CONTENT STRUCTURE AND PROGRAM DEVELOPMENT IN ENVIRONMENTAL HYDRAULICS: TRANSPORT THEORY IN FLUID FLOW

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INTRODUCTION AND OBJECTIVES

Transport theory provides not only with a conceptual basis ranging from the Reynolds Theorem to the mass/energy transfer due to chemical and biological processes, and phase change , but also with a methodological framework to establish similarities between momentum, energy and mass fluxes, which, focused on the diffusive analogy and introducing turbulence description in a pedagogic manner, makes it possible to understand in depth different processes that may appear differently from a simple analysis but which can be described similarly.

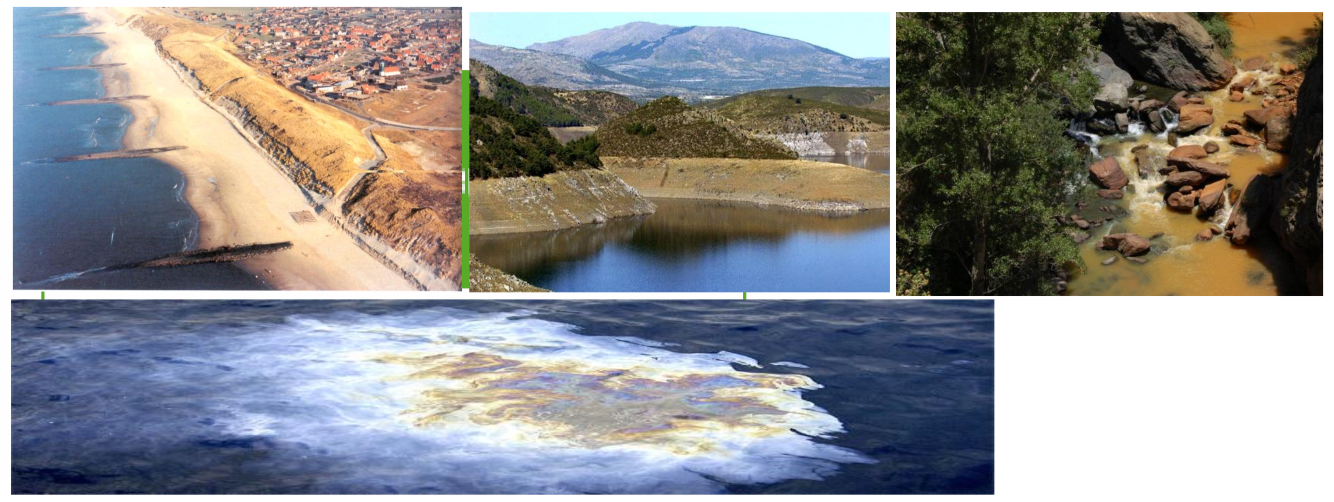
MÁSTER OFICIAL
Universidades de Granada, Córdoba y Málaga

Environmental Hydraulics
Official Postgraduate Program: Biogeochemical Fluid Dynamics and their Applications

1-YR -MASTER ACADEMIC STRUCURE AND DOCTORATE DEGREE

First Quarter	Second Quarter
Obligatory Courses (30 ECTS credits)	Specialization (30 ECTS credits) 24 ECTS credits + 6 ECTS credits (Masters Thesis)

Máster Degree in Environmental Hydraulics by the Universities of Cordoba, Granada, and Malaga



(1) METHODS

(a) ACADEMIC STRUCTURE

First Semester. Obligatory Courses, 30 ECTS credits
(CEAMA-UGR). ALL STUDENTS TOGETHER

CMI. Foundations and Methods of Environmental Hydraulics
14 ECTS credits
UI.1 Mathematical and numerical methods
UI.2 Experimental methods
UI.3 Statistical methods

CMII. Dynamics of Biogeochemical Fluids
16 ECTS credits
UII.1 Fluid mechanics
UII.2 Aquatic ecology
UII.3 Transport and mixing phenomena
UII.4 Atmospheric dynamics

Integrated Management of Ports and Coastal Zones
30 ECTS credits (University of Granada)

Integrated Basin Management
30 ECTS (University of Córdoba)

Vehicle Aerodynamics
30 ECTS (University of Malaga)

Management of Aquatic Ecosystems
30 ECTS credits (University of Granada)

(b) CONTENTS AND EVALUATION

Part I. Transport phenomena in fluids
Topic 1. Momentum, energy, and mass transport in fluids
Topic 2. Reynolds transport theorems
Part II Mass transport in fluid media
Topic 3. Mass transport mechanisms
Topic 4. Mass transport and turbulence.
Topic 5. 1-D systems
Part III Energy transport in fluid media
Topic 6. Energy transport mechanisms
Topic 7. Energy transport and turbulence
Topic 8. Fundamentals of energy transport by radiation.

