	0.032	3.586	0.027	3.568	0.023
3.616	0.037	3.703	0.031	3.594	0.025	3.576	0.023
3.624	0.036	3.710	0.031	3.601	0.025	3.583	0.022
3.631	0.035	3.718	0.030	3.609	0.026	3.591	0.023
3.639	0.041	3.726	0.030	3.616	0.025	3.598	0.022
3.646	0.041	3.733	0.029	3.623	0.025	3.605	0.022
3.654	0.037	3.741	0.029	3.631	0.024	3.613	0.022
3.661	0.037	3.748	0.028	3.638	0.025	3.620	0.022
3.669	0.037	3.756	0.028	3.646	0.025	3.628	0.022
3.676	0.036	3.764	0.028	3.653	0.025	3.635	0.022
3.684	0.039	3.771	0.028	3.661	0.024	3.642	0.020
3.691	0.039	3.779	0.028	3.668	0.023	3.650	0.021
3.699	0.039	3.787	0.027	3.675	0.023	3.657	0.022
3.706	0.034	3.794	0.027	3.683	0.024	3.664	0.020
3.714	0.034	3.802	0.027	3.690	0.023	3.672	0.019

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.721	0.032	3.810	0.028	3.698	0.023	3.679	0.020
3.729	0.033	3.817	0.040	3.705	0.023	3.687	0.020
3.736	0.032	3.825	0.029	3.712	0.023	3.694	0.020
3.744	0.031	3.833	0.026	3.720	0.024	3.701	0.019
3.751	0.031	3.840	0.026	3.727	0.024	3.709	0.019
3.758	0.031	3.848	0.025	3.735	0.023	3.716	0.020
3.766	0.030	3.856	0.025	3.742	0.022	3.724	0.019
3.773	0.031	3.863	0.024	3.750	0.023	3.731	0.019
3.781	0.030	3.871	0.024	3.757	0.023	3.738	0.020
3.788	0.029	3.879	0.024	3.764	0.023	3.746	0.025
3.796	0.028	3.886	0.023	3.772	0.023	3.753	0.023
3.803	0.027	3.894	0.022	3.779	0.023	3.760	0.020
3.811	0.027	3.901	0.023	3.787	0.022	3.768	0.019
3.818	0.026	3.909	0.022	3.794	0.022	3.775	0.019
3.826	0.027	3.917	0.022	3.802	0.023	3.783	0.019
3.833	0.026	3.924	0.021	3.809	0.022	3.790	0.019
3.841	0.027	3.932	0.021	3.816	0.022	3.797	0.019
3.848	0.025	3.940	0.022	3.824	0.022	3.805	0.019
3.856	0.025	3.947	0.021	3.831	0.022	3.812	0.018
3.863	0.025	3.955	0.021	3.839	0.022	3.820	0.018
3.871	0.025	3.963	0.020	3.846	0.022	3.827	0.018
3.878	0.031	3.970	0.021	3.854	0.020	3.834	0.018

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.885	0.025	3.978	0.021	3.861	0.020	3.842	0.018
3.893	0.025	3.986	0.021	3.868	0.022	3.849	0.018
3.900	0.024	3.993	0.021	3.876	0.020	3.857	0.017
3.908	0.024	4.001	0.026	3.883	0.020	3.864	0.017
3.915	0.023	4.009	0.027	3.891	0.020	3.871	0.017
3.923	0.022	4.016	0.020	3.898	0.020	3.879	0.017
3.930	0.023	4.024	0.020	3.906	0.020	3.886	0.018
3.938	0.023	4.032	0.021	3.913	0.020	3.893	0.017
3.945	0.023	4.039	0.020	3.920	0.020	3.901	0.017
3.953	0.022	4.047	0.020	3.928	0.020	3.908	0.018
3.960	0.022	4.054	0.019	3.935	0.020	3.916	0.017
3.968	0.021	4.062	0.019	3.943	0.021	3.923	0.017
3.975	0.021	4.070	0.019	3.950	0.020	3.930	0.017
3.983	0.021	4.077	0.018	3.958	0.020	3.938	0.017
3.990	0.019	4.085	0.019	3.965	0.020	3.945	0.018
3.998	0.019	4.093	0.018	3.972	0.020	3.953	0.018
4.005	0.018	4.100	0.017	3.980	0.019	3.960	0.018
4.013	0.021	4.108	0.018	3.987	0.020	3.967	0.017
4.020	0.026	4.116	0.018	3.995	0.021	3.975	0.017
4.027	0.021	4.123	0.017	4.002	0.019	3.982	0.017
4.035	0.018	4.131	0.017	4.009	0.020	3.990	0.017
4.042	0.018	4.139	0.019	4.017	0.020	3.997	0.017

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.050	0.018	4.146	0.017	4.024	0.020	4.004	0.017
4.057	0.018	4.154	0.017	4.032	0.019	4.012	0.017
4.065	0.018	4.162	0.016	4.039	0.019	4.019	0.015
4.072	0.018	4.169	0.016	4.047	0.019	4.026	0.016
4.080	0.018	4.177	0.016	4.054	0.019	4.034	0.015
4.087	0.018	4.185	0.016	4.061	0.019	4.041	0.015
4.095	0.018	4.192	0.016	4.069	0.020	4.049	0.015
4.102	0.017	4.200	0.016	4.076	0.019	4.056	0.015
4.110	0.016	4.207	0.017	4.084	0.018	4.063	0.014
4.117	0.016	4.215	0.018	4.091	0.020	4.071	0.017
4.125	0.016	4.223	0.026	4.099	0.019	4.078	0.019
4.132	0.016	4.230	0.020	4.106	0.020	4.086	0.017
4.140	0.016	4.238	0.019	4.113	0.019	4.093	0.015
4.147	0.015	4.246	0.018	4.121	0.019	4.100	0.016
4.154	0.016	4.253	0.017	4.128	0.018	4.108	0.015
4.162	0.015	4.261	0.016	4.136	0.019	4.115	0.015
4.169	0.015	4.269	0.016	4.143	0.019	4.123	0.015
4.177	0.015	4.276	0.018	4.151	0.019	4.130	0.017
4.184	0.013	4.284	0.019	4.158	0.019	4.137	0.016
4.192	0.015	4.292	0.017	4.165	0.018	4.145	0.015
4.199	0.014	4.299	0.017	4.173	0.018	4.152	0.016
4.207	0.013	4.307	0.018	4.180	0.019	4.159	0.017

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.214	0.013	4.315	0.017	4.188	0.019	4.167	0.015
4.222	0.013	4.322	0.017	4.195	0.019	4.174	0.015
4.229	0.012	4.330	0.017	4.203	0.018	4.182	0.016
4.237	0.013	4.338	0.016	4.210	0.018	4.189	0.016
4.244	0.012	4.345	0.016	4.217	0.019	4.196	0.015
4.252	0.013	4.353	0.017	4.225	0.019	4.204	0.015
4.259	0.012	4.360	0.017	4.232	0.019	4.211	0.015
4.267	0.012	4.368	0.016	4.240	0.018	4.219	0.015
4.274	0.012	4.376	0.018	4.247	0.019	4.226	0.016
4.282	0.012	4.383	0.018	4.255	0.018	4.233	0.017
4.289	0.010	4.391	0.016	4.262	0.019	4.241	0.014
4.296	0.010	4.399	0.017	4.269	0.019	4.248	0.017
4.304	0.012	4.406	0.016	4.277	0.019	4.255	0.015
4.311	0.012	4.414	0.016	4.284	0.019	4.263	0.015
4.319	0.012	4.422	0.016	4.292	0.019	4.270	0.015
4.326	0.012	4.429	0.017	4.299	0.019	4.278	0.014
4.334	0.012	4.437	0.020	4.306	0.018	4.285	0.016
4.341	0.010	4.445	0.018	4.314	0.019	4.292	0.015
4.349	0.010	4.452	0.017	4.321	0.018	4.300	0.015
4.356	0.010	4.460	0.016	4.329	0.018	4.307	0.015
4.364	0.010	4.468	0.017	4.336	0.018	4.315	0.015
4.371	0.010	4.475	0.016	4.344	0.018	4.322	0.015

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.379	0.009	4.483	0.016	4.351	0.018	4.329	0.016
4.386	0.010	4.491	0.016	4.358	0.018	4.337	0.015
4.394	0.008	4.498	0.016	4.366	0.019	4.344	0.015
4.401	0.009	4.506	0.016	4.373	0.018	4.352	0.015
4.409	0.009	4.513	0.016	4.381	0.018	4.359	0.015
4.416	0.008	4.521	0.018	4.388	0.018	4.366	0.015
4.423	0.009	4.529	0.016	4.396	0.018	4.374	0.015
4.431	0.008	4.536	0.016	4.403	0.018	4.381	0.015
4.438	0.009	4.544	0.016	4.410	0.019	4.388	0.015
4.446	0.007	4.552	0.016	4.418	0.019	4.396	0.015
4.453	0.008	4.559	0.016	4.425	0.019	4.403	0.016
4.461	0.007	4.567	0.016	4.433	0.017	4.411	0.015
4.468	0.008	4.575	0.016	4.440	0.018	4.418	0.015
4.476	0.007	4.582	0.016	4.448	0.018	4.425	0.015
4.483	0.006	4.590	0.016	4.455	0.018	4.433	0.016
4.491	0.006	4.598	0.015	4.462	0.019	4.440	0.015
4.498	0.006	4.605	0.016	4.470	0.018	4.448	0.015
4.506	0.006	4.613	0.015	4.477	0.018	4.455	0.015
4.513	0.006	4.621	0.015	4.485	0.018	4.462	0.015
4.521	0.007	4.628	0.016	4.492	0.018	4.470	0.015
4.528	0.007	4.636	0.016	4.500	0.019	4.477	0.016
4.536	0.010	4.644	0.016	4.507	0.018	4.485	0.015

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.543	0.006	4.651	0.016	4.514	0.020	4.492	0.017
4.551	0.006	4.659	0.016	4.522	0.018	4.499	0.016
4.558	0.006	4.666	0.016	4.529	0.019	4.507	0.016
4.565	0.006	4.674	0.016	4.537	0.018	4.514	0.016
4.573	0.006	4.682	0.016	4.544	0.018	4.521	0.016
4.580	0.005	4.689	0.015	4.552	0.019	4.529	0.015
4.588	0.005	4.697	0.015	4.559	0.020	4.536	0.015
4.595	0.005	4.705	0.015	4.566	0.019	4.544	0.015
4.603	0.004	4.712	0.016	4.574	0.018	4.551	0.017
4.610	0.005	4.720	0.015	4.581	0.019	4.558	0.015
4.618	0.005	4.728	0.016	4.589	0.019	4.566	0.015
4.625	0.005	4.735	0.017	4.596	0.019	4.573	0.015
4.633	0.005	4.743	0.016	4.603	0.019	4.581	0.015
4.640	0.004	4.751	0.016	4.611	0.018	4.588	0.016
4.648	0.004	4.758	0.017	4.618	0.018	4.595	0.017
4.655	0.005	4.766	0.016	4.626	0.018	4.603	0.015
4.663	0.004	4.774	0.016	4.633	0.018	4.610	0.015
4.670	0.004	4.781	0.016	4.641	0.017	4.617	0.016
4.678	0.004	4.789	0.016	4.648	0.018	4.625	0.016
4.685	0.004	4.797	0.015	4.655	0.018	4.632	0.015
4.692	0.004	4.804	0.016	4.663	0.019	4.640	0.015
4.700	0.004	4.812	0.015	4.670	0.018	4.647	0.015

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.707	0.004	4.819	0.016	4.678	0.018	4.654	0.014
4.715	0.004	4.827	0.021	4.685	0.018	4.662	0.014
4.722	0.004	4.835	0.016	4.693	0.019	4.669	0.015
4.730	0.004	4.842	0.015	4.700	0.020	4.677	0.015
4.737	0.004	4.850	0.016	4.707	0.019	4.684	0.015
4.745	0.004	4.858	0.016	4.715	0.019	4.691	0.015
4.752	0.003	4.865	0.016	4.722	0.017	4.699	0.016
4.760	0.003	4.873	0.016	4.730	0.018	4.706	0.015
4.767	0.003	4.881	0.015	4.737	0.017	4.714	0.015
4.775	0.003	4.888	0.016	4.745	0.018	4.721	0.015
4.782	0.004	4.896	0.016	4.752	0.019	4.728	0.015
4.790	0.003	4.904	0.014	4.759	0.019	4.736	0.015
4.797	0.003	4.911	0.015	4.767	0.019	4.743	0.015
4.805	0.003	4.919	0.015	4.774	0.019	4.750	0.015
4.812	0.003	4.927	0.016	4.782	0.018	4.758	0.014
4.819	0.002	4.934	0.015	4.789	0.019	4.765	0.015
4.827	0.002	4.942	0.015	4.797	0.018	4.773	0.015
4.834	0.002	4.950	0.014	4.804	0.018	4.780	0.015
4.842	0.003	4.957	0.014	4.811	0.018	4.787	0.014
4.849	0.002	4.965	0.016	4.819	0.018	4.795	0.015
4.857	0.003	4.972	0.016	4.826	0.018	4.802	0.014
4.864	0.003	4.980	0.020	4.834	0.019	4.810	0.016

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.872	0.002	4.988	0.016	4.841	0.018	4.817	0.015
4.879	0.002	4.995	0.016	4.849	0.019	4.824	0.015
4.887	0.002	5.003	0.016	4.856	0.019	4.832	0.015
4.894	0.002	5.011	0.015	4.863	0.018	4.839	0.014
4.902	0.002	5.018	0.016	4.871	0.018	4.847	0.016
4.909	0.002	5.026	0.016	4.878	0.018	4.854	0.015
4.917	0.002	5.034	0.016	4.886	0.018	4.861	0.015
4.924	0.002	5.041	0.014	4.893	0.018	4.869	0.015
4.932	0.002	5.049	0.015	4.900	0.018	4.876	0.015
4.939	0.001	5.057	0.015	4.908	0.019	4.883	0.015
4.947	0.001	5.064	0.016	4.915	0.017	4.891	0.015
4.954	0.001	5.072	0.015	4.923	0.018	4.898	0.015
4.961	0.002	5.080	0.014	4.930	0.018	4.906	0.014
4.969	0.001	5.087	0.015	4.938	0.017	4.913	0.015
4.976	0.001	5.095	0.015	4.945	0.019	4.920	0.015
4.984	0.001	5.103	0.015	4.952	0.018	4.928	0.015
4.991	0.001	5.110	0.015	4.960	0.018	4.935	0.015
4.999	0.001	5.118	0.014	4.967	0.019	4.943	0.014
5.006	0.000	5.125	0.015	4.975	0.018	4.950	0.016
5.014	0.000	5.133	0.014	4.982	0.018	4.957	0.015
5.021	0.000	5.141	0.015	4.990	0.018	4.965	0.015
5.029	0.001	5.148	0.015	4.997	0.018	4.972	0.014

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.036	0.000	5.156	0.015	5.004	0.018	4.980	0.014
5.044	0.000	5.164	0.016	5.012	0.018	4.987	0.014
5.051	0.000	5.171	0.016	5.019	0.018	4.994	0.015
5.059	0.000	5.179	0.015	5.027	0.018	5.002	0.013
5.066	0.000	5.187	0.016	5.034	0.018	5.009	0.014
5.074	0.000	5.194	0.016	5.042	0.018	5.016	0.015
5.081	-0.001	5.202	0.019	5.049	0.019	5.024	0.015
5.088	-0.001	5.210	0.021	5.056	0.018	5.031	0.015
5.096	0.000	5.217	0.027	5.064	0.017	5.039	0.015
5.103	0.000	5.225	0.032	5.071	0.018	5.046	0.015
5.111	0.000	5.233	0.033	5.079	0.018	5.053	0.015
5.118	0.000	5.240	0.032	5.086	0.019	5.061	0.015
5.126	0.000	5.248	0.031	5.094	0.019	5.068	0.016
5.133	-0.001	5.256	0.051	5.101	0.018	5.076	0.014
5.141	-0.001	5.263	0.074	5.108	0.018	5.083	0.014
5.148	0.000	5.271	0.071	5.116	0.019	5.090	0.015
5.156	-0.001	5.278	0.063	5.123	0.018	5.098	0.015
5.163	0.000	5.286	0.055	5.131	0.018	5.105	0.015
5.171	-0.001	5.294	0.044	5.138	0.018	5.112	0.015
5.178	-0.001	5.301	0.034	5.146	0.018	5.120	0.015
5.186	0.000	5.309	0.027	5.153	0.018	5.127	0.014
5.193	0.000	5.317	0.019	5.160	0.018	5.135	0.014

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.201	0.000	5.324	0.014	5.168	0.018	5.142	0.014
5.208	0.001	5.332	0.010	5.175	0.018	5.149	0.014
5.216	0.000	5.340	0.007	5.183	0.017	5.157	0.014
5.223	0.001	5.347	0.005	5.190	0.018	5.164	0.014
5.230	0.000	5.355	0.003	5.197	0.018	5.172	0.014
5.238	0.001	5.363	0.003	5.205	0.018	5.179	0.014
5.245	-0.001	5.370	0.002	5.212	0.018	5.186	0.015
5.253	0.000	5.378	0.000	5.220	0.018	5.194	0.015
5.260	-0.001	5.386	0.000	5.227	0.018	5.201	0.014
5.268	-0.001	5.393	0.000	5.235	0.018	5.209	0.014
5.275	-0.001	5.401	0.000	5.242	0.017	5.216	0.014
5.283	-0.001	5.409	0.000	5.249	0.018	5.223	0.014
5.290	-0.001	5.416	0.009	5.257	0.017	5.231	0.015
5.298	-0.001	5.424	0.012	5.264	0.017	5.238	0.015
5.305	-0.001	5.431	0.004	5.272	0.017	5.245	0.015
5.313	0.000	5.439	0.001	5.279	0.017	5.253	0.014
5.320	-0.002	5.447	0.003	5.287	0.018	5.260	0.014
5.328	-0.001	5.454	0.002	5.294	0.018	5.268	0.015
5.335	-0.002	5.462	0.004	5.301	0.017	5.275	0.014
5.343	-0.003	5.470	0.004	5.309	0.018	5.282	0.015
5.350	-0.003	5.477	0.004	5.316	0.018	5.290	0.014
5.357	-0.003	5.485	0.005	5.324	0.017	5.297	0.014

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.365	-0.003	5.493	0.006	5.331	0.017	5.305	0.014
5.372	-0.003	5.500	0.008	5.339	0.017	5.312	0.013
5.380	-0.004	5.508	0.008	5.346	0.018	5.319	0.014
5.387	-0.003	5.516	0.009	5.353	0.018	5.327	0.014
5.395	-0.004	5.523	0.010	5.361	0.017	5.334	0.014
5.402	-0.004	5.531	0.011	5.368	0.017	5.342	0.012
5.410	-0.003	5.539	0.011	5.376	0.017	5.349	0.014
5.417	-0.003	5.546	0.011	5.383	0.017	5.356	0.013
5.425	-0.003	5.554	0.013	5.391	0.017	5.364	0.012
5.432	-0.004	5.562	0.013	5.398	0.017	5.371	0.012
5.440	-0.004	5.569	0.014	5.405	0.017	5.378	0.012
5.447	-0.001	5.577	0.015	5.413	0.017	5.386	0.013
5.455	-0.003	5.584	0.016	5.420	0.017	5.393	0.012
5.462	-0.003	5.592	0.016	5.428	0.017	5.401	0.013
5.470	-0.003	5.600	0.018	5.435	0.017	5.408	0.013
5.477	-0.002	5.607	0.018	5.443	0.018	5.415	0.013
5.485	-0.002	5.615	0.017	5.450	0.017	5.423	0.013
5.492	-0.003	5.623	0.018	5.457	0.017	5.430	0.013
5.499	-0.003	5.630	0.018	5.465	0.017	5.438	0.013
5.507	-0.002	5.638	0.019	5.472	0.017	5.445	0.014
5.514	-0.003	5.646	0.020	5.480	0.017	5.452	0.014
5.522	-0.003	5.653	0.020	5.487	0.017	5.460	0.014

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.529	-0.004	5.661	0.021	5.494	0.017	5.467	0.013
5.537	-0.004	5.669	0.022	5.502	0.017	5.475	0.014
5.544	-0.004	5.676	0.024	5.509	0.017	5.482	0.014
5.552	-0.004	5.684	0.023	5.517	0.017	5.489	0.013
5.559	-0.006	5.692	0.040	5.524	0.017	5.497	0.013
5.567	-0.004	5.699	0.116	5.532	0.017	5.504	0.014
5.574	-0.004	5.707	0.058	5.539	0.017	5.511	0.014
5.582	-0.004	5.715	0.049	5.546	0.017	5.519	0.014
5.589	-0.004	5.722	0.040	5.554	0.015	5.526	0.014
5.597	-0.006	5.730	0.034	5.561	0.017	5.534	0.014
5.604	-0.004	5.737	0.065	5.569	0.015	5.541	0.014
5.612	-0.004	5.745	0.080	5.576	0.017	5.548	0.013
5.619	-0.006	5.753	0.082	5.584	0.017	5.556	0.013
5.626	-0.006	5.760	0.076	5.591	0.017	5.563	0.014
5.634	-0.006	5.768	0.063	5.598	0.017	5.571	0.015
5.641	-0.006	5.776	0.050	5.606	0.016	5.578	0.014
5.649	-0.006	5.783	0.039	5.613	0.017	5.585	0.012
5.656	-0.006	5.791	0.032	5.621	0.017	5.593	0.014
5.664	-0.006	5.799	0.025	5.628	0.017	5.600	0.014
5.671	-0.006	5.806	0.023	5.636	0.015	5.607	0.013
5.679	-0.006	5.814	0.031	5.643	0.014	5.615	0.013
5.686	-0.007	5.822	0.051	5.650	0.015	5.622	0.013

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.694	-0.006	5.829	0.088	5.658	0.015	5.630	0.014
5.701	-0.006	5.837	0.116	5.665	0.017	5.637	0.014
5.709	-0.007	5.845	0.122	5.673	0.017	5.644	0.012
5.716	-0.006	5.852	0.114	5.680	0.017	5.652	0.013
5.724	-0.006	5.860	0.105	5.688	0.017	5.659	0.014
5.731	-0.007	5.868	0.096	5.695	0.015	5.667	0.014
5.739	-0.007	5.875	0.088	5.702	0.015	5.674	0.013
5.746	-0.007	5.883	0.082	5.710	0.015	5.681	0.013
5.754	-0.007	5.890	0.087	5.717	0.015	5.689	0.013
5.761	-0.008	5.898	0.090	5.725	0.015	5.696	0.014
5.768	-0.007	5.906	0.094	5.732	0.016	5.704	0.013
5.776	-0.008	5.913	0.097	5.740	0.017	5.711	0.013
5.783	-0.006	5.921	0.095	5.747	0.015	5.718	0.013
5.791	-0.008	5.929	0.114	5.754	0.016	5.726	0.014
5.798	-0.006	5.936	0.129	5.762	0.015	5.733	0.014
5.806	-0.006	5.944	0.131	5.769	0.015	5.740	0.014
5.813	-0.006	5.952	0.129	5.777	0.016	5.748	0.014
5.821	-0.006	5.959	0.121	5.784	0.015	5.755	0.015
5.828	-0.006	5.967	0.113	5.791	0.017	5.763	0.014
5.836	-0.006	5.975	0.104	5.799	0.015	5.770	0.014
5.843	-0.007	5.982	0.095	5.806	0.017	5.777	0.014
5.851	-0.007	5.990	0.089	5.814	0.015	5.785	0.014

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.858	-0.006	5.998	0.085	5.821	0.015	5.792	0.014
5.866	-0.007	6.005	0.082	5.829	0.016	5.800	0.013
5.873	-0.007	6.013	0.079	5.836	0.016	5.807	0.014
5.881	-0.007	6.021	0.084	5.843	0.015	5.814	0.014
5.888	-0.006	6.028	0.082	5.851	0.016	5.822	0.013
5.895	-0.007	6.036	0.081	5.858	0.015	5.829	0.013
5.903	-0.009	6.043	0.078	5.866	0.015	5.837	0.012
5.910	-0.009	6.051	0.075	5.873	0.015	5.844	0.013
5.918	-0.009	6.059	0.070	5.881	0.015	5.851	0.013
5.925	-0.008	6.066	0.065	5.888	0.015	5.859	0.012
5.933	-0.009	6.074	0.062	5.895	0.015	5.866	0.011
5.940	-0.009	6.082	0.060	5.903	0.015	5.873	0.013
5.948	-0.008	6.089	0.059	5.910	0.016	5.881	0.014
5.955	-0.009	6.097	0.059	5.918	0.015	5.888	0.012
5.963	-0.009	6.105	0.057	5.925	0.015	5.896	0.014
5.970	-0.009	6.112	0.055	5.933	0.015	5.903	0.014
5.978	-0.009	6.120	0.054	5.940	0.016	5.910	0.014
5.985	-0.009	6.128	0.052	5.947	0.016	5.918	0.013
5.993	-0.008	6.135	0.049	5.955	0.014	5.925	0.014
6.000	-0.009	6.143	0.056	5.962	0.015	5.933	0.014
6.008	-0.009	6.151	0.058	5.970	0.014	5.940	0.014
6.015	-0.009	6.158	0.060	5.977	0.015	5.947	0.014

Table A2. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
6.023	-0.008	6.166	0.062	5.985	0.015	5.955	0.014
6.030	-0.007	6.174	0.063	5.992	0.016	5.962	0.014
6.037	-0.009	6.181	0.064	5.999	0.015	5.969	0.017
6.045	-0.009	6.189	0.063	6.007	0.015	5.977	0.016

Table A3. **Breakthrough concentrations of the tet^R and tet^S *E.coli* strains at 12% of soil moisture content and under ionic strength condition of 10 mM NaCl. Where, PV is the pore volume of the sand packed column at 12% of soil moisture content and C/Co is the normalized breakthrough concentrations.**

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.008	-0.001	0.007	0.000	0.007	0.000	0.007	0.001
0.015	-0.002	0.015	-0.001	0.015	-0.001	0.015	0.001
0.023	-0.002	0.022	0.000	0.022	0.000	0.022	0.000
0.030	-0.004	0.030	-0.001	0.029	-0.001	0.030	0.000
0.038	-0.004	0.037	0.000	0.037	-0.001	0.037	0.001
0.046	-0.004	0.044	-0.001	0.044	0.000	0.045	0.001
0.053	-0.005	0.052	-0.001	0.052	0.000	0.052	0.001
0.061	-0.005	0.059	-0.001	0.059	0.000	0.060	0.001
0.068	-0.005	0.067	-0.001	0.066	-0.001	0.067	0.001
0.076	-0.004	0.074	-0.001	0.074	0.000	0.075	0.000
0.084	-0.005	0.081	-0.003	0.081	-0.002	0.082	0.002
0.091	-0.004	0.089	-0.003	0.088	-0.001	0.090	0.002

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.099	-0.005	0.096	-0.003	0.096	-0.002	0.097	0.001
0.106	-0.005	0.104	-0.003	0.103	-0.001	0.105	0.001
0.114	-0.005	0.111	-0.003	0.111	-0.002	0.112	0.001
0.122	-0.005	0.118	-0.003	0.118	-0.002	0.120	0.000
0.129	-0.005	0.126	-0.003	0.125	-0.001	0.127	0.002
0.137	-0.004	0.133	-0.003	0.133	-0.002	0.135	0.001
0.144	-0.004	0.141	-0.003	0.140	-0.001	0.142	0.001
0.152	-0.004	0.148	-0.003	0.147	-0.002	0.150	0.000
0.160	-0.005	0.155	-0.003	0.155	-0.002	0.157	0.001
0.167	-0.005	0.163	-0.003	0.162	-0.003	0.165	0.001
0.175	-0.006	0.170	-0.003	0.170	-0.003	0.172	0.001
0.182	-0.006	0.178	-0.003	0.177	-0.002	0.180	0.001
0.190	-0.006	0.185	-0.004	0.184	-0.004	0.187	0.001
0.198	-0.006	0.192	-0.004	0.192	-0.004	0.195	0.001
0.205	-0.005	0.200	-0.004	0.199	-0.004	0.202	0.001
0.213	-0.006	0.207	-0.004	0.206	-0.004	0.210	0.001
0.220	-0.006	0.215	-0.004	0.214	-0.003	0.217	0.001
0.228	-0.006	0.222	-0.004	0.221	-0.004	0.225	0.001
0.236	-0.005	0.229	-0.004	0.228	-0.004	0.232	0.001
0.243	-0.006	0.237	-0.003	0.236	-0.004	0.240	0.001
0.251	-0.006	0.244	-0.003	0.243	-0.004	0.247	0.002
0.258	-0.005	0.252	-0.004	0.251	-0.004	0.255	0.002

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.266	-0.006	0.259	-0.003	0.258	-0.004	0.262	0.001
0.274	-0.008	0.266	-0.001	0.265	-0.004	0.270	0.002
0.281	-0.006	0.274	-0.001	0.273	-0.004	0.277	0.002
0.289	-0.007	0.281	-0.001	0.280	-0.004	0.285	0.003
0.296	-0.006	0.289	-0.001	0.287	-0.004	0.292	0.003
0.304	-0.006	0.296	-0.001	0.295	-0.004	0.300	0.002
0.312	-0.006	0.303	-0.001	0.302	-0.004	0.307	0.004
0.319	-0.005	0.311	-0.001	0.310	-0.004	0.315	0.003
0.327	-0.005	0.318	-0.001	0.317	-0.004	0.322	0.004
0.334	-0.005	0.326	-0.001	0.324	-0.004	0.330	0.003
0.342	-0.006	0.333	-0.001	0.332	-0.002	0.337	0.004
0.350	-0.007	0.340	-0.003	0.339	-0.003	0.345	0.004
0.357	-0.007	0.348	-0.001	0.346	-0.004	0.352	0.004
0.365	-0.006	0.355	-0.003	0.354	-0.003	0.360	0.004
0.372	-0.007	0.363	-0.003	0.361	-0.004	0.367	0.004
0.380	-0.006	0.370	-0.004	0.369	-0.004	0.375	0.004
0.388	-0.005	0.377	-0.003	0.376	-0.002	0.382	0.004
0.395	-0.006	0.385	-0.004	0.383	-0.001	0.390	0.004
0.403	-0.006	0.392	-0.003	0.391	-0.001	0.397	0.004
0.410	-0.006	0.400	-0.003	0.398	0.000	0.405	0.004
0.418	-0.006	0.407	-0.004	0.405	-0.002	0.412	0.004
0.426	-0.007	0.414	-0.003	0.413	-0.002	0.420	0.005

