

SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY
SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

COURSE TITLE: WATER POLLUTION (Outline & Lab Manual)

CODE NO.: BIO 129-4 SEMESTER: II, V

PROGRAM: WATER RESOURCES TECH./ENVIRONMENTAL ENGINEERING TECH.
PULP & PAPER ENGINEERING

AUTHOR: V. WALKER

DATE: JANUARY 1992 PREVIOUS OUTLINE DATED: JANUARY 1991

APPROVED: *[Signature]* DEAN *Dec 19/91* DATE

288 Jan 92

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PREREQUISITE: AQUATIC BIOLOGY 125-3

I. PHILOSOPHY/GOALS:

This is a course designed to provide an introduction to the biological effects of water pollution and to ways of detecting, describing and quantifying these effects in the field and the laboratory. Types and sources of pollution, sampling strategies and legislation governing water quality will be discussed.

II. STUDENT PERFORMANCE OBJECTIVES:

Upon successful completion of this course the student will be able to:

1. Define pollution and discuss its complexity in aquatic ecosystems.
2. Discuss the physical, biological and ecological relationships in lentic versus lotic environments.
3. List and discuss the water pollution categories and their impact on aquatic systems.
4. List and discuss the major sources of water pollution.
5. Outline the procedure for setting up a bioassay and discuss the determination of LC50's, ET50's and toxicity curves.
6. Describe the transition in macroinvertebrates, bacteria, algae and fish with increasing eutrophy.
7. Demonstrate the use of various biotic and diversity indices to assess water quality.
8. Discuss the objectives and testing procedure of the Public Health Lab in Sault Ste. Marie.
9. List and discuss the various legislation governing water quality.

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III. TOPICS TO BE COVERED:

WEEK

1,2	UNIT 1	INTRODUCTION
		<ul style="list-style-type: none"> - what is pollution? - complexity of pollution - the ecosystem concept - biomonitoring - (Video: Great Lakes Troubled Waters)
2,3,4	UNIT 2	FRESHWATER SYSTEMS
		<ul style="list-style-type: none"> - general characteristics - the lotic environment - the lentic environment - stability of ecosystems - seasonal production cycles
3	LAB 1	WINTER LAKE STUDY
4	TERM TEST #1	
5,6	UNIT 3	TYPES AND SOURCES OF POLLUTION
		<ul style="list-style-type: none"> - Water pollution categories: <ul style="list-style-type: none"> - disease causing agents - inorganic chemicals and minerals - plant nutrients (nitrogen, phosphorus cycles) - sediments - heat - radioactive substances - oxygen demanding wastes - synthetic organic chemicals - Areas of concern in the Great Lakes Basin - Major sources of water pollution - (Video: Early Warning) - (Speaker: Pollution Probe)
7	LAB 2	TEMPERATURE AND OXYGEN
7,8,9	UNIT 4	TOXICOLOGY
		<ul style="list-style-type: none"> - types of toxic pollutants - toxicity - acute toxicity determination - factors affecting toxicity - toxic substances and health effects in Wildlife - human health
9	TERM TEST #2	

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WEEK

10	LAB 3	BIOASSAY
10,11	UNIT 5	BIOLOGICAL ASPECTS OF WATER POLLUTION - eutrophication - macroinvertebrates - bacteria - algae - fish - (Speaker: MOE)
12	LAB 4	STANDARD BACTERIAL PLATE COUNT AND BACTERIAL STAINING
12, 13	UNIT 6	STUDENT PRESENTATIONS
14	UNIT 7	SAMPLING FOR WATER QUALITY - (Speaker: EB Eddy representative) - apparatus - sampling sites - sampling strategy - (Speaker: APHU) - index species (SCI, biotic, diversity, indices)
15	UNIT 8	LEGAL ASPECTS OF WATER POLLUTION - acts and legislation governing water quality - MOE speaker - (Video: Speaking Out - The Politics of Garbage) - (Video: Strike Force)
15	TERM TEST #3	

NOTE: Schedule subject to change

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IV. EVALUATION METHODS:

Oral Presentation:	10 marks	90% and over	- A+
Lab Reports:	40 marks,	80	- A
Term Tests (3):	50 marks	70	- B
		60	- C
	<u>100</u> marks	Under 60%	- R

Students with a final grade of less than 60% will receive an "R" grade. All labs must be submitted for a passing grade.

ATTENDANCE:

Lab attendance is **compulsory**. Students missing labs without documented reason run the risk of repeating the course.

