

**STUDENT/FACULTY
RESEARCH OPPORTUNITES
IN THE
ENVIRONMENTAL SCIENCE
DEPARTMENT**

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The construction of the new Science Annex has not only provided the Environmental Science Department with its first dedicated laboratory and teaching research space, but has also provided the funds to purchase a wide range of state-of-the-art new equipment, most of which is now housed in Science Annex 310. When combined with the field and analytical capabilities the department enjoys at Oldham Pond, there is virtually no limit to the possibilities for first-quality research and publication for both students and faculty.

If you have a worthwhile problem to solve, the facilities of our department should be able to help you accomplish your goals. Additionally, the knowledge gained by students learning how to operate these instruments can be invaluable in opening career opportunities.

We've prepared this document to introduce our Environmental and Earth Science majors to the opportunities available to conduct research within the department. We have listed below a brief description of many of the major analytical instruments that the department has, along with some of their uses, and some of the potential and actual research applications.

INSTRUMENTS

ATOMIC ABSORPTION SPECTROMETER

Description

The Shimadzu AA-6701F Atomic Absorption spectrometer is used to analyze the concentration in a liquid solution of most of the elements on the periodic table. The unit is capable of flame (air-acetylene and air-NO) and furnace operation which gives it great sensitivity and range. It is also equipped with an auto-sampler so that it can be set up to automatically perform repeated analysis, unattended on as many as 60 samples. The software used to control the instrument has also recently been updated.



Capabilities

Atomic absorption is most commonly used for the analysis of trace and common metals in water, rock and soil. The method is less useful for elements that commonly form anions – such as oxygen, carbon, nitrogen, oxygen, etc.

Types of Research Commonly Employing This Instrument

Atomic absorption has been used extensively for analyzing pollutants in water and sediment and for the precise determination of the metal concentrations in ores and other earth materials. Water samples can usually be analyzed directly, while sediment and rock samples need to be treated to place their elements in solution.

ION-CHROMATOGRAPHY

Description

In chromatography, ionic elements and compounds are separated by some physical/chemical processes while flowing, at high pressure, through the instrument system in either gaseous or liquid form. The Dionex DX120 ion chromatograph is a medium-pressure liquid chromatograph that can be used for a variety of analyses. Located in our Oldham Pond site, the Dionex is currently set up for the analysis of anions and cations dissolved in water. Ion-chromatography is the standard method for the analysis of such anionic species as fluoride, chloride, nitrite and nitrate, and sulfate in environmental water samples.



Capabilities

The DX120 is set up to analyze water samples as small as 50 μL although actual samples need to be larger to allow for line flushing. The instrument is provided with an auto-sampler for analysis of up to seventy-two 10 mL samples or one-hundred 0.5 mL samples. With the currently installed analytical columns, this unit is ideal for the analysis of F^- , Cl^- , NO_2^- , NO_3^- , and SO_4^{2-} anions in water samples at concentrations above about 50 $\mu\text{g/L}$. PO_4^{3-} can be analyzed at concentrations above about 250 $\mu\text{g/L}$.

Types of Research Commonly Employing This Instrument

Ion-chromatography in conjunction with the measurement of pH and alkalinity can be used to establish the major ion concentration of surface, ground and sediment pore waters. When used in conjunction with the analysis of phosphate by colorimetric methods, ion-chromatography is the primary means by which dissolved inorganic nutrient concentrations in water are determined. When used with the Shimadzu TOC/TN, a complete description of the speciation of N & P in water can be established. Such data are critical for studies of trophic status in aquatic systems.

PARTICLE SIZE ANALYSIS

Description



The Shimadzu SALD3101 Particle size distribution (texture) in soil and sediments is a fundamental property which controls both the physical and chemical characteristics of earth materials. The operation of the Shimadzu SALD 3101 is based on the scattering of a laser beam by particles suspended in a liquid, usually water. Analysis in replicate takes only a few minutes and usually requires less than a gram of sample. Samples are suspended in water after being chemically and/or physically dispersed.

Capabilities

Our instrument is capable of determining the particle size distribution across a range of sizes from 0.5 microns (50 nano-meters) up to about 3 millimeters on a few milligrams sample of material suspended in water.

Types of Research Commonly Employing This Instrument

Particle size distribution is fundamental to the study of soil since the distribution of particle sizes determines porosity, permeability and a host of other soil physical and chemical properties. Particle size distribution has also been employed extensively in sedimentology to study the origin, transport and fate of particles in sedimentary environments.

CHNS/O ANALYZER

Description

The Perkin-Elmer Series II Model 2400 CHNS/O Analyzer is used to obtain the proportions of carbon, hydrogen, nitrogen, sulfur and oxygen in organic matter in solid or liquid samples. As configured in our laboratory, this instrument would be used to determine the ratio or abundance of four elements – C, H, N, & S – in a soil or sediment sample. The unit is supplied with an auto-sampler that can hold 60 samples for programmed, automatic analyses. A micro-balance with a precision of 10^{-4} milligrams is used to weigh the sample prior to analysis.



Capabilities

Analyses, which usually take only a few minutes each, are performed on very small, milligram-sized samples. The samples are combusted in an oven and the measurement of C, H, N, & S is made on the gases emitted during that combustion. The precision of the results is very high.