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.433	-0.005	0.422	-0.003	0.420	-0.001	0.427	0.004
0.441	-0.006	0.429	-0.004	0.427	-0.001	0.435	0.004
0.448	-0.006	0.437	-0.003	0.435	-0.002	0.442	0.004
0.456	-0.007	0.444	-0.003	0.442	-0.002	0.450	0.005
0.464	-0.006	0.451	-0.003	0.450	-0.002	0.457	0.005
0.471	-0.006	0.459	-0.003	0.457	-0.001	0.465	0.006
0.479	-0.005	0.466	-0.004	0.464	-0.001	0.472	0.005
0.486	-0.006	0.474	-0.003	0.472	-0.001	0.480	0.005
0.494	-0.005	0.481	-0.004	0.479	-0.002	0.487	0.007
0.502	-0.006	0.488	-0.004	0.486	-0.003	0.495	0.005
0.509	-0.006	0.496	-0.003	0.494	-0.001	0.502	0.005
0.517	-0.005	0.503	-0.004	0.501	-0.001	0.510	0.007
0.524	-0.005	0.511	-0.003	0.509	-0.002	0.517	0.006
0.532	-0.005	0.518	-0.003	0.516	-0.001	0.525	0.007
0.540	-0.005	0.525	-0.003	0.523	-0.002	0.532	0.007
0.547	-0.005	0.533	-0.001	0.531	-0.001	0.540	0.006
0.555	-0.005	0.540	-0.003	0.538	-0.001	0.547	0.007
0.562	-0.005	0.548	-0.003	0.545	-0.001	0.555	0.007
0.570	-0.004	0.555	-0.003	0.553	-0.001	0.562	0.007
0.578	-0.004	0.562	-0.003	0.560	-0.001	0.570	0.007
0.585	-0.005	0.570	-0.003	0.568	-0.001	0.577	0.007
0.593	-0.003	0.577	-0.004	0.575	-0.001	0.585	0.007

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.600	-0.003	0.585	-0.004	0.582	-0.001	0.592	0.007
0.608	-0.004	0.592	-0.003	0.590	-0.002	0.600	0.007
0.616	-0.004	0.599	-0.003	0.597	-0.002	0.607	0.008
0.623	-0.004	0.607	-0.003	0.604	-0.002	0.615	0.008
0.631	-0.004	0.614	-0.004	0.612	-0.002	0.622	0.009
0.638	-0.004	0.622	-0.003	0.619	-0.001	0.630	0.009
0.646	-0.004	0.629	-0.003	0.626	0.000	0.637	0.010
0.654	-0.004	0.636	-0.003	0.634	-0.001	0.645	0.009
0.661	-0.004	0.644	-0.003	0.641	-0.001	0.652	0.010
0.669	-0.003	0.651	-0.004	0.649	0.000	0.660	0.009
0.676	-0.004	0.659	-0.003	0.656	0.000	0.667	0.010
0.684	-0.004	0.666	-0.003	0.663	0.000	0.675	0.012
0.692	-0.004	0.673	-0.003	0.671	0.000	0.682	0.012
0.699	-0.004	0.681	-0.003	0.678	0.000	0.690	0.012
0.707	-0.002	0.688	-0.004	0.685	0.000	0.697	0.012
0.714	-0.002	0.696	-0.003	0.693	0.001	0.705	0.012
0.722	-0.002	0.703	-0.003	0.700	0.000	0.712	0.013
0.730	-0.001	0.710	-0.003	0.708	0.001	0.720	0.013
0.737	-0.001	0.718	-0.001	0.715	0.002	0.727	0.014
0.745	-0.002	0.725	-0.003	0.722	0.001	0.735	0.015
0.752	-0.001	0.733	0.000	0.730	0.002	0.742	0.014
0.760	-0.001	0.740	0.000	0.737	0.001	0.750	0.015

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.768	0.000	0.747	0.000	0.744	0.002	0.757	0.016
0.775	0.001	0.755	-0.001	0.752	0.004	0.765	0.016
0.783	0.001	0.762	0.000	0.759	0.002	0.772	0.016
0.790	0.002	0.770	0.001	0.767	0.002	0.780	0.018
0.798	0.005	0.777	0.001	0.774	0.002	0.787	0.017
0.806	0.005	0.784	0.002	0.781	0.002	0.795	0.019
0.813	0.005	0.792	0.003	0.789	0.002	0.802	0.019
0.821	0.006	0.799	0.003	0.796	0.004	0.810	0.020
0.828	0.008	0.807	0.004	0.803	0.004	0.817	0.020
0.836	0.009	0.814	0.005	0.811	0.005	0.825	0.020
0.844	0.011	0.821	0.007	0.818	0.005	0.832	0.021
0.851	0.013	0.829	0.010	0.825	0.006	0.840	0.022
0.859	0.016	0.836	0.010	0.833	0.006	0.847	0.022
0.866	0.016	0.844	0.011	0.840	0.007	0.855	0.022
0.874	0.018	0.851	0.012	0.848	0.007	0.862	0.023
0.882	0.019	0.858	0.014	0.855	0.008	0.870	0.023
0.889	0.021	0.866	0.016	0.862	0.009	0.877	0.024
0.897	0.023	0.873	0.017	0.870	0.009	0.885	0.023
0.904	0.026	0.881	0.017	0.877	0.010	0.892	0.025
0.912	0.028	0.888	0.019	0.884	0.010	0.900	0.025
0.919	0.029	0.895	0.020	0.892	0.010	0.907	0.025
0.927	0.031	0.903	0.022	0.899	0.011	0.915	0.026

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.935	0.033	0.910	0.023	0.907	0.011	0.922	0.026
0.942	0.036	0.918	0.025	0.914	0.010	0.930	0.026
0.950	0.039	0.925	0.026	0.921	0.010	0.937	0.027
0.957	0.041	0.932	0.029	0.929	0.012	0.945	0.028
0.965	0.045	0.940	0.030	0.936	0.013	0.952	0.028
0.973	0.045	0.947	0.031	0.943	0.013	0.960	0.028
0.980	0.047	0.955	0.033	0.951	0.013	0.967	0.029
0.988	0.050	0.962	0.036	0.958	0.013	0.975	0.030
0.995	0.052	0.969	0.037	0.966	0.014	0.982	0.028
1.003	0.055	0.977	0.038	0.973	0.015	0.990	0.030
1.011	0.060	0.984	0.041	0.980	0.015	0.997	0.031
1.018	0.061	0.992	0.043	0.988	0.017	1.005	0.029
1.026	0.065	0.999	0.044	0.995	0.017	1.012	0.029
1.033	0.067	1.006	0.047	1.002	0.018	1.020	0.031
1.041	0.068	1.014	0.048	1.010	0.019	1.027	0.030
1.049	0.085	1.021	0.049	1.017	0.020	1.035	0.031
1.056	0.090	1.029	0.052	1.024	0.020	1.042	0.031
1.064	0.088	1.036	0.053	1.032	0.021	1.050	0.031
1.071	0.073	1.043	0.056	1.039	0.021	1.057	0.031
1.079	0.075	1.051	0.057	1.047	0.022	1.065	0.033
1.087	0.076	1.058	0.059	1.054	0.024	1.072	0.033
1.094	0.080	1.066	0.060	1.061	0.024	1.080	0.031

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.102	0.085	1.073	0.066	1.069	0.024	1.087	0.033
1.109	0.090	1.080	0.076	1.076	0.025	1.095	0.033
1.117	0.090	1.088	0.086	1.083	0.025	1.102	0.033
1.125	0.093	1.095	0.082	1.091	0.025	1.110	0.033
1.132	0.094	1.103	0.076	1.098	0.026	1.117	0.034
1.140	0.095	1.110	0.075	1.106	0.027	1.125	0.034
1.147	0.097	1.117	0.075	1.113	0.027	1.132	0.034
1.155	0.097	1.125	0.074	1.120	0.035	1.140	0.034
1.163	0.099	1.132	0.075	1.128	0.046	1.147	0.034
1.170	0.099	1.140	0.078	1.135	0.038	1.155	0.035
1.178	0.102	1.147	0.079	1.142	0.032	1.162	0.034
1.185	0.104	1.154	0.081	1.150	0.031	1.170	0.035
1.193	0.109	1.162	0.086	1.157	0.029	1.177	0.034
1.201	0.112	1.169	0.086	1.165	0.031	1.185	0.034
1.208	0.115	1.177	0.087	1.172	0.030	1.192	0.034
1.216	0.113	1.184	0.089	1.179	0.031	1.200	0.032
1.223	0.113	1.191	0.091	1.187	0.032	1.207	0.034
1.231	0.117	1.199	0.094	1.194	0.032	1.215	0.035
1.239	0.117	1.206	0.100	1.201	0.033	1.222	0.035
1.246	0.121	1.214	0.108	1.209	0.033	1.230	0.035
1.254	0.119	1.221	0.108	1.216	0.035	1.237	0.036
1.261	0.125	1.228	0.109	1.223	0.035	1.245	0.035

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.269	0.125	1.236	0.110	1.231	0.034	1.252	0.036
1.277	0.164	1.243	0.112	1.238	0.034	1.260	0.036
1.284	0.179	1.251	0.112	1.246	0.034	1.267	0.036
1.292	0.195	1.258	0.113	1.253	0.035	1.275	0.036
1.299	0.126	1.265	0.117	1.260	0.035	1.282	0.036
1.307	0.127	1.273	0.118	1.268	0.037	1.290	0.037
1.315	0.128	1.280	0.112	1.275	0.035	1.297	0.038
1.322	0.131	1.288	0.099	1.282	0.037	1.305	0.036
1.330	0.132	1.295	0.094	1.290	0.037	1.312	0.038
1.337	0.132	1.302	0.175	1.297	0.038	1.320	0.038
1.345	0.134	1.310	0.232	1.305	0.038	1.327	0.039
1.353	0.134	1.317	0.146	1.312	0.038	1.335	0.039
1.360	0.134	1.325	0.168	1.319	0.039	1.342	0.038
1.368	0.135	1.332	0.167	1.327	0.039	1.350	0.039
1.375	0.137	1.339	0.184	1.334	0.040	1.357	0.039
1.383	0.137	1.347	0.172	1.341	0.040	1.365	0.039
1.391	0.139	1.354	0.158	1.349	0.039	1.372	0.038
1.398	0.141	1.362	0.150	1.356	0.040	1.380	0.039
1.406	0.143	1.369	0.142	1.364	0.040	1.387	0.039
1.413	0.142	1.376	0.138	1.371	0.042	1.395	0.039
1.421	0.142	1.384	0.132	1.378	0.041	1.402	0.039
1.429	0.145	1.391	0.130	1.386	0.043	1.410	0.040

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.436	0.146	1.399	0.124	1.393	0.042	1.417	0.041
1.444	0.150	1.406	0.118	1.400	0.042	1.425	0.041
1.451	0.201	1.413	0.112	1.408	0.042	1.432	0.041
1.459	0.248	1.421	0.114	1.415	0.045	1.440	0.040
1.467	0.222	1.428	0.122	1.422	0.044	1.447	0.042
1.474	0.154	1.436	0.122	1.430	0.046	1.455	0.041
1.482	0.147	1.443	0.122	1.437	0.046	1.462	0.041
1.489	0.149	1.450	0.125	1.445	0.046	1.470	0.041
1.497	0.150	1.458	0.127	1.452	0.046	1.477	0.044
1.505	0.150	1.465	0.128	1.459	0.046	1.485	0.045
1.512	0.151	1.473	0.130	1.467	0.047	1.492	0.045
1.520	0.152	1.480	0.135	1.474	0.047	1.500	0.045
1.527	0.153	1.487	0.139	1.481	0.047	1.507	0.046
1.535	0.155	1.495	0.143	1.489	0.048	1.515	0.044
1.543	0.155	1.502	0.147	1.496	0.047	1.522	0.045
1.550	0.153	1.510	0.150	1.504	0.048	1.530	0.046
1.558	0.152	1.517	0.149	1.511	0.048	1.537	0.046
1.565	0.152	1.524	0.146	1.518	0.049	1.545	0.046
1.573	0.153	1.532	0.146	1.526	0.049	1.552	0.046
1.581	0.153	1.539	0.141	1.533	0.050	1.560	0.046
1.588	0.156	1.547	0.138	1.540	0.050	1.567	0.039
1.596	0.161	1.554	0.138	1.548	0.050	1.575	0.034

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.603	0.164	1.561	0.138	1.555	0.051	1.582	0.034
1.611	0.166	1.569	0.138	1.563	0.050	1.590	0.045
1.619	0.168	1.576	0.139	1.570	0.050	1.597	0.047
1.626	0.168	1.584	0.140	1.577	0.050	1.605	0.046
1.634	0.169	1.591	0.141	1.585	0.052	1.612	0.046
1.641	0.170	1.598	0.144	1.592	0.052	1.620	0.047
1.649	0.170	1.606	0.148	1.599	0.051	1.627	0.047
1.657	0.170	1.613	0.145	1.607	0.052	1.635	0.048
1.664	0.173	1.621	0.144	1.614	0.052	1.642	0.047
1.672	0.170	1.628	0.144	1.621	0.052	1.650	0.048
1.679	0.214	1.635	0.147	1.629	0.052	1.657	0.047
1.687	0.251	1.643	0.148	1.636	0.053	1.665	0.047
1.695	0.328	1.650	0.151	1.644	0.055	1.672	0.047
1.702	0.182	1.658	0.153	1.651	0.054	1.680	0.047
1.710	0.174	1.665	0.151	1.658	0.054	1.687	0.047
1.717	0.183	1.672	0.151	1.666	0.053	1.695	0.047
1.725	0.184	1.680	0.154	1.673	0.055	1.702	0.047
1.733	0.183	1.687	0.156	1.680	0.055	1.710	0.046
1.740	0.179	1.695	0.158	1.688	0.055	1.717	0.047
1.748	0.176	1.702	0.159	1.695	0.054	1.725	0.047
1.755	0.174	1.709	0.158	1.703	0.055	1.732	0.047
1.763	0.172	1.717	0.158	1.710	0.054	1.740	0.048

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.771	0.170	1.724	0.158	1.717	0.056	1.747	0.049
1.778	0.170	1.732	0.158	1.725	0.055	1.755	0.048
1.786	0.169	1.739	0.158	1.732	0.055	1.762	0.049
1.793	0.168	1.746	0.159	1.739	0.054	1.770	0.047
1.801	0.169	1.754	0.160	1.747	0.055	1.777	0.048
1.809	0.166	1.761	0.160	1.754	0.056	1.785	0.048
1.816	0.166	1.769	0.161	1.762	0.065	1.792	0.048
1.824	0.168	1.776	0.157	1.769	0.086	1.800	0.049
1.831	0.166	1.783	0.156	1.776	0.074	1.807	0.049
1.839	0.165	1.791	0.160	1.784	0.059	1.815	0.048
1.847	0.167	1.798	0.162	1.791	0.057	1.822	0.049
1.854	0.168	1.806	0.162	1.798	0.058	1.830	0.048
1.862	0.143	1.813	0.164	1.806	0.058	1.837	0.049
1.869	0.150	1.820	0.166	1.813	0.059	1.845	0.049
1.877	0.194	1.828	0.168	1.820	0.060	1.852	0.049
1.885	0.184	1.835	0.171	1.828	0.060	1.860	0.049
1.892	0.180	1.843	0.172	1.835	0.061	1.867	0.048
1.900	0.178	1.850	0.174	1.843	0.062	1.875	0.048
1.907	0.178	1.857	0.175	1.850	0.062	1.882	0.049
1.915	0.176	1.865	0.176	1.857	0.062	1.890	0.048
1.923	0.175	1.872	0.179	1.865	0.062	1.897	0.050
1.930	0.174	1.880	0.182	1.872	0.062	1.905	0.049

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.938	0.174	1.887	0.180	1.879	0.063	1.912	0.051
1.945	0.172	1.894	0.182	1.887	0.062	1.920	0.049
1.953	0.170	1.902	0.182	1.894	0.063	1.927	0.051
1.961	0.170	1.909	0.183	1.902	0.064	1.935	0.051
1.968	0.170	1.917	0.186	1.909	0.066	1.942	0.049
1.976	0.170	1.924	0.183	1.916	0.066	1.950	0.050
1.983	0.170	1.931	0.185	1.924	0.066	1.957	0.050
1.991	0.170	1.939	0.185	1.931	0.065	1.965	0.049
1.999	0.168	1.946	0.178	1.938	0.067	1.972	0.049
2.006	0.171	1.954	0.174	1.946	0.067	1.980	0.049
2.014	0.171	1.961	0.174	1.953	0.066	1.987	0.050
2.021	0.171	1.968	0.174	1.961	0.067	1.995	0.050
2.029	0.170	1.976	0.178	1.968	0.068	2.002	0.047
2.037	0.170	1.983	0.178	1.975	0.065	2.010	0.047
2.044	0.169	1.991	0.179	1.983	0.064	2.017	0.048
2.052	0.170	1.998	0.180	1.990	0.065	2.025	0.048
2.059	0.169	2.005	0.183	1.997	0.065	2.032	0.050
2.067	0.170	2.013	0.186	2.005	0.064	2.040	0.050
2.075	0.170	2.020	0.189	2.012	0.064	2.047	0.051
2.082	0.170	2.028	0.186	2.019	0.066	2.055	0.050
2.090	0.170	2.035	0.193	2.027	0.066	2.062	0.050
2.097	0.158	2.042	0.194	2.034	0.066	2.070	0.051

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.105	0.139	2.050	0.198	2.042	0.066	2.077	0.051
2.113	0.178	2.057	0.188	2.049	0.067	2.085	0.051
2.120	0.185	2.065	0.186	2.056	0.068	2.092	0.052
2.128	0.182	2.072	0.185	2.064	0.068	2.100	0.051
2.135	0.183	2.079	0.186	2.071	0.068	2.107	0.052
2.143	0.184	2.087	0.187	2.078	0.068	2.115	0.052
2.151	0.180	2.094	0.191	2.086	0.068	2.122	0.052
2.158	0.180	2.102	0.188	2.093	0.069	2.130	0.052
2.166	0.178	2.109	0.172	2.101	0.070	2.137	0.057
2.173	0.177	2.116	0.169	2.108	0.068	2.145	0.057
2.181	0.175	2.124	0.171	2.115	0.072	2.152	0.057
2.189	0.175	2.131	0.175	2.123	0.072	2.160	0.059
2.196	0.174	2.139	0.175	2.130	0.072	2.167	0.057
2.204	0.173	2.146	0.176	2.137	0.072	2.175	0.057
2.211	0.175	2.153	0.178	2.145	0.073	2.182	0.059
2.219	0.173	2.161	0.180	2.152	0.074	2.190	0.057
2.227	0.176	2.168	0.181	2.160	0.074	2.197	0.059
2.234	0.173	2.176	0.182	2.167	0.075	2.205	0.059
2.242	0.170	2.183	0.185	2.174	0.075	2.212	0.060
2.249	0.169	2.190	0.189	2.182	0.076	2.220	0.059
2.257	0.169	2.198	0.195	2.189	0.076	2.227	0.060
2.265	0.170	2.205	0.193	2.196	0.076	2.235	0.059

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.272	0.170	2.213	0.193	2.204	0.077	2.242	0.060
2.280	0.172	2.220	0.185	2.211	0.078	2.250	0.061
2.287	0.164	2.227	0.183	2.218	0.078	2.257	0.061
2.295	0.202	2.235	0.184	2.226	0.077	2.265	0.061
2.303	0.197	2.242	0.183	2.233	0.078	2.272	0.060
2.310	0.190	2.250	0.186	2.241	0.076	2.280	0.061
2.318	0.185	2.257	0.186	2.248	0.078	2.287	0.061
2.325	0.186	2.265	0.186	2.255	0.079	2.295	0.061
2.333	0.186	2.272	0.186	2.263	0.077	2.302	0.063
2.341	0.186	2.279	0.184	2.270	0.078	2.310	0.061
2.348	0.186	2.287	0.175	2.277	0.078	2.317	0.062
2.356	0.185	2.294	0.172	2.285	0.079	2.325	0.061
2.363	0.185	2.302	0.175	2.292	0.079	2.332	0.061
2.371	0.184	2.309	0.176	2.300	0.080	2.340	0.062
2.379	0.184	2.316	0.173	2.307	0.080	2.347	0.061
2.386	0.183	2.324	0.176	2.314	0.081	2.355	0.061
2.394	0.182	2.331	0.180	2.322	0.081	2.362	0.062
2.401	0.184	2.339	0.179	2.329	0.081	2.370	0.063
2.409	0.184	2.346	0.183	2.336	0.081	2.377	0.063
2.417	0.183	2.353	0.183	2.344	0.081	2.385	0.063
2.424	0.185	2.361	0.185	2.351	0.081	2.392	0.063
2.432	0.185	2.368	0.186	2.359	0.081	2.400	0.064

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.439	0.186	2.376	0.186	2.366	0.081	2.407	0.064
2.447	0.188	2.383	0.186	2.373	0.081	2.415	0.063
2.455	0.190	2.390	0.187	2.381	0.078	2.422	0.063
2.462	0.195	2.398	0.188	2.388	0.078	2.430	0.061
2.470	0.229	2.405	0.190	2.395	0.081	2.437	0.062
2.477	0.214	2.413	0.188	2.403	0.081	2.445	0.061
2.485	0.199	2.420	0.188	2.410	0.080	2.452	0.061
2.493	0.195	2.427	0.190	2.418	0.080	2.460	0.062
2.500	0.193	2.435	0.189	2.425	0.077	2.467	0.061
2.508	0.193	2.442	0.191	2.432	0.079	2.475	0.061
2.515	0.193	2.450	0.193	2.440	0.080	2.482	0.062
2.523	0.191	2.457	0.191	2.447	0.082	2.490	0.063
2.531	0.191	2.464	0.192	2.454	0.081	2.497	0.064
2.538	0.190	2.472	0.192	2.462	0.081	2.505	0.063
2.546	0.190	2.479	0.192	2.469	0.082	2.512	0.064
2.553	0.185	2.487	0.191	2.476	0.082	2.520	0.064
2.561	0.183	2.494	0.192	2.484	0.082	2.527	0.063
2.569	0.182	2.501	0.193	2.491	0.082	2.535	0.064
2.576	0.183	2.509	0.193	2.499	0.084	2.542	0.063
2.584	0.185	2.516	0.193	2.506	0.085	2.550	0.065
2.591	0.187	2.524	0.193	2.513	0.082	2.557	0.063
2.599	0.188	2.531	0.191	2.521	0.082	2.565	0.064

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.607	0.186	2.538	0.198	2.528	0.081	2.572	0.064
2.614	0.188	2.546	0.239	2.535	0.081	2.580	0.065
2.622	0.188	2.553	0.326	2.543	0.081	2.587	0.065
2.629	0.197	2.561	0.195	2.550	0.085	2.595	0.064
2.637	0.212	2.568	0.191	2.558	0.085	2.602	0.064
2.645	0.219	2.575	0.192	2.565	0.085	2.610	0.065
2.652	0.192	2.583	0.192	2.572	0.085	2.617	0.062
2.660	0.188	2.590	0.195	2.580	0.085	2.625	0.063
2.667	0.185	2.598	0.194	2.587	0.083	2.632	0.061
2.675	0.184	2.605	0.194	2.594	0.083	2.640	0.063
2.683	0.183	2.612	0.198	2.602	0.083	2.647	0.061
2.690	0.180	2.620	0.201	2.609	0.083	2.655	0.061
2.698	0.181	2.627	0.203	2.617	0.082	2.662	0.060
2.705	0.178	2.635	0.203	2.624	0.083	2.670	0.061
2.713	0.175	2.642	0.201	2.631	0.081	2.677	0.060
2.721	0.172	2.649	0.202	2.639	0.083	2.685	0.059
2.728	0.173	2.657	0.197	2.646	0.081	2.692	0.059
2.736	0.170	2.664	0.197	2.653	0.080	2.700	0.057
2.743	0.170	2.672	0.193	2.661	0.079	2.707	0.057
2.751	0.170	2.679	0.193	2.668	0.079	2.715	0.057
2.758	0.168	2.686	0.191	2.675	0.079	2.722	0.056
2.766	0.165	2.694	0.190	2.683	0.078	2.730	0.055

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.774	0.162	2.701	0.190	2.690	0.077	2.737	0.053
2.781	0.160	2.709	0.189	2.698	0.077	2.745	0.052
2.789	0.160	2.716	0.188	2.705	0.076	2.752	0.052
2.796	0.157	2.723	0.186	2.712	0.075	2.760	0.050
2.804	0.156	2.731	0.185	2.720	0.074	2.767	0.049
2.812	0.166	2.738	0.184	2.727	0.067	2.775	0.049
2.819	0.197	2.746	0.182	2.734	0.086	2.782	0.047
2.827	0.171	2.753	0.182	2.742	0.067	2.790	0.046
2.834	0.147	2.760	0.182	2.749	0.068	2.797	0.046
2.842	0.144	2.768	0.179	2.757	0.066	2.805	0.044
2.850	0.140	2.775	0.178	2.764	0.068	2.812	0.043
2.857	0.141	2.783	0.178	2.771	0.067	2.820	0.043
2.865	0.139	2.790	0.177	2.779	0.064	2.827	0.041
2.872	0.137	2.797	0.175	2.786	0.064	2.835	0.040
2.880	0.134	2.805	0.173	2.793	0.062	2.842	0.033
2.888	0.131	2.812	0.172	2.801	0.063	2.850	0.034
2.895	0.129	2.820	0.171	2.808	0.061	2.857	0.029
2.903	0.125	2.827	0.170	2.816	0.061	2.865	0.038
2.910	0.122	2.834	0.170	2.823	0.058	2.872	0.038
2.918	0.121	2.842	0.168	2.830	0.058	2.880	0.038
2.926	0.119	2.849	0.170	2.838	0.057	2.887	0.038
2.933	0.117	2.857	0.168	2.845	0.055	2.895	0.036

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.941	0.115	2.864	0.168	2.852	0.055	2.902	0.038
2.948	0.113	2.871	0.165	2.860	0.053	2.910	0.036
2.956	0.111	2.879	0.164	2.867	0.052	2.917	0.035
2.964	0.109	2.886	0.164	2.874	0.053	2.925	0.034
2.971	0.107	2.894	0.162	2.882	0.051	2.932	0.033
2.979	0.105	2.901	0.162	2.889	0.051	2.940	0.031
2.986	0.104	2.908	0.160	2.897	0.049	2.947	0.031
2.994	0.109	2.916	0.158	2.904	0.050	2.955	0.030
3.002	0.107	2.923	0.156	2.911	0.048	2.962	0.028
3.009	0.160	2.931	0.155	2.919	0.047	2.970	0.028
3.017	0.111	2.938	0.153	2.926	0.046	2.977	0.027
3.024	0.097	2.945	0.152	2.933	0.046	2.985	0.027
3.032	0.094	2.953	0.151	2.941	0.045	2.992	0.025
3.040	0.093	2.960	0.150	2.948	0.045	3.000	0.024
3.047	0.091	2.968	0.148	2.956	0.043	3.007	0.023
3.055	0.090	2.975	0.147	2.963	0.043	3.015	0.022
3.062	0.088	2.982	0.146	2.970	0.042	3.022	0.023
3.070	0.087	2.990	0.144	2.978	0.042	3.030	0.020
3.078	0.084	2.997	0.142	2.985	0.041	3.037	0.020
3.085	0.083	3.005	0.142	2.992	0.040	3.045	0.020
3.093	0.081	3.012	0.140	3.000	0.038	3.052	0.019
3.100	0.080	3.019	0.138	3.007	0.038	3.060	0.018

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.108	0.079	3.027	0.136	3.015	0.038	3.067	0.018
3.116	0.078	3.034	0.135	3.022	0.037	3.075	0.018
3.123	0.077	3.042	0.135	3.029	0.037	3.082	0.018
3.131	0.075	3.049	0.132	3.037	0.037	3.090	0.017
3.138	0.073	3.056	0.132	3.044	0.035	3.097	0.018
3.146	0.072	3.064	0.130	3.051	0.035	3.105	0.016
3.154	0.072	3.071	0.130	3.059	0.035	3.112	0.016
3.161	0.071	3.079	0.128	3.066	0.034	3.120	0.016
3.169	0.069	3.086	0.126	3.073	0.033	3.127	0.015
3.176	0.069	3.093	0.125	3.081	0.033	3.135	0.014
3.184	0.068	3.101	0.124	3.088	0.032	3.142	0.014
3.192	0.067	3.108	0.122	3.096	0.032	3.150	0.015
3.199	0.066	3.116	0.122	3.103	0.032	3.157	0.016
3.207	0.069	3.123	0.120	3.110	0.032	3.165	0.014
3.214	0.072	3.130	0.118	3.118	0.030	3.172	0.012
3.222	0.109	3.138	0.118	3.125	0.031	3.180	0.010
3.230	0.071	3.145	0.118	3.132	0.030	3.187	0.007
3.237	0.064	3.153	0.116	3.140	0.030	3.195	0.005
3.245	0.062	3.160	0.114	3.147	0.031	3.202	0.004
3.252	0.060	3.167	0.112	3.155	0.028	3.210	0.004
3.260	0.060	3.175	0.112	3.162	0.029	3.217	0.005
3.268	0.059	3.182	0.110	3.169	0.029	3.225	0.005