V. REQUIRED STUDENT RESOURCES:

TEXTBOOK:

Water Pollution Outline and Lab Manual

Colborn, Theodora E. et al 1990. Great Lakes, Great Legacy? The Conservation Foundation and the Institute for Research on Public Policy

OPTIONAL PURCHASES:

Mason, C.F., 1981. Biology of Freshwater Pollution. Longman Group Ltd., New York.

Vallentyne, J.R. 1974. The Algae Bowl. Lakes and Man. Canada Dept. of the Environment, Fish and Marine Service, Mosc. Spec. Pub. No. 22:186 pp.

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VI. ADDITIONAL RESOURCE MATERIAL AVAILABLE IN THE COLLEGE LIBRARY:

Adams, S. Marshall (ed.) 1990. Biological Indicators of Stress in Fish. American Fisheries Society Symposium 8. AFS. Bethesda, Maryland QL 639.1B55 1990

Alabaster, J.S. and R. Lloyd. 1982 Water Criteria for Freshwater Fish (2nd Edition). Butterworth's Inc., Yarmouth MA.

*American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1975, Standard Methods for the Examination of Water and Wastewater. 14th ed. Am. Publ. Health Assoc., Washington, D.C.

*American Society for Testing and Materials. 1977. Bacterial Indicators - Health Hazards Associated with Water. ASTM, Phil.

*American Society for Testing and Material. 1977. Aquatic Toxicology and Hazard Evaluation. ASTM, Philadelphia.

*Andrews, W. A. 1972. A Guide to the Study of Environmental Pollution. Prentice-Hall, Inc. Scarborough, Ontario.

Ashworth, W. 1989. The Late, Great Lakes: An Environmental History. Collins Publ., Stockton, California. QH 545.A1 A57 1989

Black, John A. 1977. Water Pollution Technology. Reston Publishing Company, Inc. Virginia.

Brewer, Richard. 1979. Principles of Ecology. Saunders, Philadelphia

Brown, Lester Russell. 1988. State of the World: A Worldwatch Institution Report on Progress Toward a Sustainable Society. W. W. Norton, New York

Burns, Noel M. 1985. Erie: The Lake that Survived. Rowman & Allanheld Pub., Totowa, N.J.

*Cairns, John Jr. 1982. Biological Monitoring in Water Pollution. Pergamon.

Cairns, V.W., Hodson, Peter V. and Nriagu, J.O. 1984. Contaminant Effects on Fisheries. John Wiley & Sons, New York.

Chant, D. A. 1970. Pollution Probe. New Press, Toronto.

Colborn, Theodora E. 1990. Great Lakes, Great Legacy? Conservation Foundation and Institute for Research on Public Policy in Canada. Halifax, N.S. TD 181.G73 G73 1990

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VI. ADDITIONAL RESOURCE MATERIAL - 2

Delwiche, C.C. 1981. Denitrification, Nitrification and Atmospheric Nitrous Oxide. Wiley, New York

Edmondson, W. T. (1969). Eutrophication in North America. In - Eutrophication - Causes, Consequences, Correctives. pp. 124-49. National Academy of Sciences, Washington.

Environment Canada 1986. From Cradle to Grave. A Management Approach to Chemicals. Ministry of Supply & Services Ottawa. TD 196.C45T38 1986

Environmental Protection Agency. 198_. Water Quality Criteria. E.P.A. R3-73-033. Washington, D.C.

*Environmental Studies Board. 1983. Committee on Atmospheric Transport and Chemical Transformation in Acid Precipitation. Acid Deposition: Atmospheric Processes in Eastern North America. National Academy Press, Washington, D.C.

Evans, M. S. (ed). 1988. Toxic Contaminants and Ecosystem Health: A Great Lakes Focus. John Wiley and Sons, N.Y. TD180.A38V.21

Freeman, A.M., Robert Haveman and Allen Kneese. 1984. The Economics of Environmental Policy. R.E. Krieger Publishing Co., Inc., Florida

*Goldman, Charles R. and A. J. Horne. 1983. Limnology. McGraw-Hill, Toronto.

*Gordon, Malcolm S. 1982. Animal Physiology: Principles and Adaptations (4th edition). MacMillan Publishing Co., Inc. New York.

Gore, James A. 1985. The Restoration of Rivers and Streams: Theories and Experience. Butterworth Publishing Co., Boston

Hammer, Mark J., 1986. Water and Wastewater Technology. John Wiley and Son Inc., New York.

