Contaminants of Emerging Concern (CECs)

A Fact Sheet from the Southern California Coastal Water Research Project

January 2012

What are CECs?

CECs are a diverse group of chemicals and their by-products. CECs are used in industrial, agricultural, or consumer applications, but most are not currently regulated and routinely monitored in the environment.

The largest class of CECs is industrial chemicals, followed by ingredients in personal care products, food additives, pharmaceuticals, and pesticides.

Class	Common Examples	
Industrial chemicals	Siloxanes	Silicone-based compounds in anti-foaming agents, water-repellant coatings, sealants, and lubricants
Personal care products	Triclosan	Antibacterial agent in soap, deodorant, toothpaste, and mouthwash
Food additives	Caffeine	Natural stimulant in coffee and tea, added to soda, sports, and energy drinks
Pharmaceuticals	Ethinyl-estradiol	Synthetic hormone in oral contraceptives
Pesticides	Fipronil	Insecticide used on crops, golf courses, lawns, and household pets

Why the Focus?

Concern about CECs stems from the rapid pace of new chemical production, along with an increased focus on CEC detection in the environment and drinking water sources. More than 100,000 chemicals are currently in use, but fewer than 130 constituents are regulated as priority water pollutants. Most CECs do not have approved measurement methods, and few studies have examined the environmental fate and potential harmful effects of CECs on organisms (including humans).

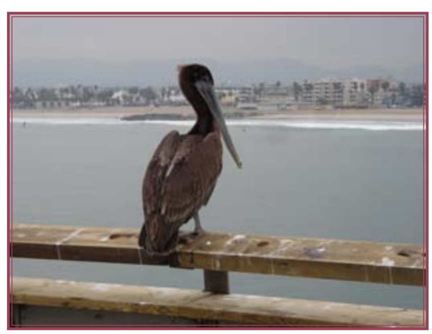
CEC detection in the environment is frequent, though generally at low concentrations. Preliminary research has found some effects on wildlife at the individual organism level, but not larger population effects. CEC effects on humans are not evident, although biological effects research is still in its early stages.

How Do CECs Enter the Environment?

CECs enter the environment through a variety of pathways and move among land, air, and water.

Common Examples

- Pharmaceuticals excreted in urine or flushed down the toilet, if not removed by standard wastewater treatment practices, are discharged with treated effluent into rivers or the ocean.
- Pesticides used on gardens, golf courses, or crops run off into streams, storm drains, and coastal waters when it rains.
- Fire retardants applied to furniture and electronics volatilize into air, leach into water, or bind to particles like house dust and soil.



Conducting Field Surveys

To address data gaps, collaborative surveys have been conducted to measure CECs in stormwater, treated wastewater, and ocean receiving waters, while investigating potential impacts to wildlife. In addition, SCCWRP and partners are researching new field and lab techniques for studying CECs.

Monitoring Mussels

Filter feeders like mussels tend to concentrate water contaminants. In 2009, scientists began measuring CECs in mussel tissue as part of the National Oceanic and Atmospheric Administration's Mussel Watch, a long-running coastal bivalve monitoring program.

Research produces new knowledge to help guide management of CECs.

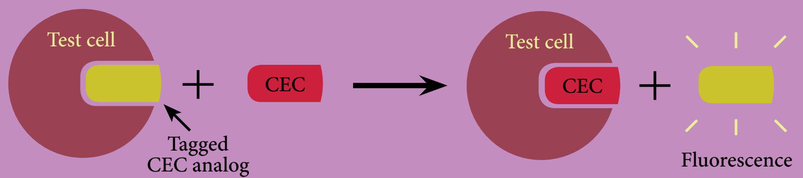
Building Scientific Consensus

Several California-based workshops and meetings have been held to build consensus on CEC issues, and two targeted expert advisory panels were formed to offer guidance to the State Water Resources Control Board. The recycled water panel proposed a list of CECs to monitor but urged development of rapid tests to screen for potential biological effects of all CECs. The second panel is formulating recommendations for fresh and marine receiving waters.

Developing New Biological Methods

Biological methods integrate monitoring for numerous chemicals by looking at their combined effects on test organisms, cells, or DNA. This approach can save time and expense, and account for broad sets of CECs (including unknowns). To efficiently screen for CEC contamination in recycled water, SCCWRP and collaborators are working to develop a battery of rapid tests linked to higher biological impacts.

Example of Rapid Water Quality Screening



1. Scientists design and grow engineered cells that respond predictably to CECs exhibiting the same mode of biological activity (e.g., those that cause genetic, immunological, or hormonal changes).
2. In the laboratory, a concentrated extract from a water sample is placed in contact with the cells for a short period of time.
3. The biochemical reaction of interest is then detected by imaging (e.g., fluorescence).