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.275	0.060	3.190	0.109	3.177	0.028	3.232	0.006
3.283	0.057	3.197	0.108	3.184	0.029	3.240	0.009
3.290	0.056	3.204	0.108	3.191	0.028	3.247	0.008
3.298	0.054	3.212	0.106	3.199	0.027	3.255	0.009
3.306	0.054	3.219	0.106	3.206	0.027	3.262	0.010
3.313	0.053	3.227	0.104	3.214	0.026	3.270	0.010
3.321	0.052	3.234	0.102	3.221	0.026	3.277	0.010
3.328	0.052	3.241	0.102	3.228	0.026	3.285	0.010
3.336	0.052	3.249	0.101	3.236	0.026	3.292	0.010
3.344	0.050	3.256	0.100	3.243	0.025	3.300	0.010
3.351	0.050	3.264	0.099	3.250	0.025	3.307	0.011
3.359	0.049	3.271	0.098	3.258	0.025	3.315	0.012
3.366	0.049	3.278	0.098	3.265	0.025	3.322	0.011
3.374	0.048	3.286	0.096	3.272	0.025	3.330	0.011
3.382	0.046	3.293	0.095	3.280	0.024	3.337	0.010
3.389	0.047	3.301	0.094	3.287	0.023	3.345	0.010
3.397	0.047	3.308	0.093	3.295	0.023	3.352	0.010
3.404	0.045	3.315	0.093	3.302	0.023	3.360	0.010
3.412	0.046	3.323	0.092	3.309	0.023	3.367	0.010
3.420	0.046	3.330	0.091	3.317	0.023	3.375	0.009
3.427	0.067	3.338	0.091	3.324	0.022	3.382	0.010
3.435	0.048	3.345	0.088	3.331	0.021	3.390	0.010

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.442	0.044	3.352	0.088	3.339	0.021	3.397	0.010
3.450	0.043	3.360	0.088	3.346	0.020	3.405	0.010
3.458	0.041	3.367	0.087	3.354	0.020	3.412	0.010
3.465	0.042	3.375	0.087	3.361	0.020	3.420	0.010
3.473	0.041	3.382	0.086	3.368	0.020	3.427	0.010
3.480	0.040	3.389	0.086	3.376	0.020	3.435	0.010
3.488	0.040	3.397	0.085	3.383	0.020	3.442	0.009
3.496	0.039	3.404	0.084	3.390	0.019	3.450	0.009
3.503	0.038	3.412	0.084	3.398	0.020	3.457	0.009
3.511	0.037	3.419	0.083	3.405	0.019	3.465	0.009
3.518	0.036	3.426	0.083	3.413	0.019	3.472	0.009
3.526	0.036	3.434	0.080	3.420	0.019	3.480	0.009
3.534	0.034	3.441	0.081	3.427	0.019	3.487	0.009
3.541	0.034	3.449	0.080	3.435	0.019	3.495	0.009
3.549	0.035	3.456	0.078	3.442	0.019	3.502	0.008
3.556	0.034	3.463	0.078	3.449	0.019	3.510	0.008
3.564	0.033	3.471	0.078	3.457	0.018	3.517	0.009
3.572	0.033	3.478	0.078	3.464	0.018	3.525	0.008
3.579	0.032	3.486	0.075	3.471	0.017	3.532	0.008
3.587	0.034	3.493	0.075	3.479	0.017	3.540	0.007
3.594	0.034	3.500	0.075	3.486	0.019	3.547	0.008
3.602	0.038	3.508	0.074	3.494	0.017	3.555	0.008

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.610	0.032	3.515	0.074	3.501	0.017	3.562	0.007
3.617	0.031	3.523	0.074	3.508	0.017	3.570	0.008
3.625	0.031	3.530	0.073	3.516	0.017	3.577	0.007
3.632	0.031	3.537	0.072	3.523	0.015	3.585	0.007
3.640	0.030	3.545	0.072	3.530	0.017	3.592	0.008
3.648	0.030	3.552	0.070	3.538	0.017	3.600	0.007
3.655	0.030	3.560	0.071	3.545	0.016	3.607	0.007
3.663	0.028	3.567	0.071	3.553	0.017	3.615	0.007
3.670	0.028	3.574	0.071	3.560	0.015	3.622	0.008
3.678	0.028	3.582	0.070	3.567	0.017	3.630	0.008
3.686	0.026	3.589	0.070	3.575	0.015	3.637	0.007
3.693	0.028	3.597	0.070	3.582	0.015	3.645	0.009
3.701	0.026	3.604	0.070	3.589	0.015	3.652	0.010
3.708	0.026	3.611	0.070	3.597	0.015	3.660	0.010
3.716	0.025	3.619	0.071	3.604	0.015	3.667	0.012
3.724	0.024	3.626	0.071	3.612	0.015	3.675	0.010
3.731	0.025	3.634	0.071	3.619	0.014	3.682	0.010
3.739	0.024	3.641	0.072	3.626	0.014	3.690	0.010
3.746	0.024	3.648	0.070	3.634	0.015	3.697	0.010
3.754	0.024	3.656	0.070	3.641	0.014	3.705	0.010
3.762	0.024	3.663	0.068	3.648	0.014	3.712	0.009
3.769	0.024	3.671	0.067	3.656	0.014	3.720	0.012

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.777	0.024	3.678	0.066	3.663	0.014	3.727	0.009
3.784	0.030	3.685	0.065	3.670	0.014	3.735	0.009
3.792	0.023	3.693	0.066	3.678	0.013	3.742	0.009
3.800	0.021	3.700	0.065	3.685	0.014	3.749	0.010
3.807	0.022	3.708	0.064	3.693	0.013	3.757	0.009
3.815	0.021	3.715	0.063	3.700	0.014	3.764	0.008
3.822	0.021	3.722	0.063	3.707	0.012	3.772	0.008
3.830	0.021	3.730	0.063	3.715	0.013	3.779	0.008
3.838	0.021	3.737	0.061	3.722	0.013	3.787	0.007
3.845	0.021	3.745	0.061	3.729	0.013	3.794	0.007
3.853	0.020	3.752	0.061	3.737	0.012	3.802	0.006
3.860	0.020	3.759	0.060	3.744	0.013	3.809	0.007
3.868	0.019	3.767	0.059	3.752	0.012	3.817	0.007
3.876	0.019	3.774	0.059	3.759	0.012	3.824	0.007
3.883	0.019	3.782	0.058	3.766	0.012	3.832	0.005
3.891	0.019	3.789	0.057	3.774	0.012	3.839	0.006
3.898	0.018	3.796	0.057	3.781	0.012	3.847	0.005
3.906	0.018	3.804	0.057	3.788	0.012	3.854	0.005
3.914	0.019	3.811	0.056	3.796	0.012	3.862	0.005
3.921	0.016	3.819	0.056	3.803	0.012	3.869	0.007
3.929	0.017	3.826	0.055	3.811	0.011	3.877	0.007
3.936	0.017	3.833	0.055	3.818	0.012	3.884	0.005

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.944	0.017	3.841	0.056	3.825	0.012	3.892	0.005
3.952	0.017	3.848	0.055	3.833	0.011	3.899	0.007
3.959	0.016	3.856	0.055	3.840	0.011	3.907	0.007
3.967	0.016	3.863	0.054	3.847	0.011	3.914	0.007
3.974	0.016	3.870	0.054	3.855	0.012	3.922	0.008
3.982	0.016	3.878	0.053	3.862	0.011	3.929	0.005
3.990	0.016	3.885	0.053	3.869	0.011	3.937	0.004
3.997	0.016	3.893	0.052	3.877	0.010	3.944	0.004
4.005	0.016	3.900	0.052	3.884	0.010	3.952	0.006
4.012	0.025	3.907	0.052	3.892	0.010	3.959	0.005
4.020	0.017	3.915	0.051	3.899	0.010	3.967	0.005
4.028	0.016	3.922	0.051	3.906	0.010	3.974	0.005
4.035	0.015	3.930	0.051	3.914	0.010	3.982	0.007
4.043	0.015	3.937	0.051	3.921	0.010	3.989	0.005
4.050	0.016	3.944	0.051	3.928	0.010	3.997	0.012
4.058	0.014	3.952	0.049	3.936	0.010	4.004	0.009
4.066	0.014	3.959	0.049	3.943	0.010	4.012	0.005
4.073	0.014	3.967	0.049	3.951	0.011	4.019	0.038
4.081	0.015	3.974	0.049	3.958	0.011	4.027	0.004
4.088	0.014	3.981	0.049	3.965	0.010	4.034	0.020
4.096	0.013	3.989	0.047	3.973	0.011	4.042	0.015
4.104	0.014	3.996	0.048	3.980	0.010	4.049	0.012

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.111	0.014	4.004	0.047	3.987	0.010	4.057	0.011
4.119	0.013	4.011	0.046	3.995	0.010	4.064	0.010
4.126	0.013	4.018	0.046	4.002	0.011	4.072	0.008
4.134	0.013	4.026	0.046	4.010	0.010	4.079	0.007
4.142	0.013	4.033	0.046	4.017	0.010	4.087	0.007
4.149	0.013	4.041	0.045	4.024	0.012	4.094	0.007
4.157	0.013	4.048	0.045	4.032	0.010	4.102	0.007
4.164	0.017	4.055	0.045	4.039	0.010	4.109	0.008
4.172	0.013	4.063	0.047	4.046	0.010	4.117	0.008
4.180	0.013	4.070	0.057	4.054	0.010	4.124	0.008
4.187	0.013	4.078	0.046	4.061	0.010	4.132	0.009
4.195	0.012	4.085	0.044	4.068	0.010	4.139	0.008
4.202	0.011	4.092	0.045	4.076	0.010	4.147	0.009
4.210	0.011	4.100	0.043	4.083	0.010	4.154	0.010
4.218	0.013	4.107	0.043	4.091	0.010	4.162	0.010
4.225	0.011	4.115	0.043	4.098	0.010	4.169	0.012
4.233	0.011	4.122	0.043	4.105	0.010	4.177	0.013
4.240	0.011	4.129	0.042	4.113	0.010	4.184	0.016
4.248	0.011	4.137	0.041	4.120	0.010	4.192	0.014
4.256	0.011	4.144	0.041	4.127	0.010	4.199	0.016
4.263	0.010	4.152	0.041	4.135	0.010	4.207	0.014
4.271	0.010	4.159	0.042	4.142	0.010	4.214	0.013

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.278	0.010	4.166	0.041	4.150	0.010	4.222	0.014
4.286	0.010	4.174	0.041	4.157	0.010	4.229	0.014
4.294	0.011	4.181	0.041	4.164	0.010	4.237	0.015
4.301	0.010	4.189	0.041	4.172	0.009	4.244	0.014
4.309	0.010	4.196	0.040	4.179	0.009	4.252	0.013
4.316	0.010	4.203	0.040	4.186	0.010	4.259	0.015
4.324	0.010	4.211	0.041	4.194	0.010	4.267	0.013
4.332	0.009	4.218	0.040	4.201	0.010	4.274	0.013
4.339	0.009	4.226	0.038	4.209	0.010	4.282	0.013
4.347	0.010	4.233	0.039	4.216	0.010	4.289	0.012
4.354	0.010	4.240	0.038	4.223	0.009	4.297	0.012
4.362	0.012	4.248	0.038	4.231	0.010	4.304	0.013
4.370	0.010	4.255	0.038	4.238	0.010	4.312	0.012
4.377	0.009	4.263	0.038	4.245	0.010	4.319	0.012
4.385	0.008	4.270	0.038	4.253	0.010	4.327	0.012
4.392	0.009	4.277	0.038	4.260	0.010	4.334	0.012
4.400	0.009	4.285	0.038	4.267	0.010	4.342	0.010
4.408	0.009	4.292	0.037	4.275	0.010	4.349	0.009
4.415	0.008	4.300	0.038	4.282	0.009	4.357	0.009
4.423	0.009	4.307	0.036	4.290	0.010	4.364	0.009
4.430	0.008	4.314	0.037	4.297	0.010	4.372	0.010
4.438	0.008	4.322	0.036	4.304	0.010	4.379	0.009

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.446	0.008	4.329	0.036	4.312	0.009	4.387	0.008
4.453	0.008	4.337	0.036	4.319	0.010	4.394	0.008
4.461	0.008	4.344	0.036	4.326	0.010	4.402	0.008
4.468	0.008	4.351	0.035	4.334	0.009	4.409	0.008
4.476	0.008	4.359	0.035	4.341	0.010	4.417	0.009
4.484	0.008	4.366	0.036	4.349	0.010	4.424	0.008
4.491	0.008	4.374	0.034	4.356	0.010	4.432	0.008
4.499	0.008	4.381	0.035	4.363	0.010	4.439	0.013
4.506	0.008	4.388	0.034	4.371	0.010	4.447	0.011
4.514	0.008	4.396	0.033	4.378	0.010	4.454	0.009
4.522	0.006	4.403	0.033	4.385	0.010	4.462	0.009
4.529	0.008	4.411	0.033	4.393	0.010	4.469	0.009
4.537	0.008	4.418	0.033	4.400	0.009	4.477	0.012
4.544	0.006	4.425	0.032	4.408	0.010	4.484	0.010
4.552	0.006	4.433	0.034	4.415	0.009	4.492	0.011
4.559	0.008	4.440	0.033	4.422	0.010	4.499	0.012
4.567	0.008	4.448	0.033	4.430	0.009	4.507	0.012
4.575	0.008	4.455	0.032	4.437	0.009	4.514	0.012
4.582	0.009	4.462	0.033	4.444	0.010	4.522	0.010
4.590	0.010	4.470	0.031	4.452	0.009	4.529	0.010
4.597	0.006	4.477	0.033	4.459	0.010	4.537	0.010
4.605	0.008	4.485	0.032	4.466	0.010	4.544	0.009

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.613	0.006	4.492	0.032	4.474	0.009	4.552	0.007
4.620	0.008	4.499	0.031	4.481	0.009	4.559	0.001
4.628	0.008	4.507	0.031	4.489	0.009	4.567	0.001
4.635	0.008	4.514	0.031	4.496	0.010	4.574	0.001
4.643	0.008	4.522	0.031	4.503	0.010	4.582	0.001
4.651	0.006	4.529	0.031	4.511	0.008	4.589	0.003
4.658	0.008	4.536	0.030	4.518	0.009	4.597	0.004
4.666	0.006	4.544	0.033	4.525	0.009	4.604	0.004
4.673	0.006	4.551	0.031	4.533	0.009	4.612	0.004
4.681	0.006	4.559	0.030	4.540	0.009	4.619	0.004
4.689	0.006	4.566	0.030	4.548	0.009	4.627	0.004
4.696	0.006	4.573	0.031	4.555	0.010	4.634	0.004
4.704	0.006	4.581	0.029	4.562	0.009	4.642	0.004
4.711	0.008	4.588	0.029	4.570	0.009	4.649	0.004
4.719	0.006	4.596	0.030	4.577	0.009	4.657	0.005
4.727	0.006	4.603	0.029	4.584	0.009	4.664	0.005
4.734	0.008	4.610	0.028	4.592	0.009	4.672	0.005
4.742	0.006	4.618	0.030	4.599	0.008	4.679	0.005
4.749	0.006	4.625	0.029	4.607	0.009	4.687	0.004
4.757	0.006	4.633	0.029	4.614	0.008	4.694	0.004
4.765	0.006	4.640	0.029	4.621	0.009	4.702	0.004
4.772	0.006	4.647	0.029	4.629	0.008	4.709	0.004

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.780	0.006	4.655	0.028	4.636	0.009	4.717	0.003
4.787	0.008	4.662	0.029	4.643	0.010	4.724	0.004
4.795	0.006	4.670	0.029	4.651	0.009	4.732	0.005
4.803	0.008	4.677	0.028	4.658	0.009	4.739	0.005
4.810	0.006	4.684	0.028	4.665	0.008	4.747	0.006
4.818	0.006	4.692	0.029	4.673	0.009	4.754	0.004
4.825	0.006	4.699	0.028	4.680	0.008	4.762	0.003
4.833	0.006	4.707	0.028	4.688	0.009	4.769	0.008
4.841	0.006	4.714	0.028	4.695	0.009	4.777	0.003
4.848	0.006	4.721	0.028	4.702	0.009	4.784	0.004
4.856	0.006	4.729	0.027	4.710	0.009	4.792	0.004
4.863	0.006	4.736	0.027	4.717	0.009	4.799	0.004
4.871	0.006	4.744	0.026	4.724	0.008	4.807	0.004
4.879	0.006	4.751	0.027	4.732	0.009	4.814	0.004
4.886	0.008	4.758	0.026	4.739	0.009	4.822	0.004
4.894	0.006	4.766	0.027	4.747	0.010	4.829	0.004
4.901	0.006	4.773	0.025	4.754	0.009	4.837	0.004
4.909	0.006	4.781	0.026	4.761	0.009	4.844	0.002
4.917	0.006	4.788	0.026	4.769	0.009	4.852	0.002
4.924	0.006	4.795	0.025	4.776	0.008	4.859	0.002
4.932	0.005	4.803	0.026	4.783	0.009	4.867	0.002
4.939	0.006	4.810	0.026	4.791	0.008	4.874	0.004

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.947	0.005	4.818	0.026	4.798	0.008	4.882	0.002
4.955	0.005	4.825	0.026	4.806	0.009	4.889	0.002
4.962	0.006	4.832	0.025	4.813	0.008	4.897	0.003
4.970	0.005	4.840	0.025	4.820	0.009	4.904	0.003
4.977	0.006	4.847	0.025	4.828	0.009	4.912	0.004
4.985	0.006	4.855	0.025	4.835	0.008	4.919	0.002
4.993	0.006	4.862	0.025	4.842	0.009	4.927	0.002
5.000	0.011	4.869	0.025	4.850	0.009	4.934	0.004
5.008	0.006	4.877	0.025	4.857	0.009	4.942	0.002
5.015	0.006	4.884	0.025	4.864	0.009	4.949	0.002
5.023	0.006	4.892	0.025	4.872	0.008	4.957	0.002
5.031	0.006	4.899	0.025	4.879	0.007	4.964	0.002
5.038	0.006	4.906	0.025	4.887	0.009	4.972	0.002
5.046	0.008	4.914	0.025	4.894	0.008	4.979	0.004
5.053	0.006	4.921	0.023	4.901	0.009	4.987	0.002
5.061	0.006	4.929	0.025	4.909	0.008	4.994	0.001
5.069	0.006	4.936	0.025	4.916	0.009	5.002	0.001
5.076	0.006	4.943	0.024	4.923	0.008	5.009	0.001
5.084	0.005	4.951	0.023	4.931	0.008	5.017	0.004
5.091	0.005	4.958	0.023	4.938	0.008	5.024	0.001
5.099	0.005	4.966	0.023	4.946	0.009	5.032	0.001
5.107	0.005	4.973	0.024	4.953	0.009	5.039	0.003

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.114	0.005	4.980	0.023	4.960	0.008	5.047	0.002
5.122	0.005	4.988	0.023	4.968	0.007	5.054	0.002
5.129	0.005	4.995	0.023	4.975	0.009	5.062	0.000
5.137	0.005	5.003	0.023	4.982	0.008	5.069	-0.001
5.145	0.004	5.010	0.023	4.990	0.008	5.077	-0.001
5.152	0.006	5.017	0.023	4.997	0.009	5.084	-0.001
5.160	0.005	5.025	0.023	5.005	0.009	5.092	0.000
5.167	0.006	5.032	0.023	5.012	0.009	5.099	0.000
5.175	0.006	5.040	0.023	5.019	0.007	5.107	-0.002
5.183	0.005	5.047	0.021	5.027	0.009	5.114	0.119
5.190	0.005	5.054	0.023	5.034	0.009	5.122	0.000
5.198	0.004	5.062	0.022	5.041	0.009	5.129	-0.003
5.205	0.005	5.069	0.021	5.049	0.007	5.137	-0.003
5.213	0.005	5.077	0.021	5.056	0.009	5.144	-0.002
5.221	0.005	5.084	0.021	5.063	0.009	5.152	-0.003
5.228	0.004	5.091	0.021	5.071	0.009	5.159	-0.003
5.236	0.004	5.099	0.021	5.078	0.009	5.167	-0.003
5.243	0.004	5.106	0.021	5.086	0.009	5.174	-0.003
5.251	0.004	5.114	0.021	5.093	0.010	5.182	-0.002
5.259	0.004	5.121	0.021	5.100	0.010	5.189	-0.001
5.266	0.005	5.128	0.021	5.108	0.009	5.197	0.001
5.274	0.004	5.136	0.021	5.115	0.009	5.204	0.000

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.281	0.004	5.143	0.021	5.122	0.007	5.212	-0.001
5.289	0.004	5.151	0.021	5.130	0.008	5.219	0.004
5.297	0.004	5.158	0.020	5.137	0.009	5.227	-0.003
5.304	0.004	5.165	0.021	5.145	0.009	5.234	-0.001
5.312	0.004	5.173	0.020	5.152	0.008	5.242	-0.002
5.319	0.004	5.180	0.020	5.159	0.008	5.249	0.000
5.327	0.004	5.188	0.020	5.167	0.007	5.257	-0.001
5.335	0.003	5.195	0.020	5.174	0.009	5.264	0.000
5.342	0.003	5.202	0.020	5.181	0.009	5.272	0.000
5.350	0.005	5.210	0.020	5.189	0.008	5.279	0.000
5.357	0.004	5.217	0.021	5.196	0.009	5.287	0.001
5.365	0.006	5.225	0.020	5.204	0.008	5.294	0.001
5.373	0.004	5.232	0.019	5.211	0.007	5.302	-0.001
5.380	0.004	5.239	0.019	5.218	0.008	5.309	0.000
5.388	0.003	5.247	0.020	5.226	0.008	5.317	0.004
5.395	0.004	5.254	0.021	5.233	0.009	5.324	0.001
5.403	0.004	5.262	0.023	5.240	0.008	5.332	-0.001
5.411	0.004	5.269	0.020	5.248	0.007	5.339	-0.003
5.418	0.003	5.276	0.019	5.255	0.008	5.347	-0.002
5.426	0.004	5.284	0.019	5.262	0.007	5.354	-0.002
5.433	0.004	5.291	0.019	5.270	0.007	5.362	-0.003
5.441	0.004	5.299	0.019	5.277	0.008	5.369	-0.001

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.449	0.004	5.306	0.019	5.285	0.008	5.377	-0.001
5.456	0.004	5.313	0.021	5.292	0.008	5.384	0.000
5.464	0.005	5.321	0.019	5.299	0.008	5.392	0.000
5.471	0.005	5.328	0.020	5.307	0.007	5.399	0.000
5.479	0.004	5.336	0.020	5.314	0.008	5.407	-0.001
5.487	0.004	5.343	0.019	5.321	0.008	5.414	0.000
5.494	0.003	5.350	0.020	5.329	0.008	5.422	0.000
5.502	0.004	5.358	0.019	5.336	0.009	5.429	0.000
5.509	0.003	5.365	0.019	5.344	0.009	5.437	0.001
5.517	0.004	5.373	0.019	5.351	0.008	5.444	0.000
5.525	0.004	5.380	0.019	5.358	0.009	5.452	0.001
5.532	0.004	5.387	0.019	5.366	0.008	5.459	-0.001
5.540	0.004	5.395	0.019	5.373	0.008	5.467	0.000
5.547	0.004	5.402	0.019	5.380	0.007	5.474	-0.001
5.555	0.004	5.410	0.019	5.388	0.008	5.482	-0.002
5.563	0.004	5.417	0.018	5.395	0.008	5.489	-0.002
5.570	0.003	5.424	0.018	5.403	0.010	5.497	-0.002
5.578	0.004	5.432	0.018	5.410	0.009	5.504	-0.001
5.585	0.004	5.439	0.019	5.417	0.009	5.512	0.000
5.593	0.005	5.447	0.017	5.425	0.009	5.519	0.001
5.601	0.004	5.454	0.018	5.432	0.007	5.527	-0.002
5.608	0.004	5.461	0.017	5.439	0.009	5.534	-0.001

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.616	0.003	5.469	0.017	5.447	0.008	5.542	-0.001
5.623	0.004	5.476	0.017	5.454	0.009	5.549	-0.003
5.631	0.004	5.484	0.017	5.461	0.007	5.557	-0.004
5.639	0.005	5.491	0.018	5.469	0.008	5.564	-0.002
5.646	0.004	5.498	0.017	5.476	0.008	5.572	-0.003
5.654	0.003	5.506	0.019	5.484	0.007	5.579	-0.003
5.661	0.003	5.513	0.017	5.491	0.008	5.587	-0.004
5.669	0.003	5.521	0.017	5.498	0.009	5.594	-0.003
5.677	0.003	5.528	0.017	5.506	0.008	5.602	-0.002
5.684	0.003	5.535	0.017	5.513	0.008	5.609	-0.002
5.692	0.003	5.543	0.017	5.520	0.008	5.617	-0.001
5.699	0.005	5.550	0.017	5.528	0.007	5.624	-0.002
5.707	0.003	5.558	0.017	5.535	0.008	5.632	-0.002
5.715	0.003	5.565	0.017	5.543	0.007	5.639	-0.001
5.722	0.003	5.572	0.017	5.550	0.008	5.647	0.000
5.730	0.003	5.580	0.017	5.557	0.008	5.654	-0.002
5.737	0.003	5.587	0.017	5.565	0.010	5.662	0.000
5.745	0.003	5.595	0.017	5.572	0.008	5.669	0.000
5.753	0.003	5.602	0.017	5.579	0.007	5.677	-0.001
5.760	0.004	5.609	0.017	5.587	0.009	5.684	-0.001
5.768	0.003	5.617	0.016	5.594	0.007	5.692	-0.003
5.775	0.004	5.624	0.017	5.602	0.008	5.699	-0.003

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.783	0.004	5.632	0.017	5.609	0.008	5.707	-0.001
5.791	0.004	5.639	0.017	5.616	0.009	5.714	-0.003
5.798	0.003	5.646	0.017	5.624	0.009	5.722	-0.003
5.806	0.004	5.654	0.017	5.631	0.007	5.729	-0.003
5.813	0.004	5.661	0.017	5.638	0.007	5.737	-0.001
5.821	0.005	5.669	0.017	5.646	0.008	5.744	-0.001
5.829	0.005	5.676	0.017	5.653	0.007	5.752	-0.001
5.836	0.004	5.683	0.015	5.660	0.007	5.759	0.000
5.844	0.008	5.691	0.016	5.668	0.008	5.767	-0.001
5.851	0.004	5.698	0.016	5.675	0.008	5.774	-0.001
5.859	0.004	5.706	0.016	5.683	0.007	5.782	-0.003
5.867	0.004	5.713	0.017	5.690	0.008	5.789	-0.003
5.874	0.003	5.720	0.016	5.697	0.009	5.797	-0.003
5.882	0.003	5.728	0.016	5.705	0.008	5.804	-0.004
5.889	0.004	5.735	0.015	5.712	0.007	5.812	-0.003
5.897	0.004	5.743	0.017	5.719	0.008	5.819	-0.003
5.905	0.004	5.750	0.015	5.727	0.008	5.827	-0.002
5.912	0.004	5.757	0.016	5.734	0.008	5.834	-0.001
5.920	0.004	5.765	0.016	5.742	0.008	5.842	-0.002
5.927	0.004	5.772	0.015	5.749	0.009	5.849	-0.003
5.935	0.004	5.780	0.017	5.756	0.008	5.857	-0.001
5.943	0.004	5.787	0.015	5.764	0.009	5.864	-0.001

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.950	0.003	5.794	0.016	5.771	0.009	5.872	-0.002
5.958	0.003	5.802	0.015	5.778	0.008	5.879	-0.003
5.965	0.003	5.809	0.015	5.786	0.008	5.887	-0.003
5.973	0.003	5.817	0.015	5.793	0.008	5.894	-0.003
5.981	0.003	5.824	0.015	5.801	0.009	5.902	-0.004
5.988	0.003	5.831	0.015	5.808	0.008	5.909	-0.003
5.996	0.003	5.839	0.015	5.815	0.009	5.917	-0.004
6.003	0.003	5.846	0.015	5.823	0.009	5.924	-0.004
6.011	0.003	5.854	0.015	5.830	0.009	5.932	-0.003
6.019	0.003	5.861	0.015	5.837	0.009	5.939	-0.002
6.026	0.003	5.868	0.015	5.845	0.007	5.947	-0.001
6.034	0.003	5.876	0.014	5.852	0.009	5.954	-0.001
6.041	0.003	5.883	0.015	5.859	0.008	5.962	-0.002
6.049	0.003	5.891	0.013	5.867	0.009	5.969	-0.003
6.057	0.003	5.898	0.015	5.874	0.009	5.977	-0.003
6.064	0.004	5.905	0.015	5.882	0.007	5.984	-0.003
6.072	0.004	5.913	0.015	5.889	0.008	5.992	-0.003
6.079	0.004	5.920	0.015	5.896	0.009	5.999	-0.004
6.087	0.005	5.928	0.015	5.904	0.009	6.007	-0.003
6.095	0.005	5.935	0.015	5.911	0.008	6.014	-0.003
6.102	0.005	5.942	0.014	5.918	0.008	6.022	-0.002
6.110	0.004	5.950	0.014	5.926	0.008	6.029	-0.003