Heath, Alan G. 1987. Water Pollution and Fish Physiology. CRC Press Inc., Boca Raton, Florida. SH174.H43 1987

*Hoar, W. S. 1983. General and Comparative Physiology (3rd Edition). Prentice-Hall, Inc., New Jersey.

Hoar, W. S., and D.J. Randall, (eds.). 1979. Fish Physiology. Vol.7: Locomotion Academic Press, Inc., London.

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ADDITIONAL RESOURCE MATERIAL - 3

*Hoar, W.S., D.J. Randall and J.R. Brett (eds). 1979. Fish Physiology. Vol.8: Bioenergetics and Growth. Academic Press, Inc., London.

Hocutt, Charles H. and Jay R. Stauffer Jr. (eds). 1980. Biological Monitoring of Fish. Lexington Books, Lexington, Mass.

Huntley, R.V. and R.Z. Rivers (eds). 1986. Proceedings of the Acid Rain Evaluation Seminar. Dept. of Fisheries and Oceans, Ottawa.

*Hynes, H. B. N. 1970. The Ecology of Running Waters. University Toronto Press, Toronto.

_____. 1974. The Biology of Polluted Waters. University Toronto Press, Toronto.

Isom, Billy G., S.D. Dennis, J.M. Bates. 1986. Impact of Acid Rain and Deposition on Aquatic Biological System. ASTM, Philadelphia.

Johnson, Raymond E. 1982. Acid Rain/Fisheries: Proceedings of an International Symposium on Acidic Precipitation and Fishery Impacts in Northeastern North America, Cornell University, Ithaca, New York, August 2-5, 1981. American Fisheries Assoc., Bethesda, Md.

Kimball, John W. 1978. Biology. 4th Ed. Addison-Wesley, Don Mills, Toronto.

*Krenkel, P.A. and Parker, F.L. 1973. Nation Symposium on Thermal Pollution Proceedings: Biological Aspects of Thermal Pollution.

*Larkin, P.A. 1974. Freshwater Pollution Canadian Style. McGill-Queen's University Press, Montreal.

*Laws, Edward A. 1981. Aquatic Pollution - An Introductory Text. John Wiley and Sons, Toronto.

Mason, C. F. 1981. Biology of Freshwater Pollution. Longman.

McKane, L. and Kandel J., 1985. Micro-Biology Essentials and Applications. McGraw-Hill Book Co., Toronto.

*McNeely, R. N., V. P. Neimanis and L. Dwyer. 1979. Water Quality Sourcebook Guide to Water Quality Parameters. Environment Canada, Inland Waters Directorate, Water Quality Branch, Ottawa.

McPhee, John 1989. The Control of Nature. Strauss, Farrar and Giroux, N.Y.

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ADDITIONAL RESOURCE MATERIAL - 4

Minns, Charles Kenneth 1986. Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Cdn. Special Publicaiton of Fisheries and Aquatic Sciences. Dept. of Fisheries & Oceans, Ottawa TD227.06 P73

Misener, A. D. and G. Daniel (eds.) 1982. Decisions for the Great Lakes. Great Lakes Tomorrow, Hiram, Ohio.

Morgan, James and Werner Stum. 1981. Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibrium in Natural Waters. Wiley, New York

Murty, A.S. 1986. Toxicity of Pesticides to Fish. CRC Press. Boca Raton, FLA.

*National Research Council of Canada. 1985. TFM and Bayer 73: Lampricides in the Equatic Environment. Pub. No. NRCC 22488, Ottawa.

Owen, O.S. 1985. Natural Resources Conservation - An Ecological Approach. MacMillan, New York

Palmer, C. Mervin. 1980. Algae and Water Pollution. Castle House Publications, Ltd., England.

Pavoni, J.L., 1977. Handbook of Water Quality Management Planning. Van Nostrand Reinhold Co., Litton Educaitional Publishing Inc., New York.

Pickering, A.D. 1981. Stress and Fish. Academic Press, San Diego, California. QL639.1 S74 1981

Rand, Gary M and Sam, R. 1985. Fundamentals of Aquatic Toxicology; Methods and Applications. Hemisphere Publications, Washington.

*Reid, George K. 1961. Ecology of Inland Waters and Estuaries. Van Nostrand Reinhold Co., Toronto.

*Ruttner, F. 1963. Fundamentals of Limnology. University of Toronto Press, Toronto.

Salle, A.J., 1967, Fundamental Principles of Bacteriology. 6th edition, McGraw-Hill Book Co., Toronto.