For more information on SCCWRP research, visit: www.sccwrp.org

Integrated Sediment Quality Assessment

A Fact Sheet from the Southern California Coastal Water Research Project

SCCWRP Established 1969

March 2012

Why Do We Care About Sediment Quality?

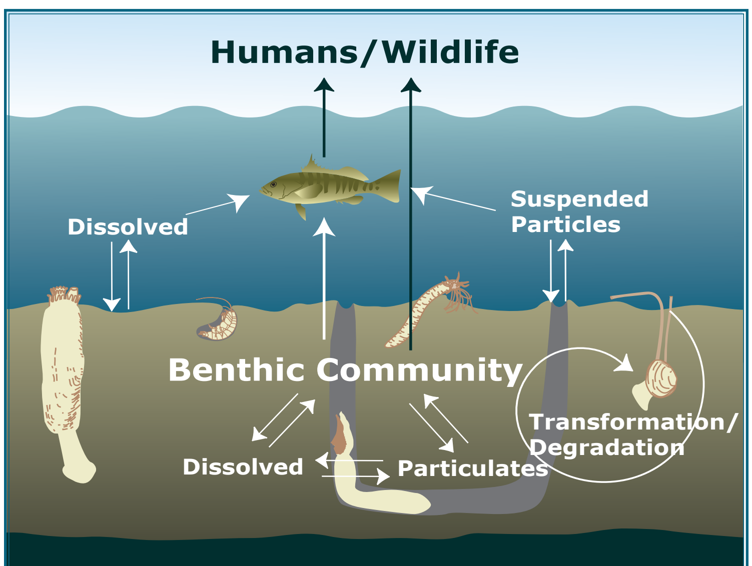
Many pollutants bind to particles that are washed into rivers and storm drains, then settle out as sediment in slower moving coastal waters. As a result, contaminants tend to accumulate in sediments, providing sentinel information about environmental conditions. These contaminants can remain in sediment for long periods and serve as a major source of exposure for aquatic life and humans who consume seafood.

Southern California regional monitoring studies have found the highest contamination levels in coastal embayments (e.g., harbors, estuaries, and marinas) where sources include past or current on-site activities and sediment deposited by rivers and drainage channels.

Interpreting Sediment Quality Is Challenging

Sediment contamination does not always pose a threat to aquatic life. To evaluate the potential for environmental impacts, scientists need to determine not only the quantity of contaminants present, but also whether they are accessible to living organisms. If contaminants are tightly bound to sediment particles, they pose little risk to aquatic life. On the other hand, some contaminants can be ingested along with sediment particles or released into adjacent water where they are more accessible to the animals living in the sediment (aka the benthic community).

Sediment Contaminant Transfer

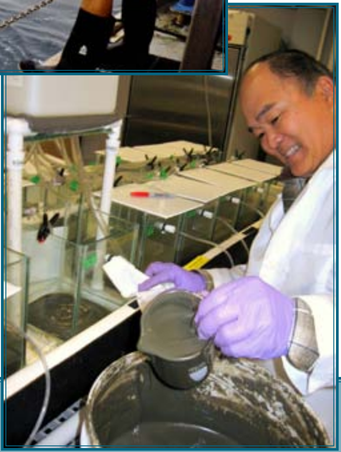


Sediment contaminants enter the food web via release into overlying water, direct contact, and sediment ingestion by benthic organisms. Concentrations in tissue increase with each step up the food web, posing the greatest risk to top-level predators.

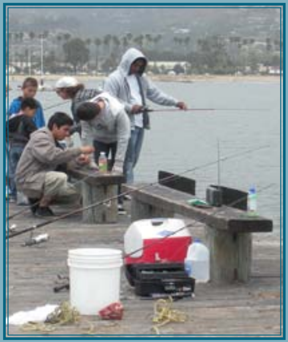
Multiple Lines of Evidence Improve Sediment Quality Assessment

Sediment chemistry analysis alone does not accurately indicate the potential for pollutant impacts owing to variability in the contaminants' biological availability. To evaluate sediment quality, scientists must consider multiple types of evidence. For example, three lines of evidence are often used to assess impacts on aquatic organisms: sediment chemistry, toxicity, and benthic community condition. Each line of evidence has some limitations, but when used in combination they produce a more robust sediment quality assessment.