Table A3. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
6.117	0.004	5.957	0.015	5.933	0.007	6.037	-0.002
6.125	0.005	5.965	0.014	5.941	0.009	6.044	-0.001
6.133	0.005	5.972	0.014	5.948	0.008	6.052	0.000
6.140	0.004	5.979	0.014	5.955	0.009	6.059	0.000
6.148	0.004	5.987	0.014	5.963	0.008	6.067	0.000
6.155	0.005	5.994	0.013	5.970	0.008	6.074	-0.003
6.163	0.004	6.002	0.013	5.977	0.008	6.082	-0.003
6.171	0.005	6.009	0.013	5.985	0.009	6.089	-0.003
6.178	0.005	6.016	0.013	5.992	0.007	6.097	-0.004
6.186	0.005	6.024	0.013	6.000	0.008	6.104	-0.004

Table A4. **Breakthrough concentrations of the tet^R and tet^S *E.coli* strains at 25% of soil moisture content under ionic strength condition of 1 mM NaCl. Where, PV is the pore volume of the sand packed column at 25% of soil moisture content and C/Co is the normalized breakthrough concentrations.**

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.000	0.002	0.000	0.000	0.000	0.002	0.000	0.017
0.012	0.002	0.012	0.000	0.012	0.002	0.012	0.017
0.024	0.002	0.024	0.000	0.024	0.000	0.024	0.017
0.036	0.002	0.036	0.000	0.036	0.000	0.037	0.016
0.048	0.007	0.048	0.000	0.049	0.001	0.049	0.015
0.060	0.007	0.060	0.001	0.061	0.002	0.061	0.015

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.072	0.007	0.072	0.001	0.073	0.000	0.073	0.014
0.084	0.006	0.083	-0.001	0.085	0.000	0.085	0.015
0.096	0.006	0.095	0.000	0.097	0.000	0.098	0.014
0.108	0.006	0.107	0.004	0.109	-0.001	0.110	0.014
0.120	0.007	0.119	0.003	0.122	-0.001	0.122	0.012
0.132	0.006	0.131	0.002	0.134	-0.001	0.134	0.011
0.144	0.007	0.143	0.003	0.146	-0.001	0.146	0.010
0.156	0.005	0.155	0.002	0.158	-0.002	0.159	0.011
0.168	0.005	0.167	0.001	0.170	-0.002	0.171	0.010
0.180	0.003	0.179	0.000	0.182	-0.001	0.183	0.008
0.192	0.003	0.191	0.000	0.194	0.000	0.195	0.007
0.204	0.003	0.203	0.000	0.207	-0.002	0.207	0.007
0.216	0.004	0.215	-0.001	0.219	-0.001	0.220	0.007
0.228	0.005	0.227	0.000	0.231	-0.001	0.232	0.006
0.240	0.004	0.238	-0.001	0.243	-0.001	0.244	0.005
0.252	0.003	0.250	-0.001	0.255	-0.002	0.256	0.006
0.264	0.005	0.262	-0.001	0.267	-0.001	0.268	0.005
0.276	0.004	0.274	-0.001	0.280	-0.001	0.281	0.005
0.288	0.005	0.286	-0.001	0.292	-0.001	0.293	0.005
0.300	0.004	0.298	-0.002	0.304	-0.001	0.305	0.004
0.312	0.002	0.310	-0.001	0.316	-0.002	0.317	0.004
0.324	0.002	0.322	-0.002	0.328	-0.002	0.330	0.002

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.335	0.002	0.334	-0.002	0.340	-0.002	0.342	0.002
0.347	0.001	0.346	-0.002	0.352	-0.001	0.354	0.004
0.359	0.001	0.358	-0.002	0.365	-0.003	0.366	0.004
0.371	0.004	0.370	-0.002	0.377	-0.003	0.378	0.002
0.383	0.003	0.381	-0.002	0.389	-0.001	0.391	0.002
0.395	0.002	0.393	-0.002	0.401	-0.001	0.403	0.002
0.407	0.003	0.405	-0.002	0.413	-0.003	0.415	0.002
0.419	0.002	0.417	-0.002	0.425	-0.003	0.427	0.002
0.431	0.003	0.429	-0.004	0.438	-0.002	0.439	0.002
0.443	0.002	0.441	-0.002	0.450	-0.001	0.452	0.001
0.455	0.002	0.453	-0.002	0.462	-0.003	0.464	0.001
0.467	0.001	0.465	-0.004	0.474	-0.003	0.476	0.001
0.479	0.001	0.477	-0.004	0.486	-0.003	0.488	0.000
0.491	0.000	0.489	-0.004	0.498	0.001	0.500	0.000
0.503	0.002	0.501	-0.004	0.511	-0.003	0.513	0.001
0.515	0.002	0.513	-0.004	0.523	-0.003	0.525	0.001
0.527	0.001	0.525	-0.004	0.535	-0.001	0.537	0.000
0.539	0.000	0.536	-0.004	0.547	-0.002	0.549	0.001
0.551	-0.001	0.548	-0.004	0.559	-0.001	0.561	0.002
0.563	-0.001	0.560	-0.001	0.571	-0.003	0.574	0.002
0.575	0.000	0.572	-0.002	0.583	-0.001	0.586	0.004
0.587	-0.001	0.584	-0.001	0.596	0.002	0.598	0.005

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.599	0.000	0.596	0.000	0.608	0.002	0.610	0.006
0.611	0.000	0.608	0.002	0.620	0.005	0.622	0.010
0.623	0.000	0.620	0.004	0.632	0.009	0.635	0.011
0.635	0.002	0.632	0.006	0.644	0.012	0.647	0.014
0.647	0.003	0.644	0.011	0.656	0.017	0.659	0.016
0.659	0.005	0.656	0.014	0.669	0.024	0.671	0.020
0.671	0.009	0.668	0.019	0.681	0.029	0.683	0.026
0.683	0.013	0.680	0.026	0.693	0.037	0.696	0.029
0.695	0.016	0.691	0.031	0.705	0.042	0.708	0.034
0.707	0.021	0.703	0.034	0.717	0.051	0.720	0.039
0.719	0.025	0.715	0.042	0.729	0.057	0.732	0.045
0.731	0.029	0.727	0.049	0.741	0.065	0.744	0.051
0.743	0.035	0.739	0.055	0.754	0.076	0.757	0.056
0.755	0.041	0.751	0.064	0.766	0.087	0.769	0.063
0.767	0.048	0.763	0.072	0.778	0.096	0.781	0.071
0.779	0.055	0.775	0.080	0.790	0.107	0.793	0.078
0.791	0.062	0.787	0.088	0.802	0.117	0.805	0.086
0.803	0.069	0.799	0.096	0.814	0.127	0.818	0.092
0.815	0.077	0.811	0.105	0.827	0.139	0.830	0.101
0.827	0.083	0.823	0.113	0.839	0.147	0.842	0.105
0.839	0.091	0.835	0.119	0.851	0.157	0.854	0.117
0.851	0.098	0.846	0.128	0.863	0.170	0.866	0.124

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.863	0.105	0.858	0.134	0.875	0.176	0.879	0.132
0.875	0.099	0.870	0.141	0.887	0.186	0.891	0.140
0.887	0.127	0.882	0.148	0.899	0.196	0.903	0.145
0.899	0.134	0.894	0.158	0.912	0.207	0.915	0.155
0.911	0.140	0.906	0.169	0.924	0.216	0.927	0.164
0.923	0.146	0.918	0.181	0.936	0.224	0.940	0.171
0.935	0.151	0.930	0.186	0.948	0.231	0.952	0.180
0.947	0.161	0.942	0.189	0.960	0.246	0.964	0.186
0.959	0.166	0.954	0.179	0.972	0.247	0.976	0.198
0.971	0.173	0.966	0.205	0.985	0.252	0.989	0.202
0.982	0.180	0.978	0.210	0.997	0.260	1.001	0.212
0.994	0.188	0.989	0.210	1.009	0.269	1.013	0.222
1.006	0.194	1.001	0.217	1.021	0.276	1.025	0.229
1.018	0.201	1.013	0.222	1.033	0.280	1.037	0.236
1.030	0.205	1.025	0.226	1.045	0.288	1.050	0.244
1.042	0.211	1.037	0.233	1.057	0.295	1.062	0.249
1.054	0.216	1.049	0.236	1.070	0.298	1.074	0.261
1.066	0.221	1.061	0.240	1.082	0.305	1.086	0.267
1.078	0.227	1.073	0.245	1.094	0.309	1.098	0.279
1.090	0.233	1.085	0.249	1.106	0.315	1.111	0.282
1.102	0.240	1.097	0.256	1.118	0.322	1.123	0.276
1.114	0.242	1.109	0.257	1.130	0.326	1.135	0.301

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.126	0.246	1.121	0.263	1.143	0.331	1.147	0.305
1.138	0.250	1.133	0.268	1.155	0.336	1.159	0.305
1.150	0.253	1.144	0.271	1.167	0.344	1.172	0.316
1.162	0.259	1.156	0.273	1.179	0.328	1.184	0.322
1.174	0.261	1.168	0.276	1.191	0.358	1.196	0.330
1.186	0.266	1.180	0.283	1.203	0.359	1.208	0.335
1.198	0.268	1.192	0.284	1.216	0.363	1.220	0.342
1.210	0.274	1.204	0.285	1.228	0.365	1.233	0.349
1.222	0.252	1.216	0.288	1.240	0.367	1.245	0.352
1.234	0.285	1.228	0.291	1.252	0.371	1.257	0.358
1.246	0.290	1.240	0.294	1.264	0.375	1.269	0.363
1.258	0.291	1.252	0.299	1.276	0.378	1.281	0.373
1.270	0.293	1.264	0.300	1.288	0.380	1.294	0.376
1.282	0.295	1.276	0.304	1.301	0.383	1.306	0.381
1.294	0.300	1.288	0.309	1.313	0.387	1.318	0.386
1.306	0.299	1.299	0.310	1.325	0.392	1.330	0.387
1.318	0.305	1.311	0.312	1.337	0.394	1.342	0.394
1.330	0.305	1.323	0.314	1.349	0.395	1.355	0.391
1.342	0.306	1.335	0.316	1.361	0.402	1.367	0.399
1.354	0.311	1.347	0.317	1.374	0.404	1.379	0.403
1.366	0.315	1.359	0.325	1.386	0.405	1.391	0.408
1.378	0.316	1.371	0.325	1.398	0.409	1.403	0.411

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.390	0.318	1.383	0.324	1.410	0.412	1.416	0.415
1.402	0.320	1.395	0.326	1.422	0.414	1.428	0.418
1.414	0.325	1.407	0.329	1.434	0.405	1.440	0.421
1.426	0.296	1.419	0.332	1.446	0.428	1.452	0.422
1.438	0.330	1.431	0.335	1.459	0.425	1.464	0.430
1.450	0.328	1.443	0.332	1.471	0.426	1.477	0.432
1.462	0.329	1.454	0.335	1.483	0.425	1.489	0.434
1.474	0.331	1.466	0.337	1.495	0.425	1.501	0.439
1.486	0.334	1.478	0.335	1.507	0.428	1.513	0.443
1.498	0.333	1.490	0.341	1.519	0.430	1.525	0.445
1.510	0.336	1.502	0.344	1.532	0.430	1.538	0.447
1.522	0.338	1.514	0.347	1.544	0.432	1.550	0.450
1.534	0.338	1.526	0.345	1.556	0.432	1.562	0.450
1.546	0.340	1.538	0.346	1.568	0.436	1.574	0.456
1.558	0.340	1.550	0.346	1.580	0.438	1.586	0.427
1.570	0.342	1.562	0.350	1.592	0.439	1.599	0.462
1.582	0.344	1.574	0.351	1.604	0.440	1.611	0.462
1.594	0.345	1.586	0.352	1.617	0.443	1.623	0.464
1.606	0.347	1.597	0.355	1.629	0.443	1.635	0.466
1.618	0.347	1.609	0.357	1.641	0.443	1.648	0.465
1.629	0.350	1.621	0.361	1.653	0.446	1.660	0.454
1.641	0.350	1.633	0.355	1.665	0.445	1.672	0.472

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.653	0.355	1.645	0.395	1.677	0.450	1.684	0.472
1.665	0.355	1.657	0.365	1.690	0.451	1.696	0.472
1.677	0.349	1.669	0.364	1.702	0.453	1.709	0.473
1.689	0.351	1.681	0.364	1.714	0.453	1.721	0.476
1.701	0.354	1.693	0.365	1.726	0.454	1.733	0.474
1.713	0.355	1.705	0.370	1.738	0.455	1.745	0.475
1.725	0.356	1.717	0.363	1.750	0.459	1.757	0.476
1.737	0.357	1.729	0.364	1.762	0.459	1.770	0.480
1.749	0.357	1.741	0.370	1.775	0.461	1.782	0.478
1.761	0.359	1.752	0.373	1.787	0.461	1.794	0.482
1.773	0.359	1.764	0.371	1.799	0.463	1.806	0.485
1.785	0.361	1.776	0.373	1.811	0.464	1.818	0.484
1.797	0.363	1.788	0.372	1.823	0.465	1.831	0.479
1.809	0.362	1.800	0.375	1.835	0.465	1.843	0.481
1.821	0.366	1.812	0.375	1.848	0.467	1.855	0.483
1.833	0.365	1.824	0.375	1.860	0.469	1.867	0.483
1.845	0.363	1.836	0.375	1.872	0.468	1.879	0.485
1.857	0.364	1.848	0.377	1.884	0.473	1.892	0.486
1.869	0.366	1.860	0.379	1.896	0.473	1.904	0.487
1.881	0.366	1.872	0.378	1.908	0.473	1.916	0.488
1.893	0.367	1.884	0.385	1.921	0.473	1.928	0.491
1.905	0.368	1.896	0.380	1.933	0.473	1.940	0.479

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.917	0.368	1.907	0.382	1.945	0.476	1.953	0.492
1.929	0.371	1.919	0.384	1.957	0.474	1.965	0.493
1.941	0.368	1.931	0.383	1.969	0.474	1.977	0.493
1.953	0.364	1.943	0.383	1.981	0.476	1.989	0.492
1.965	0.370	1.955	0.385	1.993	0.476	2.001	0.492
1.977	0.371	1.967	0.382	2.006	0.475	2.014	0.494
1.989	0.371	1.979	0.384	2.018	0.475	2.026	0.493
2.001	0.375	1.991	0.386	2.030	0.477	2.038	0.493
2.013	0.372	2.003	0.382	2.042	0.480	2.050	0.493
2.025	0.375	2.015	0.388	2.054	0.481	2.062	0.494
2.037	0.377	2.027	0.387	2.066	0.488	2.075	0.497
2.049	0.386	2.039	0.394	2.079	0.484	2.087	0.495
2.061	0.380	2.051	0.394	2.091	0.485	2.099	0.498
2.073	0.380	2.062	0.394	2.103	0.484	2.111	0.501
2.085	0.376	2.074	0.389	2.115	0.484	2.123	0.497
2.097	0.372	2.086	0.391	2.127	0.483	2.136	0.499
2.109	0.376	2.098	0.396	2.139	0.482	2.148	0.501
2.121	0.378	2.110	0.394	2.151	0.484	2.160	0.500
2.133	0.378	2.122	0.394	2.164	0.484	2.172	0.501
2.145	0.376	2.134	0.395	2.176	0.482	2.184	0.503
2.157	0.375	2.146	0.396	2.188	0.485	2.197	0.500
2.169	0.378	2.158	0.396	2.200	0.486	2.209	0.503

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.181	0.353	2.170	0.397	2.212	0.486	2.221	0.503
2.193	0.382	2.182	0.398	2.224	0.486	2.233	0.504
2.205	0.379	2.194	0.401	2.237	0.486	2.245	0.504
2.217	0.379	2.205	0.404	2.249	0.486	2.258	0.503
2.229	0.377	2.217	0.406	2.261	0.485	2.270	0.506
2.241	0.376	2.229	0.404	2.273	0.488	2.282	0.504
2.253	0.377	2.241	0.404	2.285	0.488	2.294	0.506
2.265	0.380	2.253	0.402	2.297	0.489	2.307	0.475
2.276	0.381	2.265	0.402	2.309	0.491	2.319	0.511
2.288	0.379	2.277	0.406	2.322	0.489	2.331	0.512
2.300	0.379	2.289	0.406	2.334	0.490	2.343	0.512
2.312	0.380	2.301	0.401	2.346	0.490	2.355	0.510
2.324	0.383	2.313	0.401	2.358	0.494	2.368	0.512
2.336	0.381	2.325	0.400	2.370	0.492	2.380	0.512
2.348	0.381	2.337	0.402	2.382	0.492	2.392	0.511
2.360	0.384	2.349	0.400	2.395	0.491	2.404	0.512
2.372	0.385	2.360	0.402	2.407	0.492	2.416	0.513
2.384	0.386	2.372	0.397	2.419	0.494	2.429	0.512
2.396	0.398	2.384	0.398	2.431	0.495	2.441	0.512
2.408	0.387	2.396	0.397	2.443	0.494	2.453	0.513
2.420	0.386	2.408	0.398	2.455	0.492	2.465	0.513
2.432	0.385	2.420	0.401	2.467	0.492	2.477	0.514

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.444	0.386	2.432	0.401	2.480	0.494	2.490	0.513
2.456	0.386	2.444	0.402	2.492	0.495	2.502	0.514
2.468	0.386	2.456	0.390	2.504	0.498	2.514	0.514
2.480	0.386	2.468	0.410	2.516	0.494	2.526	0.514
2.492	0.386	2.480	0.415	2.528	0.492	2.538	0.517
2.504	0.386	2.492	0.412	2.540	0.502	2.551	0.519
2.516	0.386	2.504	0.412	2.553	0.499	2.563	0.516
2.528	0.387	2.515	0.410	2.565	0.499	2.575	0.518
2.540	0.388	2.527	0.411	2.577	0.497	2.587	0.517
2.552	0.389	2.539	0.408	2.589	0.495	2.599	0.516
2.564	0.388	2.551	0.410	2.601	0.495	2.612	0.515
2.576	0.390	2.563	0.414	2.613	0.495	2.624	0.503
2.588	0.388	2.575	0.415	2.626	0.494	2.636	0.520
2.600	0.392	2.587	0.416	2.638	0.495	2.648	0.520
2.612	0.394	2.599	0.416	2.650	0.495	2.660	0.519
2.624	0.392	2.611	0.415	2.662	0.495	2.673	0.521
2.636	0.392	2.623	0.418	2.674	0.498	2.685	0.522
2.648	0.394	2.635	0.416	2.686	0.498	2.697	0.523
2.660	0.388	2.647	0.416	2.698	0.496	2.709	0.521
2.672	0.393	2.659	0.416	2.711	0.495	2.721	0.519
2.684	0.392	2.670	0.416	2.723	0.496	2.734	0.521
2.696	0.392	2.682	0.419	2.735	0.496	2.746	0.521

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.708	0.392	2.694	0.418	2.747	0.492	2.758	0.519
2.720	0.392	2.706	0.418	2.759	0.492	2.770	0.518
2.732	0.390	2.718	0.416	2.771	0.490	2.782	0.514
2.744	0.392	2.730	0.413	2.784	0.490	2.795	0.497
2.756	0.392	2.742	0.410	2.796	0.481	2.807	0.518
2.768	0.388	2.754	0.408	2.808	0.486	2.819	0.513
2.780	0.385	2.766	0.401	2.820	0.481	2.831	0.509
2.792	0.383	2.778	0.398	2.832	0.476	2.843	0.504
2.804	0.382	2.790	0.391	2.844	0.467	2.856	0.501
2.816	0.377	2.802	0.386	2.856	0.461	2.868	0.497
2.828	0.366	2.813	0.379	2.869	0.453	2.880	0.490
2.840	0.368	2.825	0.369	2.881	0.446	2.892	0.487
2.852	0.363	2.837	0.357	2.893	0.440	2.904	0.482
2.864	0.356	2.849	0.351	2.905	0.430	2.917	0.473
2.876	0.348	2.861	0.343	2.917	0.418	2.929	0.472
2.888	0.340	2.873	0.337	2.929	0.410	2.941	0.462
2.900	0.336	2.885	0.326	2.942	0.402	2.953	0.458
2.912	0.328	2.897	0.312	2.954	0.393	2.966	0.450
2.923	0.315	2.909	0.304	2.966	0.379	2.978	0.442
2.935	0.307	2.921	0.292	2.978	0.369	2.990	0.436
2.947	0.298	2.933	0.283	2.990	0.357	3.002	0.428
2.959	0.291	2.945	0.273	3.002	0.347	3.014	0.422

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.971	0.281	2.957	0.263	3.014	0.337	3.027	0.405
2.983	0.272	2.968	0.252	3.027	0.327	3.039	0.409
2.995	0.263	2.980	0.242	3.039	0.316	3.051	0.401
3.007	0.255	2.992	0.237	3.051	0.306	3.063	0.394
3.019	0.246	3.004	0.227	3.063	0.294	3.075	0.385
3.031	0.238	3.016	0.217	3.075	0.285	3.088	0.378
3.043	0.229	3.028	0.209	3.087	0.276	3.100	0.368
3.055	0.219	3.040	0.199	3.100	0.265	3.112	0.358
3.067	0.213	3.052	0.193	3.112	0.255	3.124	0.352
3.079	0.206	3.064	0.184	3.124	0.247	3.136	0.344
3.091	0.195	3.076	0.177	3.136	0.240	3.149	0.336
3.103	0.188	3.088	0.171	3.148	0.230	3.161	0.328
3.115	0.182	3.100	0.164	3.160	0.224	3.173	0.321
3.127	0.174	3.112	0.158	3.172	0.216	3.185	0.312
3.139	0.165	3.123	0.183	3.185	0.208	3.197	0.304
3.151	0.160	3.135	0.142	3.197	0.201	3.210	0.295
3.163	0.153	3.147	0.138	3.209	0.191	3.222	0.288
3.175	0.147	3.159	0.132	3.221	0.185	3.234	0.279
3.187	0.140	3.171	0.124	3.233	0.180	3.246	0.273
3.199	0.136	3.183	0.118	3.245	0.175	3.258	0.264
3.211	0.129	3.195	0.113	3.258	0.166	3.271	0.256
3.223	0.122	3.207	0.108	3.270	0.161	3.283	0.250

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.235	0.118	3.219	0.105	3.282	0.154	3.295	0.242
3.247	0.114	3.231	0.100	3.294	0.143	3.307	0.234
3.259	0.108	3.243	0.095	3.306	0.143	3.319	0.229
3.271	0.103	3.255	0.091	3.318	0.139	3.332	0.221
3.283	0.098	3.267	0.088	3.331	0.134	3.344	0.214
3.295	0.093	3.278	0.084	3.343	0.128	3.356	0.208
3.307	0.089	3.290	0.081	3.355	0.124	3.368	0.204
3.319	0.086	3.302	0.076	3.367	0.120	3.380	0.196
3.331	0.082	3.314	0.072	3.379	0.116	3.393	0.187
3.343	0.079	3.326	0.069	3.391	0.112	3.405	0.183
3.355	0.073	3.338	0.066	3.403	0.108	3.417	0.176
3.367	0.070	3.350	0.063	3.416	0.105	3.429	0.171
3.379	0.071	3.362	0.061	3.428	0.100	3.441	0.166
3.391	0.068	3.374	0.059	3.440	0.096	3.454	0.161
3.403	0.071	3.386	0.055	3.452	0.092	3.466	0.155
3.415	0.059	3.398	0.054	3.464	0.089	3.478	0.150
3.427	0.057	3.410	0.052	3.476	0.086	3.490	0.147
3.439	0.052	3.421	0.048	3.489	0.083	3.502	0.142
3.451	0.051	3.433	0.045	3.501	0.081	3.515	0.135
3.463	0.048	3.445	0.044	3.513	0.078	3.527	0.130
3.475	0.048	3.457	0.042	3.525	0.075	3.539	0.129
3.487	0.045	3.469	0.040	3.537	0.073	3.551	0.124

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.499	0.043	3.481	0.037	3.549	0.069	3.563	0.121
3.511	0.042	3.493	0.035	3.561	0.067	3.576	0.117
3.523	0.039	3.505	0.031	3.574	0.068	3.588	0.112
3.535	0.036	3.517	0.030	3.586	0.066	3.600	0.113
3.547	0.033	3.529	0.026	3.598	0.064	3.612	0.102
3.559	0.033	3.541	0.025	3.610	0.061	3.625	0.101
3.570	0.031	3.553	0.025	3.622	0.060	3.637	0.098
3.582	0.032	3.565	0.022	3.634	0.056	3.649	0.094
3.594	0.027	3.576	0.020	3.647	0.055	3.661	0.091
3.606	0.027	3.588	0.019	3.659	0.053	3.673	0.088
3.618	0.024	3.600	0.018	3.671	0.052	3.686	0.084
3.630	0.025	3.612	0.016	3.683	0.049	3.698	0.079
3.642	0.024	3.624	0.015	3.695	0.049	3.710	0.078
3.654	0.023	3.636	0.013	3.707	0.045	3.722	0.076
3.666	0.020	3.648	0.012	3.719	0.045	3.734	0.073
3.678	0.020	3.660	0.011	3.732	0.043	3.747	0.070
3.690	0.018	3.672	0.011	3.744	0.042	3.759	0.068
3.702	0.018	3.684	0.009	3.756	0.040	3.771	0.065
3.714	0.017	3.696	0.008	3.768	0.040	3.783	0.064
3.726	0.016	3.708	0.018	3.780	0.039	3.795	0.069
3.738	0.014	3.720	0.005	3.792	0.037	3.808	0.055
3.750	0.013	3.731	0.004	3.805	0.035	3.820	0.055

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.762	0.016	3.743	0.002	3.817	0.034	3.832	0.053
3.774	0.016	3.755	0.001	3.829	0.033	3.844	0.051
3.786	0.014	3.767	0.001	3.841	0.032	3.856	0.048
3.798	0.014	3.779	0.000	3.853	0.030	3.869	0.049
3.810	0.014	3.791	0.000	3.865	0.030	3.881	0.046
3.822	0.014	3.803	-0.001	3.877	0.029	3.893	0.043
3.834	0.013	3.815	-0.002	3.890	0.028	3.905	0.043
3.846	0.011	3.827	-0.002	3.902	0.027	3.917	0.042
3.858	0.011	3.839	-0.004	3.914	0.026	3.930	0.039
3.870	0.009	3.851	-0.005	3.926	0.026	3.942	0.038
3.882	0.009	3.863	-0.006	3.938	0.025	3.954	0.037
3.894	0.009	3.875	-0.006	3.950	0.022	3.966	0.036
3.906	0.009	3.886	-0.007	3.963	0.023	3.978	0.035
3.918	0.010	3.898	-0.007	3.975	0.023	3.991	0.033
3.930	0.009	3.910	-0.008	3.987	0.022	4.003	0.033
3.942	0.009	3.922	-0.008	3.999	0.020	4.015	0.031
3.954	0.009	3.934	-0.008	4.011	0.019	4.027	0.034
3.966	0.007	3.946	-0.011	4.023	0.018	4.039	0.028
3.978	0.007	3.958	-0.011	4.036	0.018	4.052	0.027
3.990	0.005	3.970	-0.012	4.048	0.017	4.064	0.027
4.002	0.005	3.982	-0.011	4.060	0.017	4.076	0.026
4.014	0.005	3.994	-0.012	4.072	0.016	4.088	0.024

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.026	0.004	4.006	-0.007	4.084	0.015	4.100	0.023
4.038	0.004	4.018	-0.014	4.096	0.014	4.113	0.023
4.050	0.005	4.029	-0.014	4.108	0.015	4.125	0.023
4.062	0.004	4.041	-0.014	4.121	0.014	4.137	0.020
4.074	0.004	4.053	-0.014	4.133	0.014	4.149	0.019
4.086	0.004	4.065	-0.015	4.145	0.012	4.161	0.019
4.098	0.003	4.077	-0.015	4.157	0.012	4.174	0.018
4.110	0.003	4.089	-0.016	4.169	0.012	4.186	0.017
4.122	0.003	4.101	-0.016	4.181	0.010	4.198	0.017
4.134	0.003	4.113	-0.017	4.194	0.010	4.210	0.016
4.146	0.002	4.125	-0.016	4.206	0.010	4.222	0.016
4.158	0.002	4.137	-0.017	4.218	0.009	4.235	0.014
4.170	0.001	4.149	-0.018	4.230	0.009	4.247	0.014
4.182	0.002	4.161	-0.017	4.242	0.009	4.259	0.012
4.194	0.001	4.173	-0.018	4.254	0.009	4.271	0.012
4.206	0.002	4.184	-0.016	4.266	0.009	4.284	0.012
4.217	0.001	4.196	-0.018	4.279	0.007	4.296	0.011
4.229	0.001	4.208	-0.019	4.291	0.007	4.308	0.010
4.241	0.001	4.220	-0.018	4.303	0.007	4.320	0.010
4.253	0.002	4.232	-0.019	4.315	0.006	4.332	0.010
4.265	0.000	4.244	-0.020	4.327	0.006	4.345	0.010
4.277	0.000	4.256	-0.019	4.339	0.005	4.357	0.009