Schmidtke, N. W. 1986. Toxic Contamination in Large Lakes. World Conference on Large Lakes. Lewis Publishers QH545.W3 W67 1986

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ADDITIONAL RESOURCE MATERIAL - 5

Shubert, Elliot L. 1984. Algae as Ecological Indicators. Academic Press, San Diego, California. QK 565.A46 1984

*Smith, R. L. 1974. Ecology and Field Biology. Harper and Row Publishers, New York.

*Sprague, J. B. 1973. The ABC's of pollution bioassay using fish. Biological Methods for the Assessment of Water Quality, ASTM STP 528, American Society for Testing and Materials, 1973, pp. 6-30. (Reprint available)

Suffet, Irwin H. 1977. Fate of Pollutants in the Air and Water Environments. Wiley, New York.

Tinsley, Ian J. 1979. Chemical Concepts in Pollution Behaviour. Wiley Interscience, New York.

Tourbier, J. and R. W. Pierson, Jr. (eds.). 1976. Biological Control of Water Pollution. University of Pennsylvania Press, Inc., PA.

Tu, Anthony T. (ed). 1982. Survey of Contemporary Toxicology, Vol. 2. Wiley, New York.

Vallentyne, J. R. 1974. The Algae Bowl. Lakes and Man. Canada Department of the Environment, Fish and Marine Service, Misc. Spec. Pub. No. 22: 186 pp.

Viessman, W.Jr. and M.J. Hammer. 1985 Water Supply and Pollution Control. Harper and Row, Publishers, New York.

Wagner R. H., 1971. Environment and Man. Norton, New York.

Warren, C. E. 1971. Biology and Water Pollution Control. Saunders, Philadelphia.

Wetzel, Robert G. 1983. Limnology (2nd Edition). Saunders. College Publishing, Toronto.

Wetzel, R. G., and G. E. Likens, 1979. Limnological Analyses. Saunders, Philadelphia.

*Wilber, Charles G. 1969. The Biological Aspects of Water Pollution. Charles C. Thomas. Illinois.

*Worf, D. L. 1980. Biological Monitoring for Environmental Effects. Lexington Books, San Diego, CA

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LAB SCHEDULE

1. Lab 1. Winter Lake Study
2. Lab 2. Temperature and Oxygen Consumption in Aquatic Organisms
3. Lab 3. Bioassay
4. Lab 4. Standard Bacterial Plate Count/Bacterial Staining

*Subject to change

PRESENTATION TOPICS

Students are required to deliver a 20-minute oral presentation during a predetermined time slot. Presentations will include visual aids as well as oral material delivered by each student. Term Test #3 will include information from students' presentations. The following topics are available for presentation:

NOTE: RELATE YOUR TOPIC TO WATER POLLUTION.

1. Mercury
2. Polychlorinated biphenyls (PCB's)
3. Oil
4. Insecticides (DDT, Dieldrin, Toxaphene, Lindane)
5. Absorbable Organic Halogen (AOX)
6. Waste heat, (thermal pollution)
7. Nuclear pollution (radioactive waste)
8. Dioxin (2,3,7,8-TCDD), Furan (2, 3, 7, 8 - TCDF)
9. Herbicides (2,4D; Glyphosate; Hexazinone)
10. Detergents
11. Acid rain

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12. Mirex
13. Water-borne pathogens
14. Food Processing Wastes
15. Alkylated lead
16. Acid mine drainage
17. Hexachlorobenzene (HCB)
18. Zebra mussels
19. Polyanuclear aromatic hydrocarbons (PAHs)

NOTE: INCLUDE IN EACH PRESENTATION:

1. Description of the pollutant.
2. Sources of the pollutant (natural, man-caused).
3. The effect of the pollutant on the aquatic environment.
4. The water quality guidelines (standards) for the pollutant.
5. Any pertinent incidents* involving the pollutant.
6. Clean up/Controls (if applicable).

*Canadian incidents if possible

Each student is responsible for producing a typed abstract (summary) of information presented as well as a list of references used.

Copies of each presentation summary and reference list will be produced (by instructor) for all students, prior to each presentation.

REPORT WRITING

All lab reports should include the following components:

1. Purpose/Objective - a brief statement outlining the intent of the exercise. Objectives may be itemized, i.e.,
 - a) to determine LC₅₀ for zinc using rainbow trout
 - b) to investigate the relationship between water temperature, pH, alkalinity and the toxicity of zinc to rainbow trout
2. Method/Procedure - a brief outline of how the exercise was conducted. In many instances "Refer to manual" will suffice.
3. Results - a presentation of results, and only results, in an organized format, i.e., TABLE FORMAT. There should be no sentences, no paragraphs--table and figures (graphs) only. Be sure all table and figures are entitled and numbered.