Sediment Quality Indicator	Benefits	Limitations
Sediment Chemistry	Quantifies individual contaminant concentrations	Does not consider bioavailability; cannot measure all contaminants or assess combined effects
Toxicity	Integrates all contaminant effects on survival, growth, or reproduction of aquatic test organisms	Lab conditions/test species may not fully reflect field conditions; does not identify the cause of toxicity
Benthic Community Condition	Integrates all contaminant effects on the resident benthic community species	Time-intensive; also affected by non-contaminant factors, such as oxygen availability or physical disturbance



Assessing Risk to Humans



Because contaminants such as mercury, DDT, and PCBs accumulate in tissue, sediment contamination affects not only sediment-dwelling organisms, but also birds, marine mammals, and people who consume seafood. Quantifying this indirect risk adds complexity to sediment quality assessment. In addition to measuring sediment and seafood contaminant concentrations, scientists use models to predict contaminant movement through the food web, based on feeding habits and movement patterns of fish. Risk also depends on individual sensitivity and the amount and type of seafood a person consumes.

Regulatory Application: Sediment Quality Objectives (SQOs)

While many environmental monitoring programs include sediment quality assessment, California's Sediment Quality Objectives (SQOs) for bays and estuaries represent the first statewide regulatory application of this approach. SCCWRP and its partners have developed many of the assessment tools for implementing this policy based on the multiple lines of evidence approach. These tools are available on SCCWRP's website.

Microbial Source Tracking & Identification

A Fact Sheet from the Southern California Coastal Water Research Project

SCCWRP
Established 1969

March 2012

Finding Sources of Contamination Helps Managers Protect Public Health

California's coastlines host millions of visitors each year. To protect public health, county health agencies and others regularly monitor water quality in streams, coastal discharges, and at beaches. If an area shows chronically high fecal bacteria levels, managers need a way to track the contamination source. Microbial source tracking and identification methods help characterize site-specific issues. With these tools, managers can better allocate resources to reduce public health risk and beach closures over the long run, improving beach access and the local economy.

Examples of Fecal Bacteria Sources & Pathways in Southern California

- Sewage leaks or spills
- Failing septic tanks
- Illegal dumping
- Homeless camps
- Pet waste
- Wildlife
- Livestock waste
- Growth on storm drain channels, sand, soil, decaying plant matter, and beach debris
- Transport in overland runoff/ stormwater

Source Tracking

Following bacterial signal back to its source (e.g., a specific storm drain, campground, or leaking sewage pipe)

Source Identification

Characterizing the origin of the bacteria (e.g., human, bird, dog, or livestock fecal material)

Indicators vs. Pathogens

Fecal material often contains pathogens (bacteria, viruses, or other microorganisms that can cause disease). Rather than testing for each individual pathogen, scientists look for the presence of "fecal indicator bacteria" (FIB). These bacteria are often found when fecal contamination is present, but may be associated with non-fecal sources like decaying plant matter. To further enhance public health protection, extensive research to investigate new source-specific monitoring methods is ongoing.

How Does Source Tracking and Identification Work?

Source tracking and identification tests detect evidence of sewage or target specific microorganisms' molecular or genetic material (called "markers"). These tests typically aim to separate human from non-human sources; some are designed to differentiate among individual animal species. Routine source-specific identification and tracking standards do not yet exist, and many newer methods are still experimental.

SCCWRP research develops new source tracking and identification methods, evaluates comparative method performance, and provides scientific guidance for management applications.

Source Tracking and Identification Examples

Method	Evidence Detected	Pros	Cons
Optical Brighteners	Laundry detergent additives found in household wastewater	Low-cost; fast results; linked to human sources	Dissipate in sunlight; low sensitivity
FIB Culture	Growth of fecal indicator bacteria	Method already used at many labs	Slow; not source-specific
Human Markers	A microbe (virus, bacteria, or protozoa) found primarily in humans	Relatively fast results; species-specific	Highly technical; higher cost
Animal Markers	A microbe found primarily in one animal species	Relatively fast results; species/source-specific	Highly technical; higher cost
Community Analysis	Many microbial markers detected simultaneously	May identify dominant source	Highly technical; higher cost

Source Identification Protocol Project (SIPP)

The State Water Resources Control Board's Clean Beach Task Force commissioned the SIPP to develop protocols for tracking and identifying bacteria sources at beaches throughout California. SCCWRP is one of four core laboratories implementing the multi-year study, which will produce a standard guidance manual for beach managers.

Method Comparison Study

Part of the SIPP calls for a large-scale method comparison study. Samples from multiple fecal sources were prepared at SCCWRP and shipped to researchers around the world for analysis. The results will clarify the performance, benefits, and drawbacks of each method; prioritize research; and set the stage for user-based testing.