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.289	0.000	4.268	-0.019	4.352	0.005	4.369	0.012
4.301	0.000	4.280	-0.019	4.364	0.005	4.381	0.006
4.313	0.002	4.292	-0.021	4.376	0.005	4.393	0.005
4.325	0.000	4.304	-0.021	4.388	0.004	4.406	0.006
4.337	-0.001	4.316	-0.020	4.400	0.004	4.418	0.006
4.349	-0.001	4.328	-0.020	4.412	0.005	4.430	0.005
4.361	-0.001	4.339	-0.019	4.424	0.002	4.442	0.005
4.373	-0.001	4.351	-0.020	4.437	0.004	4.454	0.005
4.385	-0.001	4.363	-0.020	4.449	0.002	4.467	0.004
4.397	-0.001	4.375	-0.022	4.461	0.002	4.479	0.004
4.409	-0.001	4.387	-0.022	4.473	0.002	4.491	0.004
4.421	0.000	4.399	-0.022	4.485	0.002	4.503	0.002
4.433	-0.001	4.411	-0.022	4.497	0.002	4.515	0.002
4.445	-0.002	4.423	-0.022	4.510	0.001	4.528	0.002
4.457	-0.001	4.435	-0.022	4.522	0.000	4.540	0.002
4.469	-0.001	4.447	-0.021	4.534	0.001	4.552	0.004
4.481	-0.001	4.459	-0.022	4.546	0.000	4.564	0.002
4.493	-0.002	4.471	-0.021	4.558	-0.001	4.576	0.001
4.505	-0.002	4.483	-0.022	4.570	0.000	4.589	0.000
4.517	-0.003	4.494	-0.023	4.582	0.000	4.601	0.001
4.529	-0.002	4.506	-0.024	4.595	0.000	4.613	0.001
4.541	-0.003	4.518	-0.024	4.607	-0.001	4.625	0.000

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.553	-0.002	4.530	-0.020	4.619	-0.001	4.637	0.000
4.565	-0.002	4.542	-0.023	4.631	-0.001	4.650	0.000
4.577	-0.002	4.554	-0.023	4.643	0.000	4.662	0.000
4.589	-0.002	4.566	-0.024	4.655	0.000	4.674	-0.002
4.601	-0.001	4.578	-0.024	4.668	-0.001	4.686	-0.001
4.613	-0.003	4.590	-0.024	4.680	-0.001	4.698	-0.001
4.625	-0.003	4.602	-0.024	4.692	-0.002	4.711	-0.001
4.637	-0.001	4.614	-0.025	4.704	-0.002	4.723	-0.001
4.649	-0.002	4.626	-0.024	4.716	-0.002	4.735	-0.002
4.661	-0.003	4.637	-0.025	4.728	-0.001	4.747	-0.001
4.673	-0.003	4.649	-0.025	4.740	-0.003	4.759	0.001
4.685	-0.002	4.661	-0.025	4.753	-0.003	4.772	-0.003
4.697	-0.001	4.673	-0.024	4.765	-0.001	4.784	-0.004
4.709	-0.002	4.685	-0.025	4.777	-0.002	4.796	-0.004
4.721	-0.003	4.697	-0.024	4.789	-0.004	4.808	-0.003
4.733	-0.003	4.709	-0.025	4.801	-0.003	4.820	-0.004
4.745	-0.003	4.721	-0.024	4.813	-0.003	4.833	-0.004
4.757	-0.003	4.733	-0.026	4.826	-0.004	4.845	-0.004
4.769	-0.002	4.745	-0.025	4.838	-0.004	4.857	-0.004
4.781	-0.001	4.757	-0.025	4.850	-0.004	4.869	-0.004
4.793	0.001	4.769	-0.025	4.862	-0.003	4.881	-0.004
4.805	-0.003	4.781	-0.025	4.874	-0.004	4.894	-0.004

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.817	-0.003	4.792	-0.024	4.886	-0.003	4.906	-0.004
4.829	-0.004	4.804	-0.024	4.899	-0.004	4.918	-0.005
4.841	-0.003	4.816	-0.025	4.911	-0.004	4.930	-0.004
4.853	-0.003	4.828	-0.026	4.923	-0.004	4.943	-0.004
4.864	-0.003	4.840	-0.025	4.935	-0.004	4.955	-0.005
4.876	-0.003	4.852	-0.026	4.947	-0.004	4.967	-0.004
4.888	-0.004	4.864	-0.025	4.959	-0.004	4.979	-0.005
4.900	-0.003	4.876	-0.025	4.971	-0.004	4.991	-0.006
4.912	-0.003	4.888	-0.024	4.984	-0.004	5.004	-0.005
4.924	-0.004	4.900	-0.024	4.996	-0.004	5.016	-0.006
4.936	-0.003	4.912	-0.024	5.008	-0.004	5.028	-0.005
4.948	-0.004	4.924	-0.025	5.020	-0.005	5.040	-0.006
4.960	-0.004	4.936	-0.024	5.032	-0.004	5.052	-0.004
4.972	-0.003	4.947	-0.024	5.044	-0.004	5.065	-0.004
4.984	-0.003	4.959	-0.026	5.057	-0.005	5.077	-0.006
4.996	-0.003	4.971	-0.025	5.069	-0.005	5.089	-0.006
5.008	-0.002	4.983	-0.024	5.081	-0.005	5.101	-0.006
5.020	-0.003	4.995	-0.024	5.093	-0.006	5.113	-0.004
5.032	-0.003	5.007	-0.024	5.105	-0.004	5.126	-0.006
5.044	-0.004	5.019	-0.024	5.117	-0.006	5.138	-0.006
5.056	-0.003	5.031	-0.024	5.129	-0.005	5.150	-0.006
5.068	-0.002	5.043	-0.026	5.142	-0.005	5.162	-0.006

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.080	-0.003	5.055	-0.025	5.154	-0.005	5.174	-0.006
5.092	-0.003	5.067	-0.027	5.166	-0.006	5.187	-0.002
5.104	-0.003	5.079	-0.025	5.178	-0.006	5.199	-0.007
5.116	-0.003	5.091	-0.026	5.190	-0.006	5.211	-0.006
5.128	-0.002	5.102	-0.026	5.202	-0.006	5.223	-0.006
5.140	-0.003	5.114	-0.025	5.215	-0.006	5.235	-0.006
5.152	-0.003	5.126	-0.026	5.227	-0.006	5.248	-0.006
5.164	0.000	5.138	-0.026	5.239	-0.007	5.260	-0.006
5.176	-0.002	5.150	-0.026	5.251	-0.006	5.272	-0.006
5.188	-0.003	5.162	-0.028	5.263	-0.007	5.284	-0.006
5.200	-0.002	5.174	-0.025	5.275	-0.006	5.296	-0.006
5.212	-0.002	5.186	-0.026	5.287	-0.006	5.309	-0.007
5.224	-0.001	5.198	-0.026	5.300	-0.006	5.321	-0.006
5.236	-0.001	5.210	-0.027	5.312	-0.007	5.333	-0.008
5.248	-0.001	5.222	-0.026	5.324	-0.006	5.345	-0.008
5.260	-0.002	5.234	-0.026	5.336	-0.007	5.357	-0.008
5.272	-0.001	5.245	-0.026	5.348	-0.007	5.370	-0.007
5.284	-0.001	5.257	-0.025	5.360	-0.007	5.382	-0.006
5.296	-0.001	5.269	-0.026	5.373	-0.006	5.394	-0.006
5.308	-0.001	5.281	-0.027	5.385	-0.007	5.406	-0.008
5.320	-0.001	5.293	-0.026	5.397	-0.006	5.418	-0.008
5.332	-0.001	5.305	-0.025	5.409	-0.007	5.431	-0.008

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.344	-0.001	5.317	-0.025	5.421	-0.007	5.443	-0.008
5.356	-0.001	5.329	-0.026	5.433	-0.007	5.455	-0.008
5.368	-0.001	5.341	-0.025	5.445	-0.006	5.467	-0.008
5.380	-0.001	5.353	-0.025	5.458	-0.007	5.479	-0.008
5.392	-0.001	5.365	-0.026	5.470	-0.007	5.492	-0.009
5.404	0.000	5.377	-0.026	5.482	-0.008	5.504	-0.008
5.416	0.000	5.389	-0.026	5.494	-0.007	5.516	-0.008
5.428	0.000	5.400	-0.026	5.506	-0.007	5.528	-0.008
5.440	0.000	5.412	-0.026	5.518	-0.008	5.541	-0.008
5.452	0.000	5.424	-0.025	5.531	-0.008	5.553	-0.008
5.464	0.000	5.436	-0.025	5.543	-0.007	5.565	-0.009
5.476	0.000	5.448	-0.025	5.555	-0.008	5.577	-0.008
5.488	0.001	5.460	-0.024	5.567	-0.008	5.589	-0.009
5.500	0.001	5.472	-0.025	5.579	-0.007	5.602	-0.009
5.511	0.001	5.484	-0.026	5.591	-0.007	5.614	-0.009
5.523	0.002	5.496	-0.026	5.604	-0.007	5.626	-0.009
5.535	0.001	5.508	-0.025	5.616	-0.007	5.638	-0.004
5.547	0.000	5.520	-0.025	5.628	-0.008	5.650	-0.009
5.559	0.001	5.532	-0.025	5.640	-0.008	5.663	-0.010
5.571	0.002	5.544	-0.027	5.652	-0.009	5.675	-0.009
5.583	0.001	5.555	-0.025	5.664	-0.008	5.687	-0.010
5.595	0.002	5.567	-0.026	5.676	-0.009	5.699	-0.010

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.607	0.001	5.579	-0.026	5.689	-0.008	5.711	-0.009
5.619	0.002	5.591	-0.026	5.701	-0.008	5.724	-0.011
5.631	0.002	5.603	-0.025	5.713	-0.009	5.736	-0.010
5.643	0.002	5.615	-0.026	5.725	-0.007	5.748	-0.010
5.655	0.002	5.627	-0.027	5.737	-0.007	5.760	-0.010
5.667	0.002	5.639	-0.026	5.749	-0.009	5.772	-0.010
5.679	0.003	5.651	-0.026	5.762	-0.009	5.785	-0.010
5.691	0.004	5.663	-0.026	5.774	-0.009	5.797	-0.011
5.703	0.001	5.675	-0.027	5.786	-0.009	5.809	-0.010
5.715	0.001	5.687	-0.026	5.798	-0.009	5.821	-0.011
5.727	0.002	5.699	-0.026	5.810	-0.009	5.833	-0.011
5.739	0.002	5.710	-0.026	5.822	-0.008	5.846	-0.011
5.751	0.004	5.722	-0.027	5.834	-0.009	5.858	-0.011
5.763	0.002	5.734	-0.027	5.847	-0.009	5.870	-0.011
5.775	0.004	5.746	-0.025	5.859	-0.010	5.882	-0.011
5.787	0.001	5.758	-0.025	5.871	-0.009	5.894	-0.011
5.799	0.001	5.770	-0.027	5.883	-0.009	5.907	-0.010
5.811	0.001	5.782	-0.025	5.895	-0.009	5.919	-0.009
5.823	0.001	5.794	-0.025	5.907	-0.009	5.931	-0.010
5.835	0.001	5.806	-0.026	5.920	-0.009	5.943	-0.010
5.847	0.001	5.818	-0.026	5.932	-0.011	5.955	-0.011
5.859	0.001	5.830	-0.027	5.944	-0.009	5.968	-0.011

Table A4. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.871	0.001	5.842	-0.026	5.956	-0.011	5.980	-0.011
5.883	0.001	5.853	-0.025	5.968	-0.007	5.992	-0.011
5.895	0.001	5.865	-0.025	5.980	-0.010	6.004	-0.010
5.907	0.001	5.877	-0.027	5.992	-0.011	6.016	-0.010
5.919	0.002	5.889	-0.026	6.005	-0.011	6.029	-0.010
5.931	0.001	5.901	-0.025	6.017	-0.011	6.041	-0.011
5.943	0.002	5.913	-0.026	6.029	-0.010	6.053	-0.011
5.955	0.002	5.925	-0.026	6.041	-0.011	6.065	-0.010
5.967	0.001	5.937	-0.026	6.053	-0.011	6.077	-0.010
5.979	0.004	5.949	-0.025	6.065	-0.011	6.090	-0.010
5.991	0.001	5.961	-0.025	6.078	-0.011	6.102	-0.010
6.003	0.001	5.973	-0.025	6.090	-0.011	6.114	-0.011
6.015	0.001	5.985	-0.026	6.102	-0.011	6.126	-0.011
6.027	0.001	5.997	-0.026	6.114	-0.011	6.138	-0.011
6.039	0.001	6.008	-0.025	6.126	-0.011	6.151	-0.011

Table A5. **Breakthrough concentrations of the tet^R and tet^S *E.coli* strains at 25% of soil moisture content and under ionic strength condition of 5 mM NaCl. Where, PV is the pore volume of the sand packed column at 25% of soil moisture content and C/Co is the normalized breakthrough concentrations.**

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.000	0.001	0.000	0.002	0.000	0.010	0.000	-0.001
0.012	0.002	0.012	0.000	0.012	0.009	0.012	-0.001
0.024	0.000	0.025	0.000	0.024	0.009	0.024	-0.001
0.036	0.000	0.037	0.000	0.036	0.009	0.036	0.000
0.048	0.000	0.049	-0.001	0.049	0.009	0.048	-0.001
0.060	0.000	0.061	0.000	0.061	0.008	0.060	-0.001
0.072	0.000	0.074	-0.001	0.073	0.008	0.072	-0.001
0.084	-0.001	0.086	-0.001	0.085	0.008	0.084	-0.001
0.096	0.000	0.098	-0.001	0.097	0.007	0.096	-0.001
0.108	-0.001	0.111	-0.004	0.109	0.007	0.108	-0.002
0.120	-0.001	0.123	-0.001	0.122	0.007	0.119	-0.002
0.132	0.000	0.135	0.000	0.134	0.007	0.131	-0.001
0.144	-0.002	0.147	0.000	0.146	0.006	0.143	-0.001
0.156	0.000	0.160	-0.002	0.158	0.007	0.155	-0.002
0.168	0.000	0.172	-0.002	0.170	0.005	0.167	-0.001
0.180	-0.001	0.184	-0.002	0.182	0.005	0.179	-0.004
0.192	-0.001	0.197	-0.002	0.194	0.005	0.191	-0.002
0.204	-0.002	0.209	-0.002	0.207	0.005	0.203	-0.003
0.216	-0.002	0.221	-0.001	0.219	0.006	0.215	-0.004
0.228	-0.004	0.233	-0.004	0.231	0.007	0.227	-0.003
0.240	-0.004	0.246	-0.003	0.243	0.006	0.239	-0.004

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.252	-0.004	0.258	-0.003	0.255	0.004	0.251	-0.004
0.264	-0.004	0.270	-0.003	0.267	0.003	0.263	-0.004
0.276	-0.004	0.283	-0.003	0.280	0.003	0.275	-0.004
0.288	-0.004	0.295	-0.004	0.292	0.004	0.287	-0.004
0.300	-0.005	0.307	0.007	0.304	0.003	0.299	-0.004
0.312	-0.006	0.320	-0.004	0.316	0.003	0.311	-0.004
0.324	-0.004	0.332	-0.005	0.328	0.003	0.323	-0.004
0.336	-0.006	0.344	-0.006	0.340	0.003	0.334	-0.004
0.349	-0.006	0.356	-0.005	0.352	0.002	0.346	-0.004
0.361	-0.005	0.369	-0.005	0.365	0.002	0.358	-0.005
0.373	-0.006	0.381	-0.006	0.377	0.002	0.370	-0.006
0.385	-0.006	0.393	-0.005	0.389	0.002	0.382	-0.005
0.397	-0.005	0.406	-0.006	0.401	0.002	0.394	-0.005
0.409	-0.008	0.418	-0.006	0.413	0.001	0.406	-0.003
0.421	-0.007	0.430	-0.008	0.425	0.001	0.418	-0.005
0.433	-0.007	0.442	-0.006	0.438	0.001	0.430	-0.006
0.445	-0.008	0.455	-0.006	0.450	0.001	0.442	-0.006
0.457	-0.008	0.467	-0.006	0.462	0.002	0.454	-0.006
0.469	-0.007	0.479	-0.008	0.474	0.001	0.466	-0.003
0.481	-0.009	0.492	-0.007	0.486	0.001	0.478	-0.004
0.493	-0.008	0.504	-0.007	0.498	0.000	0.490	-0.004
0.505	-0.008	0.516	-0.006	0.511	0.001	0.502	-0.004

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.517	-0.008	0.528	-0.006	0.523	0.000	0.514	-0.004
0.529	-0.009	0.541	-0.005	0.535	0.001	0.526	-0.004
0.541	-0.009	0.553	-0.004	0.547	0.001	0.538	-0.004
0.553	-0.008	0.565	-0.001	0.559	0.001	0.549	-0.004
0.565	-0.007	0.578	0.000	0.571	0.001	0.561	-0.004
0.577	-0.005	0.590	0.003	0.583	0.002	0.573	-0.004
0.589	-0.005	0.602	0.004	0.596	0.002	0.585	-0.004
0.601	-0.002	0.614	0.008	0.608	0.002	0.597	-0.002
0.613	0.000	0.627	0.012	0.620	0.003	0.609	-0.001
0.625	0.004	0.639	0.017	0.632	0.005	0.621	0.000
0.637	0.007	0.651	0.022	0.644	0.006	0.633	0.001
0.649	0.013	0.664	0.028	0.656	0.009	0.645	0.000
0.661	0.018	0.676	0.034	0.669	0.011	0.657	0.006
0.673	0.024	0.688	0.040	0.681	0.015	0.669	0.007
0.685	0.031	0.700	0.049	0.693	0.017	0.681	0.010
0.697	0.039	0.713	0.058	0.705	0.019	0.693	0.013
0.709	0.048	0.725	0.065	0.717	0.024	0.705	0.017
0.721	0.057	0.737	0.075	0.729	0.027	0.717	0.021
0.733	0.066	0.750	0.083	0.741	0.032	0.729	0.027
0.745	0.075	0.762	0.093	0.754	0.035	0.741	0.031
0.757	0.085	0.774	0.101	0.766	0.040	0.753	0.036
0.769	0.097	0.786	0.110	0.778	0.045	0.765	0.042

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.781	0.106	0.799	0.114	0.790	0.043	0.776	0.047
0.793	0.113	0.811	0.125	0.802	0.055	0.788	0.050
0.805	0.122	0.823	0.135	0.814	0.059	0.800	0.056
0.817	0.133	0.836	0.143	0.827	0.064	0.812	0.050
0.829	0.145	0.848	0.153	0.839	0.068	0.824	0.072
0.841	0.155	0.860	0.163	0.851	0.071	0.836	0.076
0.853	0.169	0.873	0.170	0.863	0.077	0.848	0.080
0.865	0.171	0.885	0.180	0.875	0.081	0.860	0.085
0.877	0.180	0.897	0.188	0.887	0.086	0.872	0.093
0.889	0.186	0.909	0.197	0.899	0.089	0.884	0.103
0.901	0.201	0.922	0.203	0.912	0.094	0.896	0.108
0.913	0.211	0.934	0.211	0.924	0.096	0.908	0.112
0.925	0.220	0.946	0.220	0.936	0.102	0.920	0.116
0.937	0.227	0.959	0.228	0.948	0.108	0.932	0.122
0.949	0.237	0.971	0.233	0.960	0.111	0.944	0.128
0.961	0.247	0.983	0.242	0.972	0.113	0.956	0.135
0.973	0.260	0.995	0.244	0.985	0.109	0.968	0.140
0.985	0.264	1.008	0.252	0.997	0.126	0.980	0.145
0.997	0.272	1.020	0.256	1.009	0.128	0.991	0.150
1.009	0.280	1.032	0.265	1.021	0.130	1.003	0.161
1.021	0.285	1.045	0.272	1.033	0.133	1.015	0.164
1.033	0.289	1.057	0.281	1.045	0.136	1.027	0.167

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.046	0.308	1.069	0.281	1.057	0.139	1.039	0.174
1.058	0.302	1.081	0.289	1.070	0.139	1.051	0.166
1.070	0.314	1.094	0.294	1.082	0.144	1.063	0.185
1.082	0.316	1.106	0.298	1.094	0.147	1.075	0.186
1.094	0.324	1.118	0.305	1.106	0.149	1.087	0.191
1.106	0.330	1.131	0.307	1.118	0.153	1.099	0.193
1.118	0.338	1.143	0.313	1.130	0.155	1.111	0.198
1.130	0.348	1.155	0.316	1.143	0.157	1.123	0.201
1.142	0.353	1.167	0.321	1.155	0.158	1.135	0.204
1.154	0.360	1.180	0.323	1.167	0.162	1.147	0.209
1.166	0.357	1.192	0.327	1.179	0.165	1.159	0.211
1.178	0.365	1.204	0.331	1.191	0.166	1.171	0.213
1.190	0.366	1.217	0.335	1.203	0.170	1.183	0.217
1.202	0.371	1.229	0.341	1.216	0.170	1.195	0.219
1.214	0.375	1.241	0.341	1.228	0.171	1.206	0.221
1.226	0.379	1.253	0.349	1.240	0.175	1.218	0.214
1.238	0.383	1.266	0.349	1.252	0.177	1.230	0.227
1.250	0.386	1.278	0.357	1.264	0.181	1.242	0.230
1.262	0.389	1.290	0.355	1.276	0.181	1.254	0.232
1.274	0.386	1.303	0.356	1.288	0.181	1.266	0.233
1.286	0.390	1.315	0.360	1.301	0.183	1.278	0.237
1.298	0.393	1.327	0.367	1.313	0.185	1.290	0.237

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.310	0.396	1.339	0.368	1.325	0.191	1.302	0.237
1.322	0.398	1.352	0.371	1.337	0.190	1.314	0.243
1.334	0.399	1.364	0.374	1.349	0.190	1.326	0.241
1.346	0.404	1.376	0.377	1.361	0.194	1.338	0.237
1.358	0.406	1.389	0.381	1.374	0.193	1.350	0.251
1.370	0.404	1.401	0.386	1.386	0.194	1.362	0.251
1.382	0.409	1.413	0.384	1.398	0.195	1.374	0.252
1.394	0.411	1.426	0.387	1.410	0.194	1.386	0.254
1.406	0.413	1.438	0.392	1.422	0.196	1.398	0.253
1.418	0.416	1.450	0.397	1.434	0.198	1.410	0.255
1.430	0.421	1.462	0.396	1.446	0.199	1.422	0.262
1.442	0.417	1.475	0.401	1.459	0.199	1.433	0.258
1.454	0.417	1.487	0.404	1.471	0.200	1.445	0.259
1.466	0.421	1.499	0.402	1.483	0.201	1.457	0.262
1.478	0.425	1.512	0.402	1.495	0.203	1.469	0.260
1.490	0.423	1.524	0.406	1.507	0.204	1.481	0.260
1.502	0.423	1.536	0.407	1.519	0.205	1.493	0.262
1.514	0.426	1.548	0.411	1.532	0.206	1.505	0.268
1.526	0.429	1.561	0.415	1.544	0.206	1.517	0.268
1.538	0.433	1.573	0.414	1.556	0.207	1.529	0.270
1.550	0.432	1.585	0.411	1.568	0.207	1.541	0.269
1.562	0.434	1.598	0.415	1.580	0.208	1.553	0.270

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.574	0.431	1.610	0.417	1.592	0.209	1.565	0.271
1.586	0.431	1.622	0.420	1.604	0.212	1.577	0.270
1.598	0.431	1.634	0.423	1.617	0.213	1.589	0.273
1.610	0.431	1.647	0.426	1.629	0.214	1.601	0.272
1.622	0.433	1.659	0.424	1.641	0.214	1.613	0.275
1.634	0.433	1.671	0.432	1.653	0.213	1.625	0.276
1.646	0.436	1.684	0.431	1.665	0.215	1.637	0.276
1.658	0.437	1.696	0.428	1.677	0.213	1.648	0.275
1.670	0.437	1.708	0.430	1.690	0.214	1.660	0.278
1.682	0.437	1.720	0.435	1.702	0.218	1.672	0.278
1.694	0.437	1.733	0.437	1.714	0.221	1.684	0.280
1.706	0.441	1.745	0.439	1.726	0.221	1.696	0.280
1.718	0.439	1.757	0.437	1.738	0.221	1.708	0.282
1.731	0.443	1.770	0.440	1.750	0.220	1.720	0.281
1.743	0.431	1.782	0.443	1.762	0.219	1.732	0.281
1.755	0.438	1.794	0.441	1.775	0.221	1.744	0.284
1.767	0.436	1.806	0.445	1.787	0.220	1.756	0.284
1.779	0.434	1.819	0.446	1.799	0.222	1.768	0.286
1.791	0.438	1.831	0.447	1.811	0.219	1.780	0.286
1.803	0.447	1.843	0.448	1.823	0.221	1.792	0.268
1.815	0.444	1.856	0.447	1.835	0.222	1.804	0.291
1.827	0.437	1.868	0.452	1.848	0.222	1.816	0.288

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.839	0.437	1.880	0.451	1.860	0.222	1.828	0.290
1.851	0.436	1.892	0.452	1.872	0.223	1.840	0.291
1.863	0.439	1.905	0.453	1.884	0.224	1.852	0.290
1.875	0.439	1.917	0.433	1.896	0.224	1.864	0.286
1.887	0.439	1.929	0.451	1.908	0.225	1.875	0.287
1.899	0.440	1.942	0.459	1.921	0.226	1.887	0.289
1.911	0.440	1.954	0.458	1.933	0.227	1.899	0.287
1.923	0.440	1.966	0.458	1.945	0.226	1.911	0.290
1.935	0.439	1.979	0.461	1.957	0.229	1.923	0.293
1.947	0.441	1.991	0.461	1.969	0.232	1.935	0.291
1.959	0.440	2.003	0.461	1.981	0.228	1.947	0.291
1.971	0.439	2.015	0.462	1.993	0.230	1.959	0.291
1.983	0.442	2.028	0.459	2.006	0.229	1.971	0.294
1.995	0.445	2.040	0.464	2.018	0.229	1.983	0.295
2.007	0.448	2.052	0.461	2.030	0.230	1.995	0.300
2.019	0.452	2.065	0.464	2.042	0.230	2.007	0.298
2.031	0.448	2.077	0.466	2.054	0.211	2.019	0.297
2.043	0.451	2.089	0.469	2.066	0.232	2.031	0.298
2.055	0.452	2.101	0.467	2.079	0.232	2.043	0.300
2.067	0.454	2.114	0.467	2.091	0.235	2.055	0.299
2.079	0.450	2.126	0.467	2.103	0.232	2.067	0.298
2.091	0.451	2.138	0.469	2.115	0.232	2.079	0.301

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.103	0.451	2.151	0.469	2.127	0.232	2.090	0.300
2.115	0.453	2.163	0.471	2.139	0.234	2.102	0.299
2.127	0.466	2.175	0.472	2.151	0.232	2.114	0.298
2.139	0.450	2.187	0.470	2.164	0.235	2.126	0.300
2.151	0.451	2.200	0.470	2.176	0.235	2.138	0.298
2.163	0.451	2.212	0.474	2.188	0.234	2.150	0.301
2.175	0.452	2.224	0.466	2.200	0.235	2.162	0.300
2.187	0.452	2.237	0.473	2.212	0.235	2.174	0.306
2.199	0.462	2.249	0.473	2.224	0.235	2.186	0.305
2.211	0.464	2.261	0.472	2.237	0.235	2.198	0.306
2.223	0.464	2.273	0.475	2.249	0.235	2.210	0.306
2.235	0.463	2.286	0.477	2.261	0.236	2.222	0.306
2.247	0.463	2.298	0.477	2.273	0.235	2.234	0.306
2.259	0.459	2.310	0.477	2.285	0.237	2.246	0.307
2.271	0.458	2.323	0.477	2.297	0.237	2.258	0.306
2.283	0.460	2.335	0.487	2.309	0.238	2.270	0.306
2.295	0.465	2.347	0.482	2.322	0.240	2.282	0.308
2.307	0.470	2.359	0.482	2.334	0.238	2.294	0.309
2.319	0.469	2.372	0.479	2.346	0.241	2.305	0.306
2.331	0.466	2.384	0.480	2.358	0.242	2.317	0.310
2.343	0.465	2.396	0.485	2.370	0.240	2.329	0.311
2.355	0.464	2.409	0.487	2.382	0.241	2.341	0.310

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.367	0.465	2.421	0.485	2.395	0.240	2.353	0.310
2.379	0.466	2.433	0.485	2.407	0.239	2.365	0.311
2.391	0.464	2.445	0.487	2.419	0.241	2.377	0.310
2.403	0.463	2.458	0.489	2.431	0.242	2.389	0.313
2.416	0.462	2.470	0.488	2.443	0.244	2.401	0.312
2.428	0.462	2.482	0.491	2.455	0.244	2.413	0.313
2.440	0.465	2.495	0.489	2.467	0.246	2.425	0.314
2.452	0.464	2.507	0.489	2.480	0.245	2.437	0.310
2.464	0.465	2.519	0.486	2.492	0.247	2.449	0.315
2.476	0.465	2.531	0.490	2.504	0.242	2.461	0.315
2.488	0.466	2.544	0.489	2.516	0.244	2.473	0.314
2.500	0.464	2.556	0.490	2.528	0.246	2.485	0.315
2.512	0.466	2.568	0.490	2.540	0.244	2.497	0.312
2.524	0.465	2.581	0.490	2.553	0.247	2.509	0.314
2.536	0.464	2.593	0.493	2.565	0.246	2.521	0.313
2.548	0.466	2.605	0.491	2.577	0.247	2.532	0.314
2.560	0.465	2.618	0.491	2.589	0.247	2.544	0.313
2.572	0.466	2.630	0.491	2.601	0.249	2.556	0.315
2.584	0.466	2.642	0.491	2.613	0.248	2.568	0.314
2.596	0.464	2.654	0.492	2.626	0.247	2.580	0.315
2.608	0.465	2.667	0.491	2.638	0.248	2.592	0.315
2.620	0.466	2.679	0.487	2.650	0.247	2.604	0.316

