**UPC2209: Pollution Control Engineering in Singapore**

Tue, Thu 4-6

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Module description:

Modelling is one of the central elements in a quantitative study. The ability to mathematically represent relationships between variables of interest (say, contaminants) allows us to test hypotheses using data. This course builds upon what you have learned in quantitative reasoning foundation viz modelling. We look at modelling within the context of pollution control engineering (specifically water pollution), and see how it allows us to describe complex systems and processes. Why does a system behave the way it does? Are we able to predict how it will evolve if left undisturbed? Can we determine how a system will respond to a change? Take the example of subsurface contamination from a leaking chemical storage tank: we may wish to determine if it poses a threat to groundwater quality. Or the example of a planned new industrial facility: what is its impact going to be on our local water quality. Oftentimes, it is not practical or even impossible to answer such questions by experiment. Therefore, we need to develop and use models to interpret observations or to make predictions.

We look at two specific classes of models that are employed in pollution control engineering: material balance models and runoff estimation models. We may think of them as examples of mechanistic and empirical models, respectively. The latter rely upon observed relationships among experimental data, and does not include much information on the underlying mechanisms. The former, on the other hand, explicitly includes mechanisms or processes involving the variables of our interest. For both material balance and runoff models, estimation of input parameters as well as validation against experimental observations are critical. Both of these conditions require data.

Therefore, the course is broken into three parts: the first two parts delve into material balance models and runoff estimation models, respectively. The last part looks at monitoring and sampling programmes that collect data for model validation, parameter estimation and other pollution control objectives.

We begin by covering some basic concepts of environmental chemistry. We will then look at how material balance models can be used to better understand organic and groundwater

pollution. Runoff estimation models are introduced through their application in flood control, an issue close to our hearts here in Singapore. Finally, we examine what goes into planning a pollution control monitoring programme, and review some case studies in sampling strategies.

This course is intended to build upon what you have learned in QRF here in USP. To get the most out of this course, you are encouraged to think about how concepts you have learned in those foundational modules can now be applied here. However, the course is open to all USP students who are interested in learning more about pollution control engineering, and you are welcome to take this module, even if you have not taken QRF previously.

Learning outcomes:

- Articulate the principle of material balance as applied to pollution control engineering, and link the principle to the three types of reactor models that can be used to describe environmental systems
- Be able to apply, and interpret the results from, reactor models in quantifying the impact of eutrophication and organic waste
- Describe the difference between general mass balance models and reactor models, and be able to perform simple calculations on groundwater pollution using a general mass balance model
- Assess the magnitude of urban runoff events using runoff estimation models, and be able to design control measures for managing urban runoff
- State the key questions that go into planning a monitoring programme, and be able to propose monitoring measures for data collection and pollution control

Course Outline (subject to change):

| Week | Topic |
|---|---|
| **1** | Introduction to pollution control engineering |
| **2** | Basics of environmental chemistry |
| **3** | Reactor models: Oxygen-demanding wastes |
| **4** | Reactor models: Eutrophication |
| **5** | Groundwater transport processes for contaminants |
| **6** | Groundwater remediation |
| | RECESS |
| **7** | Urban runoff |
| **8** | Empirical models: Estimating urban runoff |
| **9** | Controlling urban runoff: design of detention systems |
| **10** | Monitoring programmes (I) |
| **11** | Monitoring programmes (II) |
| **12** | Project Presentations |
| **13** | ***No class** |

**Brief details on assessments:**

The following are brief details on the assessments for the course. More details will be provided in instruction sheets relevant for each specific assessment.

(1) Class participation (10%)
- Discussion of homework assignments, along with contributions to class discussions, will go towards the class participation portion of the grade.

(2) Tests (40%)
- Assesses the material on the basics of environmental chemistry, reactor models and groundwater

(3) Group project (30%)
- Students will have to complete a term project (based on the urban runoff section of the module), culminating in a group presentation.

(4) Individual report (20%)
- The final assessment is an individual report due at the end of the semester. The report will be based on the empirical models and monitoring portions of the course.

**Other points to note:**

- Assignments are due by the stated deadlines, and late submissions will not be accepted
- You are expected to keep up-to-date and revise material covered in previous classes before the next class
- Please refrain from using your mobile phones in class. Leave the classroom if you need to take an urgent call.