Management Application: QMRA

One potential application of source tracking and identification methods is quantitative microbial risk assessment (QMRA). QMRA estimates the relative risk to human health based on information about differential microbial behavior among fecal sources. The US Environmental Protection Agency (EPA) is currently evaluating QMRA as a means for developing site-specific beach bacteria standards. SCCWRP will partner with the EPA to assess its applicability in a southern California pilot study.

Harmful Algal Blooms

A Fact Sheet from the Southern California Coastal Water Research Project

December 2012

What Is a Harmful Algal Bloom?

An algal "bloom" occurs when algae grow rapidly and form dense accumulations. Harmful algal blooms (HABs) are those that negatively affect the ecosystem, humans, and/or wildlife. HABs occur in both fresh and marine waters.

Why Are HABs a Concern?

HABs have a wide range of harmful consequences, but the hazard most often associated with HABs is release of toxins. Algal toxins, if ingested via shellfish or water consumption, can be lethal to wildlife, domestic animals, and humans. The direct physical effects of excessive algal growth can also be harmful to the ecosystem.

Physical Effects

Direct physical effects of HABs include:

- Oxygen depletion (as algae decompose)
- Water discoloration and odor creation
- Light reduction to aquatic plants
- Irritation and clogging of fish gills
- Hypothermia in seabirds covered by algal foam

Causes

Algal blooms occur when water conditions (e.g., light, temperature, circulation, and nutrient levels) are conducive to algal growth. For example, natural coastal upwelling of deep, nutrient-rich waters may help to fuel an algal bloom.

The indirect triggers for algal blooms are not fully understood, but recent research suggests human influences, such as reduced water circulation or excess nutrient loads from land-based sources, can contribute to increased bloom frequency and/or the severity of harmful effects.

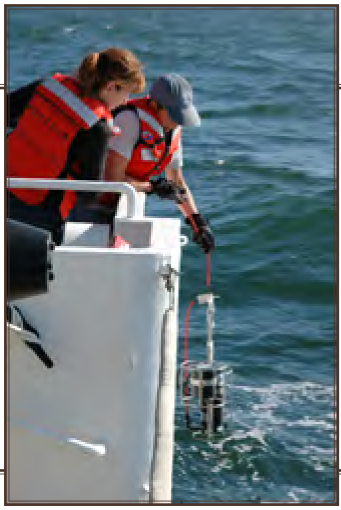
Red Tides vs. HABs

Though often used interchangeably, these terms are not equivalent. "Red tides" occur when pigments in algae make the water appear red or brown, a common occurrence in southern California coastal marine waters. Not all red tides are harmful, and fewer than 10% of all southern California HAB species cause red tides.

SCCWRP actively engages in research related to HAB causal factors as well as collaborative statewide HAB monitoring and response networks.

Investigating HAB Causal Factors

SCCWRP studies how HABs form and move in relation to multiple natural and anthropogenic factors, including nutrient supplies and chemical forms of nutrients. Recent research evaluates nutrient availability on different spatial scales, including region-wide trends and specific HAB "hot spots."



Freshwater HABs

Freshwater HABs are not as well-studied as marine HABs, but can have similar ill effects. Freshwater HAB toxins are more likely to affect water supplies, domestic animals, and livestock, and can also reach marine environments via rivers and storm drains. In southern California, toxins produced by blue-green algae (cyanobacteria) have been detected in many freshwater systems. SCCWRP is conducting ongoing research to document toxin occurrence and improve understanding of triggers.

Developing Monitoring Technology

New monitoring technologies are being tested in southern California to characterize bloom events, track algal toxins, and investigate the water quality conditions associated with HABs. These include fixed environmental sensors and autonomous underwater vehicles deployed remotely to augment information from existing satellite data collection and ship-based water sampling. Passive sampling devices called SPATT (Solid Phase Adsorption Toxin Tracking) bags are another new technology being tested to detect and track toxins in the water.

Engaging in HAB Networks

To advance the application of scientific findings to HAB management efforts, SCCWRP coordinates and participates in several work groups and monitoring networks.

- In addition to establishing an ongoing statewide monitoring network, the **California Harmful Algal Bloom Monitoring and Alert Program (HABMAP)** facilitates information exchange among scientists, managers, and wildlife rescue centers. HABMAP seeks to determine how to respond to HAB events and mitigate their impacts.
- The **Blue-Green Algae Work Group**, made up of water quality managers, public health managers, and scientists, focuses on addressing HABs in California's fresh water bodies. The group is working to develop guidelines and toxicity action levels for local, state, and tribal regulators.