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.632	0.468	2.691	0.490	2.662	0.252	2.616	0.315
2.644	0.470	2.704	0.482	2.674	0.252	2.628	0.317
2.656	0.470	2.716	0.484	2.686	0.249	2.640	0.300
2.668	0.466	2.728	0.478	2.698	0.249	2.652	0.321
2.680	0.467	2.740	0.483	2.711	0.249	2.664	0.319
2.692	0.464	2.753	0.480	2.723	0.248	2.676	0.318
2.704	0.458	2.765	0.475	2.735	0.249	2.688	0.315
2.716	0.458	2.777	0.474	2.747	0.249	2.700	0.314
2.728	0.459	2.790	0.472	2.759	0.249	2.712	0.315
2.740	0.458	2.802	0.468	2.771	0.249	2.724	0.314
2.752	0.454	2.814	0.464	2.784	0.250	2.736	0.310
2.764	0.453	2.826	0.460	2.796	0.249	2.747	0.308
2.776	0.449	2.839	0.456	2.808	0.243	2.759	0.306
2.788	0.444	2.851	0.453	2.820	0.241	2.771	0.304
2.800	0.439	2.863	0.443	2.832	0.239	2.783	0.301
2.812	0.433	2.876	0.440	2.844	0.242	2.795	0.298
2.824	0.422	2.888	0.433	2.856	0.238	2.807	0.292
2.836	0.413	2.900	0.425	2.869	0.235	2.819	0.288
2.848	0.408	2.912	0.417	2.881	0.232	2.831	0.281
2.860	0.398	2.925	0.412	2.893	0.228	2.843	0.276
2.872	0.386	2.937	0.405	2.905	0.222	2.855	0.270
2.884	0.378	2.949	0.397	2.917	0.218	2.867	0.263

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.896	0.366	2.962	0.387	2.929	0.214	2.879	0.258
2.908	0.355	2.974	0.380	2.942	0.208	2.891	0.251
2.920	0.344	2.986	0.372	2.954	0.205	2.903	0.245
2.932	0.333	2.998	0.362	2.966	0.197	2.915	0.237
2.944	0.320	3.011	0.356	2.978	0.194	2.927	0.229
2.956	0.310	3.023	0.353	2.990	0.191	2.939	0.221
2.968	0.300	3.035	0.345	3.002	0.184	2.951	0.213
2.980	0.289	3.048	0.334	3.014	0.180	2.962	0.204
2.992	0.279	3.060	0.326	3.027	0.175	2.974	0.199
3.004	0.263	3.072	0.318	3.039	0.169	2.986	0.191
3.016	0.252	3.084	0.308	3.051	0.163	2.998	0.184
3.028	0.244	3.097	0.300	3.063	0.159	3.010	0.176
3.040	0.236	3.109	0.291	3.075	0.154	3.022	0.170
3.052	0.224	3.121	0.284	3.087	0.149	3.034	0.163
3.064	0.217	3.134	0.278	3.100	0.144	3.046	0.155
3.076	0.207	3.146	0.269	3.112	0.139	3.058	0.150
3.088	0.211	3.158	0.260	3.124	0.134	3.070	0.145
3.100	0.194	3.171	0.253	3.136	0.126	3.082	0.137
3.113	0.181	3.183	0.247	3.148	0.126	3.094	0.131
3.125	0.174	3.195	0.240	3.160	0.119	3.106	0.125
3.137	0.164	3.207	0.233	3.172	0.115	3.118	0.121
3.149	0.158	3.220	0.231	3.185	0.111	3.130	0.114

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.161	0.151	3.232	0.219	3.197	0.107	3.142	0.106
3.173	0.144	3.244	0.215	3.209	0.103	3.154	0.101
3.185	0.138	3.257	0.210	3.221	0.099	3.166	0.094
3.197	0.132	3.269	0.203	3.233	0.096	3.178	0.095
3.209	0.126	3.281	0.198	3.245	0.092	3.189	0.091
3.221	0.120	3.293	0.195	3.258	0.090	3.201	0.086
3.233	0.117	3.306	0.187	3.270	0.086	3.213	0.079
3.245	0.111	3.318	0.182	3.282	0.084	3.225	0.078
3.257	0.105	3.330	0.177	3.294	0.080	3.237	0.071
3.269	0.101	3.343	0.171	3.306	0.077	3.249	0.068
3.281	0.095	3.355	0.166	3.318	0.074	3.261	0.064
3.293	0.092	3.367	0.161	3.331	0.071	3.273	0.062
3.305	0.088	3.379	0.157	3.343	0.067	3.285	0.057
3.317	0.083	3.392	0.153	3.355	0.066	3.297	0.056
3.329	0.078	3.404	0.149	3.367	0.063	3.309	0.053
3.341	0.075	3.416	0.145	3.379	0.060	3.321	0.049
3.353	0.072	3.429	0.139	3.391	0.059	3.333	0.045
3.365	0.068	3.441	0.136	3.403	0.055	3.345	0.042
3.377	0.064	3.453	0.130	3.416	0.054	3.357	0.040
3.389	0.062	3.465	0.126	3.428	0.051	3.369	0.037
3.401	0.058	3.478	0.123	3.440	0.049	3.381	0.035
3.413	0.055	3.490	0.120	3.452	0.048	3.393	0.033

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.425	0.053	3.502	0.118	3.464	0.047	3.404	0.033
3.437	0.049	3.515	0.112	3.476	0.045	3.416	0.028
3.449	0.047	3.527	0.108	3.489	0.044	3.428	0.026
3.461	0.045	3.539	0.104	3.501	0.040	3.440	0.024
3.473	0.042	3.551	0.101	3.513	0.039	3.452	0.023
3.485	0.040	3.564	0.096	3.525	0.037	3.464	0.021
3.497	0.038	3.576	0.093	3.537	0.037	3.476	0.019
3.509	0.035	3.588	0.090	3.549	0.035	3.488	0.017
3.521	0.034	3.601	0.087	3.561	0.034	3.500	0.015
3.533	0.032	3.613	0.083	3.574	0.033	3.512	0.013
3.545	0.030	3.625	0.078	3.586	0.031	3.524	0.012
3.557	0.028	3.637	0.076	3.598	0.029	3.536	0.011
3.569	0.027	3.650	0.074	3.610	0.029	3.548	0.010
3.581	0.025	3.662	0.070	3.622	0.027	3.560	0.009
3.593	0.024	3.674	0.068	3.634	0.027	3.572	0.007
3.605	0.022	3.687	0.065	3.647	0.026	3.584	0.006
3.617	0.022	3.699	0.062	3.659	0.025	3.596	0.005
3.629	0.020	3.711	0.060	3.671	0.025	3.608	0.003
3.641	0.018	3.724	0.058	3.683	0.023	3.619	0.003
3.653	0.017	3.736	0.054	3.695	0.022	3.631	0.002
3.665	0.015	3.748	0.052	3.707	0.021	3.643	0.000
3.677	0.016	3.760	0.049	3.719	0.020	3.655	-0.001

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.689	0.014	3.773	0.048	3.732	0.018	3.667	-0.001
3.701	0.013	3.785	0.044	3.744	0.018	3.679	-0.002
3.713	0.012	3.797	0.044	3.756	0.018	3.691	-0.001
3.725	0.010	3.810	0.040	3.768	0.016	3.703	-0.003
3.737	0.010	3.822	0.037	3.780	0.016	3.715	-0.005
3.749	0.009	3.834	0.036	3.792	0.015	3.727	-0.005
3.761	0.008	3.846	0.047	3.805	0.014	3.739	-0.005
3.773	0.007	3.859	0.032	3.817	0.013	3.751	-0.007
3.785	0.008	3.871	0.030	3.829	0.013	3.763	-0.007
3.798	0.007	3.883	0.028	3.841	0.012	3.775	-0.009
3.810	0.005	3.896	0.026	3.853	0.013	3.787	-0.009
3.822	0.005	3.908	0.024	3.865	0.013	3.799	-0.009
3.834	0.004	3.920	0.023	3.877	0.011	3.811	-0.009
3.846	0.004	3.932	0.021	3.890	0.011	3.823	-0.010
3.858	0.002	3.945	0.020	3.902	0.011	3.835	-0.010
3.870	0.002	3.957	0.017	3.914	0.010	3.846	-0.011
3.882	0.002	3.969	0.016	3.926	0.009	3.858	-0.012
3.894	0.000	3.982	0.014	3.938	0.008	3.870	-0.012
3.906	0.000	3.994	0.014	3.950	0.009	3.882	-0.013
3.918	-0.001	4.006	0.012	3.963	0.007	3.894	-0.013
3.930	-0.001	4.018	0.010	3.975	0.008	3.906	-0.013
3.942	-0.001	4.031	0.010	3.987	0.007	3.918	-0.013

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.954	-0.002	4.043	0.008	3.999	0.007	3.930	-0.014
3.966	-0.002	4.055	0.008	4.011	0.006	3.942	-0.015
3.978	-0.002	4.068	0.005	4.023	0.005	3.954	-0.016
3.990	-0.004	4.080	0.003	4.036	0.005	3.966	-0.016
4.002	-0.002	4.092	0.003	4.048	0.005	3.978	-0.016
4.014	-0.004	4.104	0.000	4.060	0.006	3.990	-0.016
4.026	-0.005	4.117	0.000	4.072	0.007	4.002	-0.017
4.038	-0.005	4.129	0.000	4.084	0.004	4.014	-0.017
4.050	-0.005	4.141	-0.002	4.096	0.004	4.026	-0.017
4.062	-0.005	4.154	-0.002	4.108	0.003	4.038	-0.017
4.074	-0.006	4.166	-0.003	4.121	0.003	4.050	-0.018
4.086	-0.006	4.178	-0.004	4.133	0.004	4.061	-0.019
4.098	-0.006	4.190	-0.004	4.145	0.002	4.073	-0.018
4.110	-0.007	4.203	-0.005	4.157	0.002	4.085	-0.019
4.122	-0.007	4.215	-0.006	4.169	0.002	4.097	-0.017
4.134	-0.008	4.227	-0.008	4.181	0.002	4.109	-0.020
4.146	-0.006	4.240	-0.008	4.194	0.001	4.121	-0.019
4.158	-0.008	4.252	-0.008	4.206	0.002	4.133	-0.020
4.170	-0.008	4.264	-0.008	4.218	0.001	4.145	-0.020
4.182	-0.007	4.277	0.006	4.230	0.001	4.157	-0.020
4.194	-0.008	4.289	-0.009	4.242	0.001	4.169	-0.021
4.206	-0.010	4.301	-0.011	4.254	0.001	4.181	-0.021

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.218	-0.008	4.313	-0.011	4.266	0.001	4.193	-0.022
4.230	-0.010	4.326	-0.013	4.279	0.000	4.205	-0.021
4.242	-0.010	4.338	-0.013	4.291	0.000	4.217	-0.021
4.254	-0.009	4.350	-0.013	4.303	0.000	4.229	-0.021
4.266	-0.010	4.363	-0.013	4.315	0.000	4.241	-0.022
4.278	-0.011	4.375	-0.013	4.327	0.000	4.253	-0.022
4.290	-0.010	4.387	-0.014	4.339	-0.002	4.265	-0.022
4.302	-0.010	4.399	-0.014	4.352	-0.002	4.277	-0.022
4.314	-0.011	4.412	-0.015	4.364	-0.001	4.288	-0.023
4.326	-0.011	4.424	-0.016	4.376	-0.001	4.300	-0.023
4.338	-0.011	4.436	-0.016	4.388	-0.001	4.312	-0.023
4.350	-0.012	4.449	-0.016	4.400	-0.001	4.324	-0.023
4.362	-0.011	4.461	-0.013	4.412	-0.002	4.336	-0.023
4.374	-0.011	4.473	-0.016	4.424	-0.002	4.348	-0.023
4.386	-0.012	4.485	-0.018	4.437	-0.002	4.360	-0.023
4.398	-0.012	4.498	-0.018	4.449	-0.002	4.372	-0.022
4.410	-0.012	4.510	-0.017	4.461	-0.002	4.384	-0.023
4.422	-0.012	4.522	-0.018	4.473	-0.002	4.396	-0.024
4.434	-0.012	4.535	-0.018	4.485	-0.002	4.408	-0.024
4.446	-0.012	4.547	-0.018	4.497	-0.002	4.420	-0.024
4.458	-0.012	4.559	-0.020	4.510	-0.002	4.432	-0.024
4.470	-0.013	4.571	-0.018	4.522	-0.002	4.444	-0.024

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.483	-0.012	4.584	-0.019	4.534	-0.004	4.456	-0.024
4.495	-0.014	4.596	-0.018	4.546	-0.003	4.468	-0.024
4.507	-0.014	4.608	-0.019	4.558	-0.002	4.480	-0.024
4.519	-0.012	4.621	-0.019	4.570	-0.004	4.492	-0.026
4.531	-0.013	4.633	-0.019	4.582	-0.002	4.503	-0.026
4.543	-0.014	4.645	-0.020	4.595	-0.004	4.515	-0.026
4.555	-0.014	4.657	-0.009	4.607	-0.004	4.527	-0.026
4.567	-0.014	4.670	-0.018	4.619	-0.004	4.539	-0.026
4.579	-0.014	4.682	-0.021	4.631	-0.004	4.551	-0.024
4.591	-0.015	4.694	-0.021	4.643	-0.004	4.563	-0.026
4.603	-0.013	4.707	-0.021	4.655	-0.004	4.575	-0.026
4.615	-0.013	4.719	-0.021	4.668	-0.004	4.587	-0.026
4.627	-0.012	4.731	-0.021	4.680	-0.004	4.599	-0.024
4.639	-0.014	4.743	-0.021	4.692	-0.004	4.611	-0.026
4.651	-0.015	4.756	-0.021	4.704	-0.004	4.623	-0.026
4.663	-0.015	4.768	-0.022	4.716	-0.005	4.635	-0.026
4.675	-0.015	4.780	-0.022	4.728	-0.001	4.647	-0.024
4.687	-0.015	4.793	-0.021	4.740	-0.004	4.659	-0.026
4.699	-0.014	4.805	-0.021	4.753	-0.004	4.671	-0.026
4.711	-0.015	4.817	-0.021	4.765	-0.005	4.683	-0.026
4.723	-0.014	4.830	-0.022	4.777	-0.004	4.695	-0.027
4.735	-0.016	4.842	-0.023	4.789	-0.005	4.707	-0.026

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.747	-0.015	4.854	-0.023	4.801	-0.005	4.718	-0.026
4.759	-0.014	4.866	-0.024	4.813	-0.005	4.730	-0.026
4.771	-0.015	4.879	-0.024	4.826	-0.006	4.742	-0.027
4.783	-0.015	4.891	-0.009	4.838	-0.006	4.754	-0.027
4.795	-0.015	4.903	-0.024	4.850	-0.006	4.766	-0.028
4.807	-0.015	4.916	-0.024	4.862	-0.006	4.778	-0.026
4.819	-0.016	4.928	-0.024	4.874	-0.005	4.790	-0.027
4.831	-0.014	4.940	-0.024	4.886	-0.005	4.802	-0.027
4.843	-0.014	4.952	-0.024	4.899	-0.005	4.814	-0.027
4.855	-0.014	4.965	-0.024	4.911	-0.006	4.826	-0.027
4.867	-0.015	4.977	-0.024	4.923	-0.006	4.838	-0.027
4.879	-0.016	4.989	-0.024	4.935	-0.006	4.850	-0.027
4.891	-0.015	5.002	-0.025	4.947	-0.006	4.862	-0.027
4.903	-0.016	5.014	-0.024	4.959	-0.006	4.874	-0.026
4.915	-0.016	5.026	-0.024	4.971	-0.005	4.886	-0.027
4.927	-0.016	5.038	-0.024	4.984	-0.005	4.898	-0.027
4.939	-0.016	5.051	-0.026	4.996	-0.006	4.910	-0.027
4.951	-0.015	5.063	-0.026	5.008	-0.006	4.922	-0.027
4.963	-0.016	5.075	-0.026	5.020	-0.006	4.934	-0.028
4.975	-0.015	5.088	-0.026	5.032	-0.006	4.945	-0.028
4.987	-0.016	5.100	-0.026	5.044	-0.006	4.957	-0.028
4.999	-0.015	5.112	-0.026	5.057	-0.007	4.969	-0.028

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.011	-0.016	5.124	-0.019	5.069	-0.005	4.981	-0.027
5.023	-0.015	5.137	-0.024	5.081	-0.007	4.993	-0.028
5.035	-0.016	5.149	-0.026	5.093	-0.006	5.005	-0.028
5.047	-0.016	5.161	-0.026	5.105	-0.006	5.017	-0.028
5.059	-0.015	5.174	-0.026	5.117	-0.006	5.029	-0.029
5.071	-0.016	5.186	-0.026	5.129	-0.007	5.041	-0.028
5.083	-0.016	5.198	-0.027	5.142	-0.006	5.053	-0.028
5.095	-0.016	5.210	-0.027	5.154	-0.006	5.065	-0.028
5.107	-0.015	5.223	-0.027	5.166	-0.006	5.077	-0.029
5.119	-0.016	5.235	-0.027	5.178	-0.006	5.089	-0.029
5.131	-0.015	5.247	-0.027	5.190	-0.006	5.101	-0.028
5.143	-0.016	5.260	-0.027	5.202	-0.006	5.113	-0.029
5.155	-0.016	5.272	-0.026	5.215	-0.006	5.125	-0.028
5.167	-0.016	5.284	-0.027	5.227	-0.006	5.137	-0.029
5.180	-0.015	5.296	-0.027	5.239	-0.006	5.149	-0.028
5.192	-0.016	5.309	-0.028	5.251	-0.006	5.160	-0.029
5.204	-0.016	5.321	-0.028	5.263	-0.006	5.172	-0.028
5.216	-0.016	5.333	-0.028	5.275	-0.006	5.184	-0.028
5.228	-0.016	5.346	-0.028	5.287	-0.006	5.196	-0.028
5.240	-0.016	5.358	-0.029	5.300	-0.006	5.208	-0.029
5.252	-0.018	5.370	-0.028	5.312	-0.006	5.220	-0.029
5.264	-0.016	5.383	-0.028	5.324	-0.004	5.232	-0.029

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.276	-0.016	5.395	-0.028	5.336	-0.003	5.244	-0.029
5.288	-0.016	5.407	-0.016	5.348	-0.007	5.256	-0.028
5.300	-0.016	5.419	-0.028	5.360	-0.006	5.268	-0.029
5.312	-0.016	5.432	-0.029	5.373	-0.007	5.280	-0.029
5.324	-0.016	5.444	-0.028	5.385	-0.008	5.292	-0.027
5.336	-0.016	5.456	-0.029	5.397	-0.006	5.304	-0.029
5.348	-0.018	5.469	-0.028	5.409	-0.006	5.316	-0.029
5.360	-0.016	5.481	-0.029	5.421	-0.007	5.328	-0.029
5.372	-0.016	5.493	-0.029	5.433	-0.007	5.340	-0.029
5.384	-0.016	5.505	-0.028	5.445	-0.007	5.352	-0.029
5.396	-0.016	5.518	-0.029	5.458	-0.006	5.364	-0.030
5.408	-0.016	5.530	-0.029	5.470	-0.007	5.375	-0.030
5.420	-0.016	5.542	-0.029	5.482	-0.008	5.387	-0.030
5.432	-0.016	5.555	-0.028	5.494	-0.007	5.399	-0.029
5.444	-0.016	5.567	-0.029	5.506	-0.007	5.411	-0.028
5.456	-0.016	5.579	-0.029	5.518	-0.007	5.423	-0.029
5.468	-0.018	5.591	-0.029	5.531	-0.008	5.435	-0.030
5.480	-0.016	5.604	-0.028	5.543	-0.007	5.447	-0.030
5.492	-0.016	5.616	-0.023	5.555	-0.007	5.459	-0.030
5.504	-0.016	5.628	-0.030	5.567	-0.008	5.471	-0.029
5.516	-0.016	5.641	-0.030	5.579	-0.008	5.483	-0.029
5.528	-0.016	5.653	-0.029	5.591	-0.007	5.495	-0.029

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.540	-0.018	5.665	-0.030	5.604	-0.007	5.507	-0.029
5.552	-0.016	5.677	-0.030	5.616	-0.007	5.519	-0.029
5.564	-0.016	5.690	-0.031	5.628	0.001	5.531	-0.029
5.576	-0.016	5.702	-0.031	5.640	-0.007	5.543	-0.031
5.588	-0.016	5.714	-0.030	5.652	-0.008	5.555	-0.030
5.600	-0.018	5.727	-0.031	5.664	-0.008	5.567	-0.029
5.612	-0.018	5.739	-0.030	5.676	-0.007	5.579	-0.029
5.624	-0.018	5.751	-0.030	5.689	-0.008	5.591	-0.029
5.636	-0.016	5.763	-0.031	5.701	-0.008	5.602	-0.029
5.648	-0.016	5.776	-0.032	5.713	-0.008	5.614	-0.030
5.660	-0.018	5.788	-0.031	5.725	-0.008	5.626	-0.030
5.672	-0.018	5.800	-0.031	5.737	-0.006	5.638	-0.029
5.684	-0.016	5.813	-0.031	5.749	-0.007	5.650	-0.030
5.696	-0.018	5.825	-0.031	5.762	-0.007	5.662	-0.029
5.708	-0.015	5.837	-0.030	5.774	-0.007	5.674	-0.030
5.720	-0.016	5.849	-0.032	5.786	-0.006	5.686	-0.029
5.732	-0.018	5.862	-0.032	5.798	-0.006	5.698	-0.030
5.744	-0.018	5.874	-0.032	5.810	-0.008	5.710	-0.029
5.756	-0.018	5.886	-0.032	5.822	-0.006	5.722	-0.030
5.768	-0.016	5.899	-0.032	5.834	-0.008	5.734	-0.031
5.780	-0.018	5.911	-0.032	5.847	-0.007	5.746	-0.032
5.792	-0.018	5.923	-0.032	5.859	-0.007	5.758	-0.030

Table A5. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.804	-0.018	5.936	-0.032	5.871	-0.008	5.770	-0.031
5.816	-0.018	5.948	-0.032	5.883	-0.008	5.782	-0.031
5.828	-0.018	5.960	-0.030	5.895	-0.008	5.794	-0.031
5.840	-0.016	5.972	-0.032	5.907	-0.008	5.806	-0.031
5.852	-0.016	5.985	-0.032	5.920	-0.008	5.817	-0.030
5.865	-0.018	5.997	-0.031	5.932	-0.006	5.829	-0.032
5.877	-0.018	6.009	-0.032	5.944	-0.006	5.841	-0.032
5.889	-0.018	6.022	-0.032	5.956	-0.008	5.853	-0.030
5.901	-0.018	6.034	-0.032	5.968	-0.009	5.865	-0.031
5.913	-0.018	6.046	-0.032	5.980	-0.008	5.877	-0.031
5.925	-0.018	6.058	-0.032	5.992	-0.008	5.889	-0.032
5.937	-0.018	6.071	-0.032	6.005	-0.008	5.901	-0.031

Table A6. Breakthrough concentrations of the tet^R and tet^S *E.coli* strains at 25% of soil moisture content and under ionic strength condition of 10 mM NaCl. Where, PV is the pore volume of the sand packed column at 25% of soil moisture content and C/Co is the normalized breakthrough concentrations.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.000	-0.001	0.000	0.012	0.000	0.001	0.000	0.015
0.012	-0.001	0.012	0.011	0.012	0.001	0.012	0.015
0.024	-0.002	0.024	0.012	0.024	0.002	0.024	0.015
0.036	-0.003	0.036	0.012	0.036	0.001	0.036	0.014
0.048	-0.004	0.048	0.011	0.048	0.000	0.048	0.014

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.060	0.000	0.060	0.011	0.060	0.001	0.060	0.013
0.072	-0.004	0.072	0.010	0.072	0.000	0.072	0.014
0.084	-0.004	0.084	0.012	0.084	0.000	0.084	0.012
0.096	-0.004	0.096	0.011	0.096	0.000	0.096	0.012
0.108	-0.005	0.109	0.009	0.108	0.000	0.108	0.012
0.120	-0.004	0.121	0.009	0.120	0.000	0.120	0.012
0.132	-0.006	0.133	0.008	0.132	0.000	0.132	0.012
0.144	-0.006	0.145	0.008	0.144	0.000	0.144	0.010
0.156	-0.006	0.157	0.011	0.156	0.000	0.156	0.011
0.168	-0.006	0.169	0.009	0.168	0.000	0.168	0.010
0.180	-0.006	0.181	0.010	0.180	0.000	0.180	0.012
0.192	-0.006	0.193	0.009	0.192	-0.002	0.192	0.010
0.203	-0.008	0.205	0.010	0.204	-0.001	0.203	0.012
0.215	-0.008	0.217	0.011	0.216	0.000	0.215	0.012
0.227	-0.008	0.229	0.009	0.228	-0.002	0.227	0.010
0.239	-0.009	0.241	0.008	0.240	-0.001	0.239	0.011
0.251	-0.009	0.253	0.008	0.252	0.001	0.251	0.012
0.263	-0.009	0.265	0.008	0.264	-0.002	0.263	0.010
0.275	-0.009	0.277	0.008	0.276	-0.002	0.275	0.011
0.287	-0.009	0.289	0.008	0.288	-0.002	0.287	0.010
0.299	-0.010	0.301	0.008	0.300	-0.003	0.299	0.010
0.311	-0.010	0.314	0.008	0.312	-0.002	0.311	0.010

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.323	-0.010	0.326	0.007	0.324	-0.003	0.323	0.010
0.335	-0.011	0.338	0.007	0.335	-0.002	0.335	0.010
0.347	-0.010	0.350	0.008	0.347	-0.003	0.347	0.009
0.359	-0.011	0.362	0.006	0.359	0.002	0.359	0.010
0.371	-0.011	0.374	0.005	0.371	-0.002	0.371	0.010
0.383	-0.011	0.386	0.005	0.383	-0.004	0.383	0.011
0.395	-0.011	0.398	0.005	0.395	-0.004	0.395	0.008
0.407	-0.010	0.410	0.004	0.407	-0.004	0.407	0.008
0.419	-0.013	0.422	0.003	0.419	-0.004	0.419	0.008
0.431	-0.013	0.434	0.003	0.431	-0.004	0.431	0.007
0.443	-0.012	0.446	0.003	0.443	-0.004	0.443	0.006
0.455	-0.013	0.458	0.002	0.455	-0.002	0.455	0.007
0.467	-0.009	0.470	0.002	0.467	-0.004	0.467	0.007
0.479	-0.009	0.482	0.001	0.479	-0.003	0.479	0.006
0.491	-0.010	0.494	0.002	0.491	-0.004	0.491	0.006
0.503	-0.013	0.506	-0.001	0.503	-0.005	0.503	0.006
0.515	-0.014	0.519	0.000	0.515	-0.004	0.515	0.006
0.527	-0.013	0.531	-0.001	0.527	-0.003	0.527	0.005
0.539	-0.014	0.543	-0.001	0.539	-0.005	0.539	0.006
0.551	-0.013	0.555	-0.002	0.551	-0.006	0.551	0.005
0.563	-0.014	0.567	-0.002	0.563	-0.005	0.563	0.005
0.575	-0.013	0.579	-0.002	0.575	-0.005	0.575	0.002

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.587	-0.013	0.591	-0.002	0.587	-0.005	0.587	0.001
0.598	-0.014	0.603	-0.003	0.599	-0.006	0.598	0.001
0.610	-0.013	0.615	-0.002	0.611	-0.005	0.610	0.001
0.622	-0.012	0.627	-0.002	0.623	-0.004	0.622	0.000
0.634	-0.011	0.639	-0.002	0.635	-0.004	0.634	0.001
0.646	-0.009	0.651	-0.001	0.647	-0.002	0.646	0.001
0.658	-0.006	0.663	0.000	0.659	-0.002	0.658	0.002
0.670	-0.006	0.675	0.000	0.671	-0.001	0.670	0.004
0.682	-0.003	0.687	0.002	0.683	0.000	0.682	0.004
0.694	0.002	0.699	0.004	0.695	0.003	0.694	0.006
0.706	0.003	0.712	0.006	0.707	0.005	0.706	0.012
0.718	0.007	0.724	0.008	0.719	0.008	0.718	0.014
0.730	0.010	0.736	0.011	0.731	0.012	0.730	0.015
0.742	0.015	0.748	0.016	0.743	0.014	0.742	0.018
0.754	0.019	0.760	0.020	0.755	0.018	0.754	0.020
0.766	0.024	0.772	0.022	0.767	0.022	0.766	0.023
0.778	0.030	0.784	0.026	0.779	0.023	0.778	0.027
0.790	0.036	0.796	0.031	0.791	0.034	0.790	0.030
0.802	0.042	0.808	0.036	0.803	0.037	0.802	0.037
0.814	0.047	0.820	0.042	0.815	0.042	0.814	0.041
0.826	0.055	0.832	0.048	0.827	0.047	0.826	0.044
0.838	0.061	0.844	0.054	0.839	0.052	0.838	0.047