Types of Research Commonly Employing This Instrument

The analyses performed by this instrument are used primarily to characterize organic matter. For example, transformations of organic matter in soil over time lead to changes in the ratio of nitrogen, sulfur, hydrogen and oxygen relative to carbon.

SCANNING ELECTRON MICROSCOPE

Description



The EVEX 3000 scanning electron microscope (SEM) can produce 3D images of objects at up to 30,000 times magnification while simultaneously providing a quantitative map of elemental distribution across the surface of the magnified object. The EVEX unit along with its computer is housed on a mobile “cart” that can

be moved from laboratory to classroom for demonstration purposes.

Capabilities

The EVEX SEM achieves its mapping capability through the use of energy-dispersive electron spectroscopy (EDS) analysis. The electron beam that produces the image also excites the elements in the sample to emit x-rays. These x-rays are then picked up by a detector and used to establish the elemental composition of the sample at the specific point where the electron beam is currently hitting the sample.

Types of Research Commonly Employing This Instrument

Scanning microscopy is the standard method for obtaining 3D images of objects at moderate magnifications. When combined with elemental mapping, SEM is a powerful tool for analyzing fossils and minerals in rocks and soil.

TOTAL ORGANIC CARBON/TOTAL NITROGEN ANALYZER

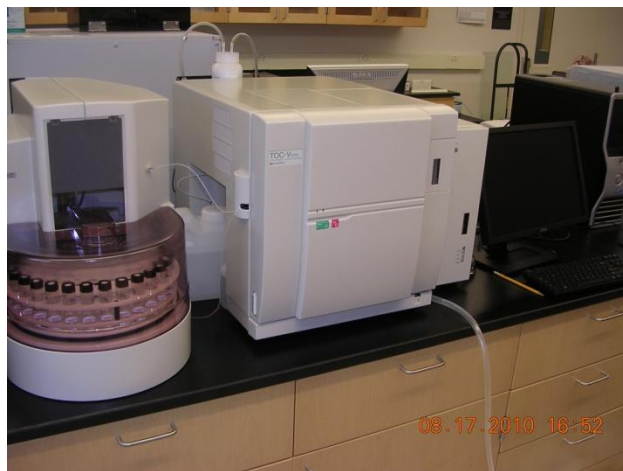
Description

The Shimadzu Model TOC/TN Analyzer is used to measure total (inorganic and organic) carbon and nitrogen concentrations in water samples. Organic C analyses are performed by combusting the sample in air and measuring CO₂ emitted during that combustion using an infrared absorption detector. Inorganic carbon is measured after acidification of the sample and measurement of the evolved CO₂. Nitrogen is measured via a chemi-fluorescence technique after ozonation of evolved gases following combustion in an oven.

Capabilities

The TOC/TN instrument sequentially analyzes water samples for inorganic and organic carbon. When combined with the inorganic nitrite and nitrate analyses on water samples obtained by the DIONEX IC, the total nitrogen concentration (equivalent to Kjeldahl N) obtained by this unit can be used to establish organic N by difference.

The unit requires about 25 mL of water sample. It is equipped with an ASI-V auto-sampler that can hold 92 samples. Each analysis takes about 5 to 10 minutes. The unit can be programmed in any of its operational modes to run unattended and shut down automatically.



Types of Research Commonly Employing This Instrument

TOC/TN analysis is done routinely as a measure of water quality, for example, at water treatment plants (both water supply and waste treatment). It can be used to study natural streams, ponds and lake waters, but is also a critically important instrument in water treatment (supply and waste) plants. Manufacturing plants that require highly purified water for operations also regularly use this type of instrument.

X-RAY POWDER DIFFRACTOMETER

Description



The Shimadzu LabX XRD 6000 X-ray powder diffraction employs an intense, focused beam of x-rays which are directed at the surface of a powdered mineral sample(s). The x-rays are diffracted by the inter-atomic planes within a mineral into a characteristic patterns of peaks which correspond to the distances between the mineral atoms. The signal from the instrument is sent to an attached computer for display and analysis. The computer also controls the operation of the instrument.

Capabilities

Quantitative analyses using x-ray diffraction usually takes about 1 hour per sample. The Shimadzu LabX XRD 6000 can perform analyses of powdered samples either one at a time or using a 5-sample automatic changer. The results are used for qualitative analysis (mineral identification) by comparison with a database stored in the computer. Quantitative determination of mineral structure can also be done using the peak intensity information provided by the instrument. Mixtures of known, pure minerals, and semi-quantitative mineral abundance in a mixture, can be performed.

Types of Research Commonly Employing This Instrument

X-ray powder diffraction is the standard method for the identification and analysis of crystalline materials such as silicate minerals in rocks. X-ray diffraction is the most commonly used means of establishing the basic structure of minerals. When dealing

with mineral mixtures such as rocks, x-ray diffraction can also provide semi-quantitative results for mineral percentages.

Other Laboratory & Field Equipment

In addition to the major pieces of equipment listed above, the department has a wide range of smaller instruments (such as the UV/vis spectrometers) and field equipment for conducting research and sampling in soil, air and water analysis in the field.