



# OPTIMIZING CONTAMINANT REMOVAL

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# BACKGROUND INTRO AND MOTIVATION

Almost at a catastrophic level, Brazilian bays and rivers are subject to countless illegal polluting sources, such as domestic sewage and industrial effluents. During the last summer Olympics in 2016 they had a great challenge of using the bodies of water for the aquatic. Unfortunately Brazil has not taken much care of the water and with the fast growth of urban areas much waste winds up in rivers killing many important water resources.

Rio Tiete is the 6<sup>th</sup> most polluted river in the world in the 2<sup>nd</sup> biggest city in the world.

# BACKGROUND INTRO AND MOTIVATION

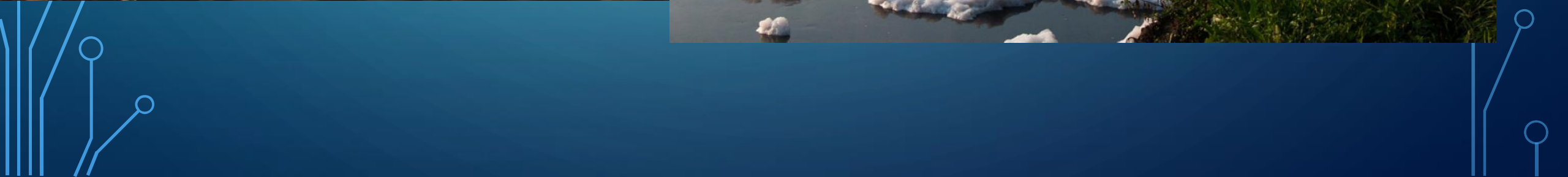
Tiete river is 1.136 km long and intersects the state of Sao Paulo from East to West. In the city of Sao Paulo, the river is alongside with Marginal Tiete which carries 2 million cars a day. There have been projects to clean since 1992 with little success. As you pass by you might smell the river which has an aroma of reminiscent rotten eggs with an ashen gray color. Until late 1960's, it used to have fish, but since there is almost no oxygen left in it only capybaras and alligators can be found next to it. The River was destroyed by the sewage that disposed directly in it.











# OBJECTIVE

- This project investigates methodology for application of pump rate optimization for maximum removal of contaminants as to different percentages in the Tiete River, SP – Brazil.

# IMPLEMENTATION

```
import numpy as np
import flopy
import flopy.utils.binaryfile as bf
import matplotlib.pyplot as plt

class mymf:
    """
    modflow model for multiple well pumping
    every values are represented as 2D np array
    """
    def __init__(self,init_head):
        """
        initialize parameters
        :param init_head: integer
        """

        # Assign name for modflow model object
        modelname = 'modflow'

        # Model domain and grid definition - we consider those values as
        given
        Lx = 1000.
        Ly = 1000.
        ztop = 0.
        zbot = -50.
        nlay = 1
        nrow = 50
        ncol = 50
        delr = Lx / ncol # spacings along a row, can be an array
        delc = Ly / nrow # spacings along a column, can be an array
        delv = (ztop - zbot) / nlay
        botm = np.linspace(ztop, zbot, nlay + 1)
```

- This imports the packages needed for this model
- Plot here the parameters for the river Tiete.
- Length 715 miles
- Depth 23 ft



```
# Create modflow model object
self.mf = flopy.modflow.Modflow(modelname, exe_name='mf2005')

# Create the discretization object
self.dis = flopy.modflow.ModflowDis(self.mf, nlay, nrow, ncol, delr=delr,
                                     delc=delc,
                                     top=ztop, botm=botm[1:])

# Add BAS package
bas = flopy.modflow.ModflowBas(self.mf, ibound=ibound, strt=strt)

# Add LPF package to the MODFLOW model
# hk array of horizontal hydraulic conductivity, vka vertical hydraulic
conductivity
lpf = flopy.modflow.ModflowLpf(self.mf, hk=10., vka=10., ipakcb=53)

# Add OC package to the MODFLOW model
spd = {(0, 0): ['print head', 'print budget', 'save head', 'save budget']}
oc = flopy.modflow.ModflowOc(self.mf, stress_period_data=spd, compact=True)

# Add PCG package to the MODFLOW model
pcg = flopy.modflow.ModflowPcg(self.mf)

# linkage to mt3dms LMT package
lmt = flopy.modflow.ModflowLmt(self.mf, output_file_name='mt3d_link.ft1')
```

- Packages needed
- BAS, DIS, LPF, OC PCG, MODFLOW
- mt3dms

```

# create mt3dms model object
mt = flopy.mt3d.Mt3dms(modflowmodel=self.mf,
                      modelname=self.modelname, exe_name='./mt3dms5b.exe',
                      ftlfilename='mt3d_link.ftl')

# basic transport package
btn = flopy.mt3d.Mt3dBtn(mt, prsity=0.3, icbund=1, sconc=0.0,
                        ncomp=1, perlen=5000,
                        nper=1, nstp=50, tsmult=1.0, nprs=-1,
                        nprobs=10, cinact=-1, chkmas=True)

# advaction package
adv = flopy.mt3d.Mt3dAdv(mt, mixelm=-1, percel=0.75)
# dispersion package
dsp = flopy.mt3d.Mt3dDsp(mt, al=10.0, trpt=0.1, trpv=0.1,
                        dmcoef=1.e-5)

# source/sink package
ssm_data = {}
itype = flopy.mt3d.Mt3dSsm.itype_dict()

ssm_data[0] = [(0, well_rc[0], well_rc[1], C, itype['WEL'])]

ssm = flopy.mt3d.Mt3dSsm(mt, stress_period_data=ssm_data)

```

- River boundaries are changed in my ssm data to know about the bottom of the river, dictating the flow.

- CALCULATE THE DIFFERENCE BETWEEN THE CONCENTRATION BEFORE AND AFTER PUMPING
- CALCULATE THE COST FOR THE PUMPING
- HOW MUCH PUMPING IS NECESSARY TO REMOVE 10%, 25% , 50 % AND 90%.
- CALCULATE HOW LONG IT TAKES FOR EACH DESIRED FINAL CONCENTRATION
- CALCULATE EACH COST
- OPTIMIZE LOWEST COST WITH HIGHEST PUMPING RATE



# REFERENCES

- [http://www.who.int/water\\_sanitation\\_health/resourcesquality/wpccasestudy6.pdf](http://www.who.int/water_sanitation_health/resourcesquality/wpccasestudy6.pdf)
- <https://news.nationalgeographic.com/news/2010/09/photogalleries/100921-toxic-foam-river-brazil-science-environment-pictures/>
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- CETESB 1994 Projeto Tietê, Despoluição Industrial. Relatório de Acompanhamento, Setembro 1994. Companhia de Tecnologia de Saneamento Ambiental, São Paulo.
- Alonso, L.R. and Serpa, E.L. 1994 O Controle da Poluição Industrial no Projeto Tietê, 1994. Companhia de Tecnologia de Saneamento Ambiental (CETESB), São Paulo.