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
0.850	0.067	0.856	0.061	0.851	0.058	0.850	0.051
0.862	0.075	0.868	0.065	0.863	0.064	0.862	0.053
0.874	0.071	0.880	0.080	0.875	0.067	0.874	0.059
0.886	0.091	0.892	0.083	0.887	0.071	0.886	0.065
0.898	0.099	0.904	0.090	0.899	0.079	0.898	0.069
0.910	0.104	0.917	0.097	0.911	0.084	0.910	0.073
0.922	0.109	0.929	0.105	0.923	0.092	0.922	0.077
0.934	0.118	0.941	0.112	0.935	0.095	0.934	0.083
0.946	0.126	0.953	0.120	0.947	0.103	0.946	0.088
0.958	0.136	0.965	0.126	0.959	0.107	0.958	0.092
0.970	0.143	0.977	0.135	0.971	0.110	0.970	0.096
0.981	0.149	0.989	0.141	0.982	0.114	0.981	0.101
0.993	0.160	1.001	0.149	0.994	0.119	0.993	0.106
1.005	0.170	1.013	0.156	1.006	0.122	1.005	0.111
1.017	0.176	1.025	0.160	1.018	0.126	1.017	0.114
1.029	0.181	1.037	0.168	1.030	0.122	1.029	0.120
1.041	0.188	1.049	0.173	1.042	0.140	1.041	0.131
1.053	0.193	1.061	0.181	1.054	0.144	1.053	0.131
1.065	0.202	1.073	0.186	1.066	0.148	1.065	0.135
1.077	0.209	1.085	0.192	1.078	0.152	1.077	0.139
1.089	0.214	1.097	0.199	1.090	0.155	1.089	0.142
1.101	0.222	1.109	0.205	1.102	0.156	1.101	0.146

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.113	0.229	1.122	0.201	1.114	0.161	1.113	0.150
1.125	0.237	1.134	0.222	1.126	0.163	1.125	0.153
1.137	0.242	1.146	0.225	1.138	0.168	1.137	0.159
1.149	0.248	1.158	0.228	1.150	0.170	1.149	0.161
1.161	0.254	1.170	0.236	1.162	0.179	1.161	0.166
1.173	0.258	1.182	0.243	1.174	0.184	1.173	0.170
1.185	0.264	1.194	0.246	1.186	0.185	1.185	0.173
1.197	0.271	1.206	0.252	1.198	0.187	1.197	0.175
1.209	0.274	1.218	0.255	1.210	0.190	1.209	0.180
1.221	0.281	1.230	0.262	1.222	0.192	1.221	0.184
1.233	0.286	1.242	0.277	1.234	0.196	1.233	0.187
1.245	0.291	1.254	0.275	1.246	0.198	1.245	0.167
1.257	0.295	1.266	0.280	1.258	0.202	1.257	0.201
1.269	0.300	1.278	0.285	1.270	0.203	1.269	0.202
1.281	0.285	1.290	0.289	1.282	0.209	1.281	0.203
1.293	0.313	1.302	0.294	1.294	0.198	1.293	0.203
1.305	0.317	1.314	0.296	1.306	0.221	1.305	0.207
1.317	0.321	1.327	0.299	1.318	0.224	1.317	0.208
1.329	0.323	1.339	0.304	1.330	0.223	1.329	0.211
1.341	0.326	1.351	0.298	1.342	0.227	1.341	0.213
1.353	0.329	1.363	0.313	1.354	0.229	1.353	0.217
1.365	0.332	1.375	0.312	1.366	0.230	1.365	0.218

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.376	0.337	1.387	0.314	1.378	0.230	1.376	0.220
1.388	0.340	1.399	0.320	1.390	0.235	1.388	0.223
1.400	0.343	1.411	0.322	1.402	0.236	1.400	0.224
1.412	0.345	1.423	0.326	1.414	0.240	1.412	0.227
1.424	0.348	1.435	0.328	1.426	0.243	1.424	0.228
1.436	0.350	1.447	0.333	1.438	0.245	1.436	0.230
1.448	0.353	1.459	0.334	1.450	0.249	1.448	0.234
1.460	0.349	1.471	0.337	1.462	0.211	1.460	0.234
1.472	0.362	1.483	0.349	1.474	0.258	1.472	0.238
1.484	0.364	1.495	0.349	1.486	0.261	1.484	0.236
1.496	0.365	1.507	0.351	1.498	0.259	1.496	0.240
1.508	0.366	1.519	0.352	1.510	0.260	1.508	0.241
1.520	0.369	1.532	0.356	1.522	0.261	1.520	0.234
1.532	0.369	1.544	0.358	1.534	0.263	1.532	0.249
1.544	0.371	1.556	0.361	1.546	0.266	1.544	0.249
1.556	0.373	1.568	0.363	1.558	0.266	1.556	0.249
1.568	0.374	1.580	0.363	1.570	0.269	1.568	0.249
1.580	0.377	1.592	0.367	1.582	0.259	1.580	0.251
1.592	0.378	1.604	0.370	1.594	0.278	1.592	0.251
1.604	0.354	1.616	0.371	1.606	0.279	1.604	0.252
1.616	0.384	1.628	0.360	1.618	0.279	1.616	0.253
1.628	0.384	1.640	0.384	1.629	0.281	1.628	0.253

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.640	0.387	1.652	0.381	1.641	0.282	1.640	0.256
1.652	0.385	1.664	0.383	1.653	0.281	1.652	0.254
1.664	0.387	1.676	0.385	1.665	0.283	1.664	0.258
1.676	0.388	1.688	0.385	1.677	0.285	1.676	0.257
1.688	0.388	1.700	0.388	1.689	0.285	1.688	0.264
1.700	0.389	1.712	0.388	1.701	0.287	1.700	0.265
1.712	0.391	1.724	0.391	1.713	0.289	1.712	0.265
1.724	0.392	1.737	0.392	1.725	0.295	1.724	0.264
1.736	0.394	1.749	0.375	1.737	0.297	1.736	0.265
1.748	0.394	1.761	0.398	1.749	0.295	1.748	0.264
1.760	0.394	1.773	0.397	1.761	0.295	1.760	0.265
1.771	0.395	1.785	0.396	1.773	0.297	1.771	0.266
1.783	0.396	1.797	0.398	1.785	0.297	1.783	0.267
1.795	0.423	1.809	0.398	1.797	0.297	1.795	0.268
1.807	0.401	1.821	0.400	1.809	0.297	1.807	0.267
1.819	0.400	1.833	0.400	1.821	0.300	1.819	0.269
1.831	0.400	1.845	0.403	1.833	0.299	1.831	0.269
1.843	0.401	1.857	0.403	1.845	0.298	1.843	0.269
1.855	0.402	1.869	0.383	1.857	0.305	1.855	0.270
1.867	0.403	1.881	0.407	1.869	0.306	1.867	0.272
1.879	0.404	1.893	0.405	1.881	0.309	1.879	0.238
1.891	0.403	1.905	0.406	1.893	0.308	1.891	0.280

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
1.903	0.403	1.917	0.405	1.905	0.308	1.903	0.277
1.915	0.403	1.929	0.407	1.917	0.309	1.915	0.278
1.927	0.431	1.942	0.407	1.929	0.309	1.927	0.277
1.939	0.407	1.954	0.408	1.941	0.309	1.939	0.279
1.951	0.407	1.966	0.408	1.953	0.309	1.951	0.274
1.963	0.407	1.978	0.411	1.965	0.311	1.963	0.272
1.975	0.405	1.990	0.408	1.977	0.274	1.975	0.274
1.987	0.407	2.002	0.421	1.989	0.316	1.987	0.274
1.999	0.406	2.014	0.417	2.001	0.316	1.999	0.272
2.011	0.407	2.026	0.415	2.013	0.316	2.011	0.272
2.023	0.407	2.038	0.418	2.025	0.316	2.023	0.275
2.035	0.408	2.050	0.417	2.037	0.316	2.035	0.275
2.047	0.409	2.062	0.417	2.049	0.314	2.047	0.275
2.059	0.408	2.074	0.418	2.061	0.315	2.059	0.276
2.071	0.404	2.086	0.417	2.073	0.317	2.071	0.276
2.083	0.414	2.098	0.418	2.085	0.317	2.083	0.280
2.095	0.409	2.110	0.419	2.097	0.318	2.095	0.280
2.107	0.414	2.122	0.420	2.109	0.318	2.107	0.282
2.119	0.413	2.135	0.421	2.121	0.318	2.119	0.280
2.131	0.412	2.147	0.403	2.133	0.319	2.131	0.253
2.143	0.413	2.159	0.427	2.145	0.319	2.143	0.289
2.155	0.414	2.171	0.425	2.157	0.323	2.155	0.286

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.166	0.412	2.183	0.425	2.169	0.326	2.166	0.286
2.178	0.414	2.195	0.425	2.181	0.324	2.178	0.285
2.190	0.415	2.207	0.426	2.193	0.324	2.190	0.284
2.202	0.414	2.219	0.425	2.205	0.323	2.202	0.284
2.214	0.446	2.231	0.427	2.217	0.324	2.214	0.285
2.226	0.416	2.243	0.426	2.229	0.323	2.226	0.285
2.238	0.416	2.255	0.434	2.241	0.323	2.238	0.283
2.250	0.416	2.267	0.434	2.253	0.324	2.250	0.283
2.262	0.416	2.279	0.423	2.265	0.324	2.262	0.283
2.274	0.415	2.291	0.441	2.276	0.324	2.274	0.286
2.286	0.415	2.303	0.436	2.288	0.324	2.286	0.284
2.298	0.414	2.315	0.436	2.300	0.331	2.298	0.285
2.310	0.414	2.327	0.435	2.312	0.332	2.310	0.284
2.322	0.409	2.340	0.436	2.324	0.330	2.322	0.285
2.334	0.419	2.352	0.435	2.336	0.330	2.334	0.262
2.346	0.419	2.364	0.436	2.348	0.331	2.346	0.289
2.358	0.418	2.376	0.437	2.360	0.330	2.358	0.289
2.370	0.418	2.388	0.437	2.372	0.328	2.370	0.287
2.382	0.418	2.400	0.438	2.384	0.328	2.382	0.287
2.394	0.416	2.412	0.448	2.396	0.328	2.394	0.285
2.406	0.416	2.424	0.444	2.408	0.328	2.406	0.285
2.418	0.418	2.436	0.442	2.420	0.328	2.418	0.284

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.430	0.418	2.448	0.441	2.432	0.328	2.430	0.283
2.442	0.416	2.460	0.442	2.444	0.334	2.442	0.284
2.454	0.418	2.472	0.442	2.456	0.334	2.454	0.283
2.466	0.419	2.484	0.444	2.468	0.332	2.466	0.285
2.478	0.418	2.496	0.444	2.480	0.331	2.478	0.284
2.490	0.418	2.508	0.445	2.492	0.331	2.490	0.284
2.502	0.433	2.520	0.444	2.504	0.331	2.502	0.284
2.514	0.421	2.532	0.446	2.516	0.338	2.514	0.275
2.526	0.420	2.545	0.482	2.528	0.340	2.526	0.287
2.538	0.421	2.557	0.449	2.540	0.340	2.538	0.286
2.550	0.420	2.569	0.446	2.552	0.339	2.550	0.287
2.561	0.419	2.581	0.447	2.564	0.340	2.561	0.285
2.573	0.419	2.593	0.447	2.576	0.339	2.573	0.284
2.585	0.418	2.605	0.446	2.588	0.331	2.585	0.285
2.597	0.419	2.617	0.447	2.600	0.346	2.597	0.284
2.609	0.419	2.629	0.446	2.612	0.344	2.609	0.284
2.621	0.421	2.641	0.447	2.624	0.344	2.621	0.284
2.633	0.438	2.653	0.450	2.636	0.342	2.633	0.282
2.645	0.420	2.665	0.448	2.648	0.343	2.645	0.284
2.657	0.423	2.677	0.449	2.660	0.342	2.657	0.284
2.669	0.420	2.689	0.451	2.672	0.341	2.669	0.283
2.681	0.421	2.701	0.450	2.684	0.342	2.681	0.282

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.693	0.421	2.713	0.450	2.696	0.342	2.693	0.282
2.705	0.420	2.725	0.487	2.708	0.342	2.705	0.282
2.717	0.420	2.737	0.453	2.720	0.342	2.717	0.259
2.729	0.419	2.750	0.451	2.732	0.348	2.729	0.285
2.741	0.420	2.762	0.451	2.744	0.346	2.741	0.284
2.753	0.419	2.774	0.450	2.756	0.344	2.753	0.282
2.765	0.419	2.786	0.449	2.768	0.344	2.765	0.278
2.777	0.418	2.798	0.447	2.780	0.341	2.777	0.277
2.789	0.413	2.810	0.445	2.792	0.339	2.789	0.275
2.801	0.413	2.822	0.444	2.804	0.332	2.801	0.272
2.813	0.443	2.834	0.443	2.816	0.331	2.813	0.269
2.825	0.413	2.846	0.440	2.828	0.326	2.825	0.267
2.837	0.409	2.858	0.439	2.840	0.322	2.837	0.264
2.849	0.408	2.870	0.446	2.852	0.317	2.849	0.260
2.861	0.405	2.882	0.435	2.864	0.316	2.861	0.257
2.873	0.399	2.894	0.429	2.876	0.308	2.873	0.251
2.885	0.396	2.906	0.424	2.888	0.301	2.885	0.252
2.897	0.392	2.918	0.419	2.900	0.295	2.897	0.246
2.909	0.387	2.930	0.413	2.912	0.289	2.909	0.240
2.921	0.381	2.942	0.405	2.923	0.279	2.921	0.235
2.933	0.376	2.955	0.401	2.935	0.275	2.933	0.230
2.944	0.369	2.967	0.393	2.947	0.266	2.944	0.225

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
2.956	0.365	2.979	0.388	2.959	0.260	2.956	0.218
2.968	0.359	2.991	0.381	2.971	0.252	2.968	0.214
2.980	0.350	3.003	0.375	2.983	0.248	2.980	0.208
2.992	0.357	3.015	0.366	2.995	0.242	2.992	0.204
3.004	0.335	3.027	0.357	3.007	0.235	3.004	0.200
3.016	0.329	3.039	0.345	3.019	0.229	3.016	0.193
3.028	0.324	3.051	0.343	3.031	0.221	3.028	0.188
3.040	0.313	3.063	0.336	3.043	0.216	3.040	0.182
3.052	0.305	3.075	0.327	3.055	0.211	3.052	0.175
3.064	0.299	3.087	0.319	3.067	0.206	3.064	0.172
3.076	0.291	3.099	0.311	3.079	0.201	3.076	0.167
3.088	0.281	3.111	0.302	3.091	0.195	3.088	0.162
3.100	0.274	3.123	0.295	3.103	0.190	3.100	0.156
3.112	0.264	3.135	0.288	3.115	0.185	3.112	0.151
3.124	0.257	3.147	0.280	3.127	0.181	3.124	0.147
3.136	0.246	3.160	0.274	3.139	0.176	3.136	0.141
3.148	0.244	3.172	0.266	3.151	0.171	3.148	0.137
3.160	0.233	3.184	0.260	3.163	0.168	3.160	0.131
3.172	0.224	3.196	0.249	3.175	0.163	3.172	0.127
3.184	0.217	3.208	0.247	3.187	0.158	3.184	0.123
3.196	0.208	3.220	0.241	3.199	0.154	3.196	0.114
3.208	0.201	3.232	0.236	3.211	0.150	3.208	0.114

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.220	0.194	3.244	0.227	3.223	0.148	3.220	0.110
3.232	0.186	3.256	0.219	3.235	0.144	3.232	0.106
3.244	0.180	3.268	0.211	3.247	0.142	3.244	0.104
3.256	0.172	3.280	0.207	3.259	0.135	3.256	0.098
3.268	0.166	3.292	0.200	3.271	0.130	3.268	0.095
3.280	0.160	3.304	0.194	3.283	0.126	3.280	0.092
3.292	0.150	3.316	0.188	3.295	0.125	3.292	0.088
3.304	0.145	3.328	0.183	3.307	0.121	3.304	0.085
3.316	0.139	3.340	0.178	3.319	0.113	3.316	0.081
3.328	0.134	3.353	0.171	3.331	0.115	3.328	0.078
3.339	0.127	3.365	0.178	3.343	0.111	3.339	0.075
3.351	0.123	3.377	0.161	3.355	0.108	3.351	0.071
3.363	0.117	3.389	0.156	3.367	0.105	3.363	0.069
3.375	0.111	3.401	0.152	3.379	0.101	3.375	0.066
3.387	0.106	3.413	0.146	3.391	0.100	3.387	0.063
3.399	0.101	3.425	0.141	3.403	0.095	3.399	0.061
3.411	0.094	3.437	0.136	3.415	0.092	3.411	0.057
3.423	0.092	3.449	0.131	3.427	0.090	3.423	0.056
3.435	0.089	3.461	0.127	3.439	0.087	3.435	0.053
3.447	0.084	3.473	0.123	3.451	0.085	3.447	0.051
3.459	0.079	3.485	0.120	3.463	0.080	3.459	0.049
3.471	0.075	3.497	0.115	3.475	0.079	3.471	0.047

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.483	0.072	3.509	0.112	3.487	0.076	3.483	0.046
3.495	0.069	3.521	0.108	3.499	0.073	3.495	0.043
3.507	0.064	3.533	0.104	3.511	0.072	3.507	0.041
3.519	0.062	3.545	0.101	3.523	0.069	3.519	0.038
3.531	0.056	3.558	0.098	3.535	0.065	3.531	0.038
3.543	0.052	3.570	0.094	3.547	0.064	3.543	0.035
3.555	0.050	3.582	0.092	3.559	0.061	3.555	0.033
3.567	0.047	3.594	0.088	3.570	0.065	3.567	0.032
3.579	0.044	3.606	0.086	3.582	0.057	3.579	0.031
3.591	0.043	3.618	0.083	3.594	0.055	3.591	0.029
3.603	0.039	3.630	0.081	3.606	0.053	3.603	0.028
3.615	0.035	3.642	0.078	3.618	0.051	3.615	0.024
3.627	0.033	3.654	0.076	3.630	0.049	3.627	0.025
3.639	0.031	3.666	0.074	3.642	0.046	3.639	0.024
3.651	0.028	3.678	0.071	3.654	0.045	3.651	0.024
3.663	0.026	3.690	0.069	3.666	0.043	3.663	0.022
3.675	0.025	3.702	0.067	3.678	0.042	3.675	0.022
3.687	0.021	3.714	0.068	3.690	0.040	3.687	0.020
3.699	0.020	3.726	0.063	3.702	0.039	3.699	0.019
3.711	0.019	3.738	0.061	3.714	0.037	3.711	0.017
3.723	0.018	3.750	0.058	3.726	0.034	3.723	0.017
3.734	0.015	3.763	0.055	3.738	0.034	3.734	0.016

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
3.746	0.014	3.775	0.053	3.750	0.033	3.746	0.014
3.758	0.011	3.787	0.052	3.762	0.031	3.758	0.014
3.770	0.011	3.799	0.050	3.774	0.029	3.770	0.012
3.782	0.009	3.811	0.048	3.786	0.027	3.782	0.012
3.794	0.007	3.823	0.047	3.798	0.026	3.794	0.012
3.806	0.005	3.835	0.046	3.810	0.026	3.806	0.012
3.818	0.004	3.847	0.043	3.822	0.024	3.818	0.010
3.830	0.004	3.859	0.042	3.834	0.023	3.830	0.009
3.842	0.002	3.871	0.048	3.846	0.023	3.842	0.008
3.854	0.001	3.883	0.040	3.858	0.021	3.854	0.008
3.866	0.000	3.895	0.040	3.870	0.021	3.866	0.006
3.878	0.000	3.907	0.037	3.882	0.019	3.878	0.007
3.890	0.000	3.919	0.036	3.894	0.019	3.890	0.005
3.902	-0.002	3.931	0.035	3.906	0.023	3.902	0.005
3.914	-0.004	3.943	0.034	3.918	0.018	3.914	0.005
3.926	-0.005	3.955	0.033	3.930	0.015	3.926	0.004
3.938	-0.006	3.968	0.031	3.942	0.016	3.938	0.004
3.950	-0.006	3.980	0.029	3.954	0.014	3.950	0.004
3.962	-0.006	3.992	0.029	3.966	0.013	3.962	0.002
3.974	-0.008	4.004	0.028	3.978	0.012	3.974	0.002
3.986	-0.008	4.016	0.027	3.990	0.013	3.986	0.002
3.998	-0.010	4.028	0.027	4.002	0.012	3.998	0.002

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.010	-0.010	4.040	0.025	4.014	0.011	4.010	-0.001
4.022	-0.011	4.052	0.025	4.026	0.011	4.022	0.002
4.034	-0.012	4.064	0.023	4.038	0.013	4.034	0.000
4.046	-0.012	4.076	0.024	4.050	0.011	4.046	0.000
4.058	-0.011	4.088	0.022	4.062	0.008	4.058	0.001
4.070	-0.014	4.100	0.021	4.074	0.008	4.070	0.000
4.082	-0.014	4.112	0.021	4.086	0.008	4.082	0.000
4.094	-0.014	4.124	0.019	4.098	0.008	4.094	0.000
4.106	-0.015	4.136	0.018	4.110	0.008	4.106	-0.001
4.118	-0.015	4.148	0.018	4.122	0.006	4.118	-0.001
4.129	-0.016	4.160	0.016	4.134	0.007	4.129	-0.002
4.141	-0.017	4.173	0.016	4.146	0.007	4.141	-0.002
4.153	-0.017	4.185	0.015	4.158	0.006	4.153	-0.002
4.165	-0.015	4.197	0.016	4.170	0.010	4.165	-0.003
4.177	-0.018	4.209	0.016	4.182	0.007	4.177	-0.004
4.189	-0.019	4.221	0.014	4.194	0.004	4.189	-0.003
4.201	-0.019	4.233	0.014	4.206	0.005	4.201	-0.004
4.213	-0.019	4.245	0.014	4.217	0.004	4.213	-0.004
4.225	-0.018	4.257	0.015	4.229	0.004	4.225	-0.004
4.237	-0.019	4.269	0.012	4.241	0.004	4.237	-0.004
4.249	-0.019	4.281	0.012	4.253	0.004	4.249	-0.004
4.261	-0.020	4.293	0.011	4.265	0.003	4.261	-0.004

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.273	-0.020	4.305	0.011	4.277	0.003	4.273	-0.004
4.285	-0.021	4.317	0.011	4.289	0.003	4.285	-0.006
4.297	-0.021	4.329	0.010	4.301	0.004	4.297	-0.005
4.309	-0.021	4.341	0.011	4.313	0.005	4.309	-0.006
4.321	-0.021	4.353	0.010	4.325	0.002	4.321	-0.006
4.333	-0.019	4.365	0.009	4.337	0.002	4.333	-0.004
4.345	-0.021	4.378	0.008	4.349	0.001	4.345	-0.004
4.357	-0.022	4.390	0.009	4.361	0.000	4.357	-0.006
4.369	-0.023	4.402	0.009	4.373	0.000	4.369	-0.007
4.381	-0.023	4.414	0.008	4.385	0.000	4.381	-0.007
4.393	-0.023	4.426	0.008	4.397	0.000	4.393	-0.007
4.405	-0.023	4.438	0.008	4.409	0.000	4.405	-0.007
4.417	-0.024	4.450	0.008	4.421	0.000	4.417	-0.006
4.429	-0.023	4.462	0.010	4.433	0.000	4.429	-0.007
4.441	-0.022	4.474	0.007	4.445	-0.001	4.441	-0.007
4.453	-0.024	4.486	0.007	4.457	-0.001	4.453	-0.007
4.465	-0.024	4.498	0.007	4.469	0.000	4.465	-0.008
4.477	-0.021	4.510	0.006	4.481	0.000	4.477	-0.007
4.489	-0.024	4.522	0.006	4.493	-0.001	4.489	-0.007
4.501	-0.025	4.534	0.006	4.505	-0.003	4.501	-0.008
4.513	-0.025	4.546	0.006	4.517	-0.002	4.513	-0.008
4.524	-0.025	4.558	0.006	4.529	-0.002	4.524	-0.006

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.536	-0.024	4.570	0.005	4.541	-0.002	4.536	-0.006
4.548	-0.025	4.583	0.005	4.553	-0.002	4.548	-0.008
4.560	-0.025	4.595	0.005	4.565	-0.003	4.560	-0.008
4.572	-0.025	4.607	0.004	4.577	-0.003	4.572	-0.008
4.584	-0.025	4.619	0.005	4.589	-0.002	4.584	-0.008
4.596	-0.026	4.631	0.004	4.601	-0.003	4.596	-0.009
4.608	-0.026	4.643	0.003	4.613	-0.003	4.608	-0.009
4.620	-0.022	4.655	0.003	4.625	-0.003	4.620	-0.009
4.632	-0.025	4.667	0.003	4.637	-0.002	4.632	-0.009
4.644	-0.025	4.679	0.004	4.649	-0.004	4.644	-0.011
4.656	-0.026	4.691	0.004	4.661	-0.004	4.656	-0.009
4.668	-0.027	4.703	0.005	4.673	-0.005	4.668	-0.009
4.680	-0.027	4.715	0.005	4.685	-0.004	4.680	-0.011
4.692	-0.027	4.727	0.004	4.697	-0.004	4.692	-0.009
4.704	-0.027	4.739	0.003	4.709	-0.004	4.704	-0.009
4.716	-0.027	4.751	0.003	4.721	-0.004	4.716	-0.008
4.728	-0.027	4.763	0.002	4.733	-0.005	4.728	-0.009
4.740	-0.027	4.776	0.003	4.745	-0.005	4.740	-0.010
4.752	-0.025	4.788	0.003	4.757	-0.005	4.752	-0.011
4.764	-0.026	4.800	0.002	4.769	-0.004	4.764	-0.011
4.776	-0.026	4.812	0.002	4.781	-0.004	4.776	-0.011
4.788	-0.027	4.824	0.001	4.793	-0.007	4.788	-0.011

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
4.800	-0.028	4.836	0.001	4.805	-0.006	4.800	-0.010
4.812	-0.027	4.848	0.001	4.817	-0.007	4.812	-0.011
4.824	-0.028	4.860	0.001	4.829	-0.007	4.824	-0.011
4.836	-0.027	4.872	0.001	4.841	-0.007	4.836	-0.011
4.848	-0.027	4.884	0.001	4.853	-0.007	4.848	-0.011
4.860	-0.027	4.896	0.001	4.864	-0.007	4.860	-0.011
4.872	-0.027	4.908	0.001	4.876	-0.007	4.872	-0.011
4.884	-0.028	4.920	0.003	4.888	-0.007	4.884	-0.011
4.896	-0.028	4.932	0.003	4.900	-0.007	4.896	-0.011
4.907	-0.025	4.944	0.001	4.912	-0.008	4.907	-0.011
4.919	-0.029	4.956	0.001	4.924	-0.008	4.919	-0.011
4.931	-0.027	4.968	0.001	4.936	-0.007	4.931	-0.011
4.943	-0.028	4.981	0.001	4.948	-0.008	4.943	-0.011
4.955	-0.028	4.993	0.001	4.960	-0.007	4.955	-0.011
4.967	-0.027	5.005	0.001	4.972	-0.008	4.967	-0.011
4.979	-0.027	5.017	0.001	4.984	-0.004	4.979	-0.011
4.991	-0.027	5.029	0.001	4.996	-0.008	4.991	-0.011
5.003	-0.028	5.041	0.000	5.008	-0.008	5.003	-0.011
5.015	-0.027	5.053	0.000	5.020	-0.007	5.015	-0.011
5.027	-0.028	5.065	0.001	5.032	-0.008	5.027	-0.011
5.039	-0.025	5.077	0.000	5.044	-0.007	5.039	-0.011
5.051	-0.028	5.089	0.001	5.056	-0.007	5.051	-0.011

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.063	-0.028	5.101	0.001	5.068	-0.008	5.063	-0.011
5.075	-0.028	5.113	0.000	5.080	-0.007	5.075	-0.011
5.087	-0.028	5.125	0.002	5.092	-0.008	5.087	-0.010
5.099	-0.029	5.137	0.000	5.104	-0.008	5.099	-0.013
5.111	-0.028	5.149	0.000	5.116	-0.008	5.111	-0.012
5.123	-0.029	5.161	0.000	5.128	-0.008	5.123	-0.011
5.135	-0.028	5.173	0.000	5.140	-0.008	5.135	-0.012
5.147	-0.028	5.186	0.000	5.152	-0.008	5.147	-0.012
5.159	-0.028	5.198	0.000	5.164	-0.008	5.159	-0.012
5.171	-0.028	5.210	-0.001	5.176	-0.008	5.171	-0.012
5.183	-0.026	5.222	-0.001	5.188	-0.008	5.183	-0.013
5.195	-0.028	5.234	-0.001	5.200	-0.008	5.195	-0.013
5.207	-0.029	5.246	0.000	5.212	-0.005	5.207	-0.012
5.219	-0.029	5.258	-0.001	5.224	-0.008	5.219	-0.012
5.231	-0.028	5.270	-0.001	5.236	-0.008	5.231	-0.013
5.243	-0.028	5.282	-0.001	5.248	-0.009	5.243	-0.012
5.255	-0.029	5.294	-0.001	5.260	-0.008	5.255	-0.013
5.267	-0.029	5.306	-0.002	5.272	-0.008	5.267	-0.012
5.279	-0.028	5.318	-0.003	5.284	-0.008	5.279	-0.013
5.291	-0.029	5.330	-0.002	5.296	-0.008	5.291	-0.013
5.302	-0.029	5.342	-0.002	5.308	-0.007	5.302	-0.013
5.314	-0.029	5.354	-0.003	5.320	-0.008	5.314	-0.013

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.326	-0.029	5.366	-0.002	5.332	-0.008	5.326	-0.013
5.338	-0.029	5.378	-0.003	5.344	-0.007	5.338	-0.013
5.350	-0.029	5.391	-0.002	5.356	-0.009	5.350	-0.013
5.362	-0.028	5.403	-0.002	5.368	-0.009	5.362	-0.013
5.374	-0.029	5.415	-0.003	5.380	-0.008	5.374	-0.013
5.386	-0.029	5.427	-0.003	5.392	-0.008	5.386	-0.013
5.398	-0.029	5.439	-0.003	5.404	-0.008	5.398	-0.013
5.410	-0.029	5.451	-0.003	5.416	-0.008	5.410	-0.013
5.422	-0.029	5.463	-0.002	5.428	-0.008	5.422	-0.013
5.434	-0.030	5.475	-0.003	5.440	-0.008	5.434	-0.013
5.446	-0.029	5.487	-0.003	5.452	-0.008	5.446	-0.013
5.458	-0.028	5.499	-0.003	5.464	-0.008	5.458	-0.013
5.470	-0.029	5.511	-0.003	5.476	-0.008	5.470	-0.013
5.482	-0.029	5.523	-0.002	5.488	-0.009	5.482	-0.012
5.494	-0.029	5.535	-0.002	5.500	-0.009	5.494	-0.013
5.506	-0.029	5.547	-0.004	5.511	-0.008	5.506	-0.013
5.518	-0.029	5.559	-0.004	5.523	-0.008	5.518	-0.013
5.530	-0.029	5.571	-0.004	5.535	-0.008	5.530	-0.013
5.542	-0.030	5.583	-0.004	5.547	-0.009	5.542	-0.014
5.554	-0.030	5.596	-0.003	5.559	-0.009	5.554	-0.013
5.566	-0.030	5.608	-0.004	5.571	-0.009	5.566	-0.014
5.578	-0.029	5.620	-0.004	5.583	-0.009	5.578	-0.013

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.590	-0.029	5.632	-0.004	5.595	-0.009	5.590	-0.014
5.602	-0.030	5.644	-0.004	5.607	-0.008	5.602	-0.014
5.614	-0.028	5.656	-0.004	5.619	-0.008	5.614	-0.013
5.626	-0.029	5.668	-0.005	5.631	-0.008	5.626	-0.014
5.638	-0.029	5.680	-0.005	5.643	-0.008	5.638	-0.013
5.650	-0.030	5.692	-0.005	5.655	-0.007	5.650	-0.014
5.662	-0.029	5.704	-0.004	5.667	-0.009	5.662	-0.013
5.674	-0.030	5.716	-0.003	5.679	-0.010	5.674	-0.014
5.686	-0.029	5.728	-0.005	5.691	-0.010	5.686	-0.013
5.697	-0.030	5.740	-0.005	5.703	-0.010	5.697	-0.013
5.709	-0.030	5.752	-0.005	5.715	-0.009	5.709	-0.013
5.721	-0.029	5.764	-0.005	5.727	-0.010	5.721	-0.014
5.733	-0.029	5.776	-0.005	5.739	-0.009	5.733	-0.014
5.745	-0.029	5.788	-0.005	5.751	-0.010	5.745	-0.013
5.757	-0.028	5.801	-0.005	5.763	-0.009	5.757	-0.014
5.769	-0.029	5.813	-0.006	5.775	-0.010	5.769	-0.014
5.781	-0.030	5.825	-0.004	5.787	-0.007	5.781	-0.014
5.793	-0.030	5.837	-0.006	5.799	-0.010	5.793	-0.014
5.805	-0.030	5.849	-0.005	5.811	-0.010	5.805	-0.013
5.817	-0.030	5.861	-0.006	5.823	-0.010	5.817	-0.014
5.829	-0.029	5.873	-0.006	5.835	-0.010	5.829	-0.014
5.841	-0.029	5.885	-0.005	5.847	-0.010	5.841	-0.015

Table A6. Continued.