Table 1 - Physical Characteristics of the Great Lakes

Lake	Area (km ²)	Area of Drainage Basin (km ²)	Average Depth (m)	Volume (ckm)	Retention time (yr)
Superior	82,100	127,700	147	12,100	191
Michigan	57,800	118,000	85	4,920	99
Huron	59,600	134,000	59	3,540	22
Erie	25,700	78,000	19	484	2.6
Ontario	18,960	64,030	86	1,640	6

4. Calculations - one example of each different calculation used in presenting the results should appear in this section. Subsequent work using the same calculations should appear in the Appendix. Hence, with the exception of one example calculation, all calculations use to generate data in tables must be shown in the Appendix.

5. Discussion of Results and Conclusions - results are interpreted and discussed. Carefully observe data to determine trends and relationships among all parameters measured.

Are apparent relationships consistent with established relationships present in literature? In this section, you are responsible for conducting a literature search to compare your findings with that of established authors.

Be sure to refer to your data using table and figure numbers - e.g., a direct linear relationship between white sucker weight and fork length is apparent in Figure 2. This relationship agrees well with that established for white sucker by J. A. Smith (1982), W. T. Jones (1974) and B. R. Brown (1971).

If your findings are not consistent with other studies or theories, offer some explanation for the deviation.

e.g., According to Saunders (1972), the principle component of lake trout stomach samples (n=785) in Round Lake prior to 1965 was lake herring (Coregonus artedii) at 72% by volume. Data from this study, however, indicates rainbow smelt (Osmerus mordax) as the dominant food item in 525 lake trout sampled, averaging 97% of stomach contents by volume (Figures 1 and 2). This change in forage species preference is attributed to the introduction of rainbow smelt in 1969 (Wilson, 1971).

All questions posed at the end of a lab exercise should be answered in this section.

N.B. There are several acceptable methods of citing references and referring to your data within the text of your report. Footnotes are not acceptable. Quotes are not acceptable.

N.B. Scientific names of species should appear in brackets only once after the first time the common name appears in the text.

In addition to interpreting and discussing, conclusions should be clearly stated, often itemized, at the end of this section.

6. Sources of Error - itemize all conceivable sources of error.

7. Appendix

- present calculations for all values appearing in tables.

8. Reference Cited

- presented on a separate page at end of report,
- all citations in text of report must be listed alphabetically in this section and conversely all references listed in this section must be cited in the text of the report.

i.e.:

- 1) For paper presented in a journal:

Mason, C. F. and R. J. Bryant. 1974. The structure and diversity of the animal communities in a broad land reed-swamp, J. Zool., 172, 289-309.

issue no. page reference

- 2) For book references:

Hynes, H. B. N., 1970. The Ecology of Running Waters, Liverpool University Press, Liverpool.

- 3) For paper/chapter presented in publication:

Chapman, D.W. 1978. Production fish populations. In Ecology of Freshwater Fish Production (S. D. Gerking, ed.). Blackwell. Oxford.

MAJOR DO'S AND DON'TS

1. Don't use first person in report text, i.e., I, we, our.
2. Do refer to tables and figures by number. Be sure all tables and figures in Results are numbered and entitled.
3. Use correct citation of references.
4. Do not use quotes.
5. Scientific names of species need only appear once in text of report. They are placed in brackets and underlined after the common name of the species appears for the first time.

REPORT MARKING - ONE REPORT SUBMITTED PER STUDENT

SECTION	MARK	MARKING BASED ON
1. Purpose	1	Conciseness; completeness
2. Method	1 (if applicable)	Conciseness; completeness
3. Results	2	Organization; labels, numbers on tables, figures; neatness; correctness
4. Calculations	1	Correctness, completeness
5. Discussion	4 or 5 if method not applicable	Conciseness; organiz- ation; reference material used and cited; complete- ness
6. Errors	1	Completeness
TOTAL		10
7. Appendix	minus 1 mark if absent or incorrect	
8. Reference	minus 1 mark if absent or incorrect	

N.B. Ten percent (10%) deducted per day for late reports.

GLASSWARE PREPARATION

For accuracy, glassware must be properly cleaned fo all impurities prior to conducting lab exercises.

1. Wash all glassware needed in warm soapy water. Use brushes if necessary.
2. Rinse glasware 3 times under tap water.
3. Rinse glassware well with distilled water 3 times.
4. Place glassware upside down on paper towel to drain.