DIFUSSION

$$f_A = \frac{dA/dt}{\text{cross section}} = -K\frac{da_{vol}}{dr}$$

TRANSPORT THEOREM REYNOLDS

$$\frac{DB_{syst}}{Dt} = \frac{\partial}{\partial t}\iiint_{vc} b\rho\, dvol + \iint_{S,vc} b\rho \vec{q}\cdot d\vec{S}$$

TURBULENCE AND MIXING

$$a = \langle a \rangle + a'$$

(2) RESULTS

(a) DIFFUSION ANALOGY

$$\tau = -\upsilon\rho\frac{d\,|\vec{q}|}{dy} \qquad j_{calor} = -\alpha\rho c_p\frac{dT}{dy} = -k\frac{dT}{dy} \qquad j_m = -D\rho\frac{dc}{dy}$$

[K] = L² T⁻¹

$$-\overline{\langle u\rangle'\langle c\rangle'} = K_{xx}\frac{\partial\langle c\rangle}{\partial x}$$

$$-\overline{\langle w\rangle'\langle c\rangle'} = K_{zz}\frac{\partial\langle c\rangle}{\partial z}$$

$$K_{xx}, K_{zz} >> K_x, K_z$$

Dispersion coefficients → *Turbulent diffusion coefficients*

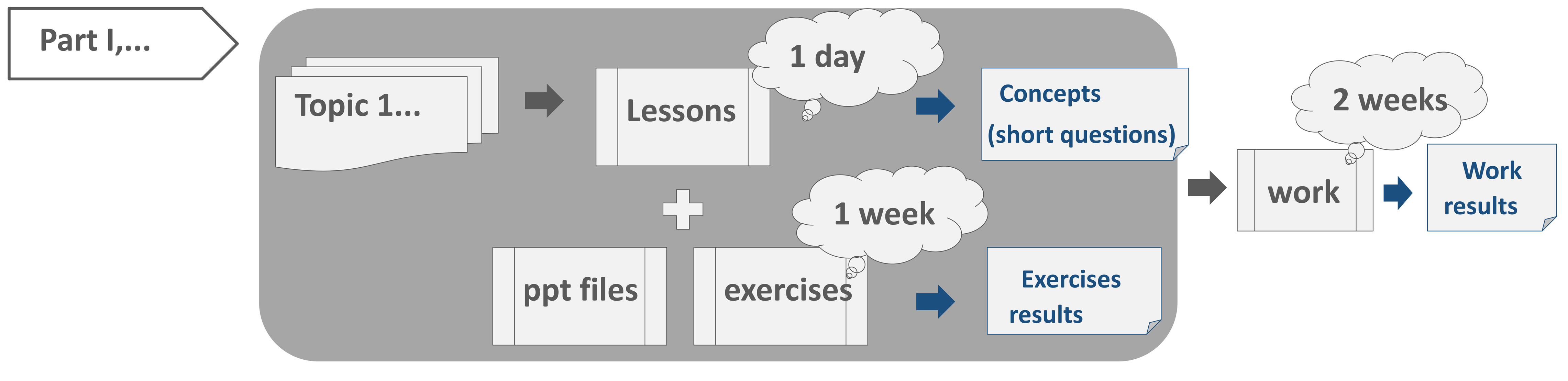
$$\langle u'c'\rangle = -K_x\frac{\partial\langle c\rangle}{\partial x}$$

$$\langle v'c'\rangle = -K_y\frac{\partial\langle c\rangle}{\partial y}$$

$$\langle w'c'\rangle = -K_z\frac{\partial\langle c\rangle}{\partial z}$$

Hydrodynamics
Mass transport in water quality issues
Evaporation
Stratification in waters
Atmospheric circulation
Oceanic currents
Fluid flow in porous media

(b) EVALUATION



Implemented on Moodle Virtual Learning Platform

Final calification:
- Participation during the lessons
- Results of exercises and works
- Seminars and Virtual forum

Gaps identification and reinforcement!

(3) CONCLUSIONS

✓Based on the Reynolds Theorem lessons and the introduction to momentum, energy and fluid mass transport equations, a block devoted to mass transport in fluids is developed. In parallel, a detailed work on the advection-diffusion equation from the microscopic molecular scale, to the turbulent scales and the space-averaged expressions, is carried out by the students along the first half of the semester, with detailed questions related to different aspects of the arising problems.
✓The conclusions let them develop by themselves the final block devoted to energy transport in fluids, by conceptual and methodological analogies with the mass transport problem.
✓The 6-yr experience has proven highly efficient to produce in the students skilled competences to describe, analyze and solve many applications in the field of Environmental Hydraulics: hillslope and river dynamics, littoral and oceanic dynamics, nutrient and energy dynamics in ecosystems, optimization of monitoring systems…. And many more… And with a special focus on the significant SCALES and the MODELLING options.

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