E.coli tet^R				E.coli tet^S			
PV (1)	C/Co (1)	PV (2)	C/Co (2)	PV (1)	C/Co (1)	PV (2)	C/Co (2)
5.853	-0.030	5.897	-0.005	5.859	-0.010	5.853	-0.014
5.865	-0.029	5.909	-0.005	5.871	-0.010	5.865	-0.014
5.877	-0.030	5.921	-0.005	5.883	-0.010	5.877	-0.015
5.889	-0.029	5.933	-0.005	5.895	-0.011	5.889	-0.014
5.901	-0.030	5.945	-0.006	5.907	-0.010	5.901	-0.014
5.913	-0.029	5.957	-0.005	5.919	-0.011	5.913	-0.014
5.925	-0.029	5.969	-0.006	5.931	-0.010	5.925	-0.014
5.937	-0.028	5.981	-0.006	5.943	-0.011	5.937	-0.016
5.949	-0.029	5.994	-0.006	5.955	-0.011	5.949	-0.016
5.961	-0.030	6.006	-0.006	5.967	-0.011	5.961	-0.016
5.973	-0.030	6.018	-0.007	5.979	-0.010	5.973	-0.017
5.985	-0.030	6.030	-0.007	5.991	-0.008	5.985	-0.018
5.997	-0.030	6.042	-0.006	6.003	-0.008	5.997	-0.017
6.009	-0.029	6.054	-0.007	6.015	-0.012	6.009	-0.018

Table A7. Remobilization of tet^R and tet^S *E.coli* strains via chemical perturbation when ionic strength was lowered from 10mM to 1 mM NaCl. C/Co is the normalized breakthrough concentrations and Time is in minutes.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
0	-0.001	-0.001	-0.001	0.000
1	0.000	0.001	0.000	0.000
2	-0.001	0.000	0.000	0.000

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
3	0.000	0.000	0.000	-0.001
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.001
7	0.000	0.001	0.000	0.001
8	0.001	0.000	0.002	0.001
9	0.001	0.001	0.001	0.001
10	0.003	0.003	0.001	0.001
11	0.002	0.002	0.000	0.004
12	0.002	0.001	0.002	0.004
13	0.002	0.001	0.002	0.005
14	0.004	0.004	0.002	0.005
15	0.004	0.003	0.003	0.006
16	0.006	0.005	0.003	0.008
17	0.006	0.006	0.003	0.009
18	0.006	0.006	0.005	0.011
19	0.008	0.009	0.006	0.011
20	0.009	0.010	0.010	0.013
21	0.009	0.011	0.009	0.015
22	0.011	0.014	0.010	0.017
23	0.013	0.017	0.012	0.021
24	0.014	0.019	0.014	0.023

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
25	0.015	0.021	0.017	0.027
26	0.017	0.023	0.020	0.031
27	0.019	0.027	0.022	0.036
28	0.022	0.031	0.025	0.042
29	0.023	0.034	0.028	0.048
30	0.015	0.038	0.032	0.054
31	0.030	0.043	0.030	0.043
32	0.032	0.047	0.043	0.069
33	0.034	0.051	0.045	0.075
34	0.036	0.056	0.049	0.083
35	0.040	0.060	0.053	0.091
36	0.043	0.064	0.056	0.101
37	0.045	0.070	0.063	0.108
38	0.048	0.074	0.064	0.119
39	0.051	0.080	0.075	0.128
40	0.053	0.084	0.079	0.137
41	0.055	0.090	0.080	0.147
42	0.061	0.094	0.083	0.157
43	0.062	0.098	0.061	0.165
44	0.062	0.088	0.093	0.173
45	0.063	0.109	0.092	0.156
46	0.065	0.112	0.093	0.192

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
47	0.066	0.114	0.097	0.197
48	0.069	0.117	0.099	0.200
49	0.070	0.118	0.099	0.204
50	0.071	0.119	0.101	0.210
51	0.072	0.122	0.103	0.213
52	0.078	0.122	0.104	0.216
53	0.078	0.122	0.108	0.218
54	0.079	0.124	0.109	0.221
55	0.080	0.125	0.112	0.223
56	0.081	0.118	0.114	0.223
57	0.083	0.129	0.115	0.202
58	0.084	0.128	0.117	0.230
59	0.086	0.126	0.123	0.229
60	0.088	0.125	0.123	0.228
61	0.090	0.124	0.125	0.229
62	0.091	0.123	0.125	0.229
63	0.082	0.122	0.127	0.227
64	0.097	0.121	0.128	0.229
65	0.097	0.122	0.128	0.227
66	0.098	0.120	0.130	0.225
67	0.100	0.118	0.131	0.226
68	0.101	0.117	0.132	0.228

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
69	0.102	0.100	0.133	0.229
70	0.103	0.119	0.121	0.225
71	0.104	0.117	0.137	0.224
72	0.104	0.114	0.136	0.223
73	0.108	0.112	0.135	0.222
74	0.107	0.111	0.136	0.221
75	0.107	0.109	0.136	0.202
76	0.109	0.110	0.135	0.220
77	0.109	0.107	0.136	0.218
78	0.110	0.107	0.135	0.214
79	0.109	0.106	0.135	0.212
80	0.109	0.103	0.134	0.209
81	0.109	0.103	0.134	0.207
82	0.100	0.103	0.134	0.205
83	0.113	0.101	0.133	0.192
84	0.110	0.082	0.107	0.200
85	0.109	0.101	0.133	0.197
86	0.109	0.099	0.133	0.194
87	0.108	0.098	0.130	0.190
88	0.107	0.095	0.128	0.188
89	0.105	0.094	0.128	0.184
90	0.105	0.094	0.125	0.183

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
91	0.105	0.092	0.124	0.180
92	0.093	0.091	0.122	0.178
93	0.107	0.090	0.122	0.176
94	0.105	0.090	0.120	0.173
95	0.103	0.089	0.120	0.171
96	0.102	0.088	0.118	0.167
97	0.102	0.088	0.118	0.163
98	0.102	0.086	0.118	0.161
99	0.101	0.085	0.117	0.157
100	0.100	0.087	0.090	0.154
101	0.099	0.085	0.117	0.153
102	0.098	0.083	0.117	0.149
103	0.090	0.083	0.115	0.148
104	0.100	0.081	0.113	0.145
105	0.098	0.080	0.111	0.142
106	0.096	0.079	0.112	0.140
107	0.095	0.078	0.111	0.137
108	0.095	0.077	0.109	0.135
109	0.094	0.075	0.108	0.133
110	0.093	0.076	0.108	0.130
111	0.092	0.074	0.107	0.132
112	0.091	0.073	0.105	0.127

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
113	0.093	0.073	0.102	0.124
114	0.091	0.073	0.105	0.120
115	0.089	0.071	0.104	0.119
116	0.088	0.071	0.103	0.117
117	0.086	0.069	0.102	0.113
118	0.086	0.068	0.101	0.113
119	0.084	0.066	0.099	0.111
120	0.083	0.066	0.099	0.107
121	0.082	0.064	0.097	0.107
122	0.081	0.064	0.097	0.105
123	0.081	0.063	0.095	0.102
124	0.079	0.063	0.095	0.100
125	0.083	0.062	0.093	0.099
126	0.079	0.060	0.074	0.096
127	0.078	0.060	0.093	0.095
128	0.076	0.059	0.092	0.095
129	0.074	0.059	0.091	0.093
130	0.074	0.059	0.089	0.092
131	0.073	0.057	0.088	0.091
132	0.072	0.055	0.087	0.089
133	0.071	0.057	0.082	0.087
134	0.070	0.056	0.080	0.085

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
135	0.069	0.055	0.079	0.085
136	0.069	0.053	0.079	0.084
137	0.068	0.052	0.077	0.082
138	0.066	0.051	0.080	0.082
139	0.065	0.051	0.080	0.081
140	0.065	0.051	0.079	0.079
141	0.064	0.050	0.079	0.080
142	0.063	0.049	0.077	0.076
143	0.063	0.047	0.061	0.076
144	0.062	0.049	0.076	0.075
145	0.060	0.049	0.075	0.073
146	0.060	0.047	0.074	0.072
147	0.062	0.046	0.071	0.071
148	0.060	0.047	0.071	0.071
149	0.058	0.045	0.071	0.070
150	0.057	0.044	0.071	0.069
151	0.056	0.038	0.070	0.066
152	0.056	0.045	0.069	0.066
153	0.055	0.045	0.069	0.066
154	0.054	0.044	0.067	0.065
155	0.055	0.042	0.067	0.066
156	0.053	0.042	0.067	0.063

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
157	0.053	0.042	0.054	0.063
158	0.051	0.041	0.065	0.063
159	0.051	0.041	0.064	0.061
160	0.051	0.041	0.063	0.060
161	0.049	0.040	0.063	0.060
162	0.051	0.040	0.061	0.058
163	0.050	0.040	0.061	0.059
164	0.049	0.033	0.059	0.058
165	0.048	0.040	0.059	0.057
166	0.046	0.039	0.059	0.056
167	0.046	0.038	0.054	0.055
168	0.046	0.038	0.054	0.055
169	0.046	0.037	0.053	0.054
170	0.045	0.037	0.052	0.054
171	0.045	0.036	0.053	0.052
172	0.045	0.036	0.052	0.052
173	0.043	0.035	0.051	0.053
174	0.045	0.035	0.044	0.052
175	0.044	0.035	0.051	0.052
176	0.042	0.035	0.050	0.050
177	0.041	0.035	0.048	0.051
178	0.041	0.034	0.048	0.050

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
179	0.040	0.034	0.048	0.049
180	0.039	0.034	0.046	0.049
181	0.039	0.027	0.046	0.049
182	0.039	0.035	0.046	0.049
183	0.039	0.034	0.045	0.049
184	0.040	0.033	0.045	0.048
185	0.039	0.033	0.044	0.047
186	0.037	0.033	0.043	0.045
187	0.038	0.032	0.044	0.048
188	0.037	0.032	0.043	0.046
189	0.037	0.032	0.042	0.044
190	0.036	0.033	0.043	0.044
191	0.037	0.031	0.042	0.044
192	0.036	0.032	0.042	0.045
193	0.036	0.031	0.040	0.044
194	0.035	0.030	0.040	0.044
195	0.036	0.031	0.040	0.044
196	0.035	0.030	0.040	0.043
197	0.036	0.027	0.040	0.041
198	0.035	0.032	0.039	0.042
199	0.034	0.031	0.039	0.043
200	0.034	0.030	0.039	0.042

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
201	0.033	0.029	0.038	0.041
202	0.032	0.028	0.033	0.040
203	0.032	0.029	0.038	0.041
204	0.032	0.028	0.038	0.040
205	0.033	0.028	0.036	0.040
206	0.032	0.029	0.037	0.040
207	0.032	0.028	0.036	0.039
208	0.031	0.028	0.036	0.039
209	0.026	0.029	0.035	0.039
210	0.032	0.028	0.035	0.039
211	0.031	0.028	0.034	0.038
212	0.031	0.027	0.034	0.038
213	0.030	0.028	0.035	0.039
214	0.031	0.028	0.033	0.039
215	0.030	0.027	0.034	0.037
216	0.030	0.022	0.033	0.037
217	0.029	0.030	0.032	0.038
218	0.030	0.028	0.034	0.037
219	0.029	0.028	0.033	0.037
220	0.028	0.028	0.033	0.036
221	0.029	0.028	0.032	0.036
222	0.028	0.027	0.032	0.036

Table A7. Continued.

	E.coli tet^R		E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
223	0.029	0.027	0.031	0.036
224	0.029	0.027	0.031	0.037
225	0.027	0.026	0.031	0.037
226	0.028	0.026	0.031	0.037
227	0.029	0.027	0.031	0.035
228	0.028	0.025	0.031	0.034
229	0.029	0.025	0.031	0.035
230	0.027	0.025	0.030	0.035
231	0.027	0.019	0.024	0.033
232	0.024	0.025	0.031	0.035
233	0.027	0.025	0.029	0.034
234	0.026	0.025	0.030	0.034
235	0.026	0.025	0.030	0.033
236	0.026	0.025	0.029	0.033
237	0.026	0.021	0.030	0.032
238	0.025	0.025	0.029	0.033
239	0.025	0.025	0.028	0.032
240	0.025		0.028	0.033
241	0.025		0.028	0.033
242	0.025		0.028	0.032
243	0.025		0.027	0.033
244	0.024		0.027	0.033

Table A7. Continued.

E.coli tet^R			E.coli tet^S	
Time	C/Co (1)	C/Co (2)	C/Co (1)	C/Co (2)
245	0.027		0.028	0.032
246	0.025		0.028	0.032
247	0.025		0.028	0.033
248	0.024		0.027	0.032
249	0.024		0.027	0.032
250	0.024		0.028	0.032
251	0.023		0.026	0.031
252	0.024		0.027	0.031

Table A8. Remobilization of tet^R and tet^S *E.coli* strains via transient flow when the soil moisture content was raised from 0.12 to ~ 0.3% while the ionic strength was maintained at 10 mM NaCl. Time 0 represents the time in minutes when the initiation of the soil moisture content increased.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
0	0.000	-0.002
1	0.000	0.000
2	0.001	0.003
3	0.004	0.003
4	0.008	0.003
5	0.008	0.006
6	0.011	0.008
7	0.012	0.009
8	0.014	0.009

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
9	0.015	0.011
10	0.016	0.011
11	0.018	0.012
12	0.018	0.013
13	0.019	0.015
14	0.023	0.015
15	0.023	0.017
16	0.023	0.018
17	0.023	0.018
18	0.024	0.019
19	0.023	0.021
20	0.024	0.023
21	0.027	0.023
22	0.026	0.024
23	0.027	0.027
24	0.028	0.027
25	0.028	0.028
26	0.029	0.028
27	0.031	0.029
28	0.031	0.030
29	0.032	0.031
30	0.031	0.030

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
31	0.032	0.032
32	0.032	0.031
33	0.032	0.032
34	0.033	0.032
35	0.032	0.031
36	0.034	0.033
37	0.033	0.033
38	0.034	0.033
39	0.033	0.033
40	0.034	0.033
41	0.034	0.033
42	0.035	0.034
43	0.035	0.032
44	0.034	0.032
45	0.034	0.031
46	0.034	0.032
47	0.034	0.032
48	0.032	0.032
49	0.033	0.032
50	0.034	0.031
51	0.034	0.029
52	0.033	0.028

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
53	0.032	0.027
54	0.032	0.027
55	0.032	0.028
56	0.031	0.027
57	0.031	0.028
58	0.031	0.027
59	0.031	0.026
60	0.031	0.026
61	0.029	0.026
62	0.029	0.026
63	0.028	0.024
64	0.027	0.023
65	0.027	0.023
66	0.027	0.022
67	0.027	0.022
68	0.027	0.022
69	0.026	0.021
70	0.026	0.019
71	0.024	0.018
72	0.024	0.018
73	0.024	0.018
74	0.024	0.018

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
75	0.024	0.018
76	0.022	0.018
77	0.023	0.018
78	0.022	0.018
79	0.020	0.018
80	0.021	0.018
81	0.020	0.018
82	0.022	0.015
83	0.021	0.015
84	0.020	0.015
85	0.021	0.015
86	0.020	0.014
87	0.019	0.014
88	0.019	0.015
89	0.018	0.014
90	0.018	0.013
91	0.018	0.013
92	0.018	0.013
93	0.018	0.012
94	0.016	0.011
95	0.017	0.011
96	0.016	0.011

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
97	0.016	0.011
98	0.016	0.010
99	0.016	0.010
100	0.016	0.010
101	0.016	0.009
102	0.014	0.009
103	0.014	0.008
104	0.014	0.009
105	0.014	0.008
106	0.014	0.007
107	0.013	0.007
108	0.014	0.008
109	0.014	0.005
110	0.013	0.005
111	0.013	0.006
112	0.012	0.004
113	0.013	0.005
114	0.012	0.004
115	0.012	0.004
116	0.012	0.003
117	0.012	0.004
118	0.012	0.003

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
119	0.012	0.005
120	0.012	0.004
121	0.011	0.005
122	0.011	0.003
123	0.010	0.004
124	0.014	0.003
125	0.012	0.002
126	0.015	0.001
127	0.013	0.003
128	0.013	0.001
129	0.013	0.002
130	0.014	0.001
131	0.012	0.002
132	0.013	0.002
133	0.012	-0.001
134	0.012	-0.001
135	0.012	0.000
136	0.011	-0.001
137	0.011	-0.001
138	0.011	-0.002
139	0.013	-0.002
140	0.011	-0.002

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
141	0.010	-0.003
142	0.011	-0.003
143	0.011	-0.002
144	0.010	-0.003
145	0.010	-0.004
146	0.011	-0.004
147	0.011	-0.004
148	0.011	-0.004
149	0.010	-0.004
150	0.011	-0.005
151	0.010	-0.004
152	0.009	-0.005
153	0.010	-0.005
154	0.009	-0.005
155	0.010	-0.005
156	0.009	-0.005
157	0.009	-0.006
158	0.009	-0.007
159	0.009	-0.006
160	0.009	-0.007
161	0.008	-0.005
162	0.008	-0.006

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
163	0.008	-0.008
164	0.008	-0.007
165	0.006	-0.007
166	0.008	-0.007
167	0.008	-0.008
168	0.006	-0.009
169	0.006	-0.008
170	0.006	-0.009
171	0.008	-0.008
172	0.008	-0.009
173	0.006	0.003
174	0.006	0.001
175	0.006	0.001
176	0.004	0.000
177	0.004	-0.001
178	0.004	-0.001
179	0.004	-0.001
180	0.004	-0.001
181	0.002	-0.002
182	0.002	-0.003
183	0.002	-0.004
184	0.002	-0.003

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
185	0.001	-0.004
186	0.001	-0.004
187	0.001	-0.005
188	0.000	-0.004
189	0.000	-0.005
190	0.001	-0.005
191	0.001	-0.005
192	0.000	-0.005
193	0.001	-0.005
194	0.000	-0.005
195	0.000	-0.005
196	0.000	-0.005
197	0.000	-0.005
198	0.000	-0.005
199	0.000	-0.005
200	0.000	-0.005
201	0.000	-0.005
202	-0.001	-0.005
203	-0.002	-0.007
204	-0.002	-0.007
205	-0.002	-0.007
206	-0.001	-0.008

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
207	-0.001	-0.007
208	-0.002	-0.007
209	-0.002	-0.007
210	-0.002	-0.007
211	-0.002	-0.007
212	-0.002	-0.008
213	-0.002	-0.007
214	-0.004	-0.008
215	-0.004	-0.009
216	-0.004	-0.009
217	-0.004	-0.009
218	-0.004	-0.009
219	-0.004	-0.009
220	-0.005	-0.009
221	-0.004	-0.010
222	-0.002	-0.009
223	-0.004	-0.008
224	-0.005	-0.009
225	-0.004	-0.011
226	-0.004	-0.010
227	-0.004	-0.009
228	-0.004	-0.010

Table A8. Continued.

E.coli tet^R		E.coli tet^S
Time	C/Co	C/Co
229	-0.005	-0.010
230	-0.006	-0.011
231	-0.006	-0.011
232	-0.005	-0.011
233	-0.005	-0.010
234	-0.005	-0.011
235	-0.006	-0.011
236	-0.005	-0.011
237	-0.005	-0.011
238	-0.006	-0.011
239	-0.006	-0.011
240	-0.006	-0.011
241	-0.006	-0.011
242	-0.005	-0.012
243	-0.007	-0.011
244	-0.007	-0.013
245	-0.007	-0.013
246	-0.007	-0.012
247	-0.007	-0.012
248	-0.008	-0.012
249	-0.007	-0.013
250	-0.007	-0.013

CURRICULUM VITAE

Lucia Feriancikova

Place of birth: Bratislava, Slovakia

EDUCATION

B. S., Comenius University in Bratislava, Slovakia, June 2001
Major: Geology

M.S., Comenius University in Bratislava, Slovakia, May 2007
Major: Geology of Mineral deposits

PhD, University of Wisconsin-Milwaukee, May 2014

Dissertation Title: Spread of emerging contaminants in the soil-groundwater system

ACCOMPLISHMENTS (AWARDS AND SCHOLARSHIPS)

- 2013 UWM Student Grant Award in Solid Waste Research Council
- 2013 UWM Distinguished Graduate Student Research Award
- 2012 UWM Graduate Student Travel Award
- 2011 UWM Graduate Student Travel Award
- 2011 UWM Research Foundation Fellowship Award
- 2010 Wisconsin Geological Society Scholarship
- 2009 UWM Chancellor Graduate Scholarship
- 2006 Comenius University in Bratislava Advancement Scholarship

ACADEMIC AND RESEARCH EXPERIENCE

- Graduate Research Assistant, University of Wisconsin-Milwaukee, 2010 – Present
  Completed projects as follows:
  - Deposition and remobilization of Graphene Oxide nanoparticles in saturated porous media
  - The effects of outer membrane proteins on mobility of *E.coli* and *Enterococcus Faecium*
  - The transport of tetracycline resistant *E.coli* in partially saturated porous media

- Transport study of *Enterococcus Faecalis*, *Faecium*, *Bacteroides* and antibiotic resistant genes (TET plasmid DNA) under various chemical coditions
- The use of biosolid-derived biochar to control the leaching of nutrients and bacteria from agricultural soil
- Bacterial transport through naturally fractured dolomite rock

- Graduate Teaching Assistant, University of Wisconsin-Milwaukee, 2008 – 2010
    - Teaching laboratory component of Introduction to the Earth course

OTHER EXPERIENCE

Supervised research assistants in their projects
Defined materials and methods for various projects
Utilized modeling programs including MODFLOW, HYDRUS 1D, CXTFIT

PROFESSIONAL MEMBERSHIPS

American Geophysical Union, 2013 - present
Geological Society of America, 2011

CONFERENCE PRESENTATIONS

Feriancikova, L.; Xu, S.: Transport of Tetracycline-Resistant and Tetracycline-Susceptible *Escherichia coli* within Unsaturated Porous Media; (Poster presentation): March 2013, Brookfield, Wisconsin, American Water Resources Association (AWRA).

Feriancikova, L.; Bardy, S.; and Xu, S.: Effects of Outer Membrane Proteins (OMPs) on the Transport of *Escherichia coli* within Saturaed Sands; (Poster presentation): December 2012, San Francisco, California, American Geophysical Union Meeting (AGU)

Feriancikova, L.; Xu, S.: Experimental and Modeling Investigation of the Transport of Grapheme Oxide within Saturated Sand Packs; (Poster presentation): December 2011, San Francisco, California, American Geophysical Union Fall Meeting (AGU)

Feriancikova, L.; Johanson, J.; and Xu, S.: Effects of enterococcal surface protein (ESP) on the transport of Enterococcus Faecium within saturated aquifer sands; (Oral presentation): October 2011, Minneapolis, Minnesota, Geological Society America Annual Meeting (GSA)

Feriancikova, L.; Xu, S.; Walczak, J.J.; Wang, L.; Bardy, S.L.; Li, J.: Effects of Starvation on the Transport of Escherichia Coli K12 in Saturated Porous Media are Dependent on pH and Ionic Strength; (Oral presentation): March 2011, Appleton, Wisconsin, American Water Resources Association (AWRA).

PUBLICATIONS

Feriancikova, L., *Wang, L., Li, J., Xu, S. Transport of Tetracycline-Resistant and Tetracycline-Susceptible Escherichia coli within Unsaturated Porous Media,* manuscript under preparation and will be submitted to Water Research.

Feriancikova, L., *Bardy, S.L., S. Xu S., Transport of tetB-containing Plasmid DNA within Aquifer Materials,* manuscript under preparation and will be submitted to Chemosphere.

Feriancikova, L*., Bardy, S.L., Xu,S., Effects of the Outer Membrane Protein (OMP) Ag43 on the Transport of Escherichia coli within Saturated Sand Packs,* manuscript under preparation and will be submitted to Water Research.

Johanson, J. J., ***Feriancikova, L.,*** *Banerjee, A., Saffarini, D., Grundl, T., Xu, S., Comparison of the Transport of Bacteroides fragilis and Escherichia coli within Saturated Sand Packs,* manuscript under preparation and will be submitted to Water Research.

Feriancikova, L., *Bardy, L., Wang, L., Li, J., Xu, S., 2013.* Effects of Outer Membrane Protein *TolC* on the Transport of *Escherichia coli* within Saturated Quartz Sands. *Environ. Sci. Technol.,* 2013, 47, 5720 – 5728.

Feriancikova, L*., Xu, S., 2012.* Deposition and Remobilization of Graphene Oxide within Saturated Sand Packs. *Journal of Hazardous Materials, 2012, DOI:0.1016/j.jhazmat.2012.07.041*

Johanson, J.J., ***Feriancikova, L.,*** *Xu, S., 2012.* Influence of Enterococcal Surface Protein (esp) on the Transport of Enterococcus faecium within Saturated Quartz Sands. *Environ. Sci. Technol.*, 2012, January 9, DOI: 10.1021/es203265m

Walczak, J.J., Wang, ***L., Feriancikova****, L., Li, J., Xu, S., 2011*. Influence of Desiccation on the Transport of Escherichia coli through Saturated Sand Packs. *Water Air Soil Pollution,* 2011, DOI:10.1007/s11270-011-0950-2.

Walczak, J.J., Wang, ***L., Feriancikova****, L., Bardy, S.L., Li, J., Xu, S., 2011*. The effects of starvation on the transport of Escherichia coli in saturated porous media are dependent on pH and ionic strength. *Colloids Surf B. Biointerfaces,* 2011 Oct. 13; 22019454

Walczak, J., S. L. Bardy, ***L. Feriancikova****, S. Xu, 2011.* Comparison of the Transport of Tetracycline-Resistant and Tetracycline-Susceptible *Escherichia coli* Isolated from Lake Michigan, *Water, Air & Soil Pollution*, 2011, 222(1-4): 305-314, DOI: 10.1007/s11270-011-0825-6.

Walczak, J.J., Bardy, S.L., ***Feriancikova, L****., Xu, S., 2010*. Influence of tetracycline resistance on the transport of manure-derived Escherichia coli in saturated porous media. *Water research,* 2010, 45(2011)1681-1690, DOI:10.1016/j.watres.2010.12.014

Lintnerová, O., ***Feriančiková, L.****, Španek, P., 2007*. Nereziduálny obsah Fe, Mn, Cu, Zn, Al a As v pôdach v okolí opusteného ložiska Smolník [Non-residual content of Fe, Mn, Cu, Zn, Al and As in soil of the abandoned Smolnik mining area], *Mineralia Slovaca*, 39 (2007), 153-164.