BIOCHEMICAL OXYGEN DEMAND IN WATER BODIES		
Fresh Water	**Water Quality**	

1. INDICATOR

(a) Name: Biochemical oxygen demand (BOD) in water bodies.

(b) Brief Definition: BOD measures the amount of oxygen required or consumed for the microbiological decomposition (oxidation) of organic material in water.

(c) Unit of Measurement: mg/l of oxygen consumed in 5 days at a constant temperature of 20°C in the dark.

(d) Placement in the CSD Indicator Set: Fresh water/Water quality.

2. POLICY RELEVANCE

(a) Purpose: The purpose of this indicator is to assess the quality of water available to consumers in localities or communities for basic and commercial needs. It is also one of a group of indicators of ecosystem health.

(b) Relevance to Sustainable/Unsustainable Development (theme/sub-theme): Sustainable development is heavily dependant on suitable water availability for a variety of uses ranging from domestic to industrial supplies. Strict water quality standards have been established to protect users from health and other adverse consequences of poor water quality. The presence of high BOD may indicate faecal contamination or increases in particulate and dissolved organic carbon from non-human and animal sources that can restrict water use and development, necessitate expensive treatment and impair ecosystem health. Human ill health due to water quality problems can reduce work capability and affect children's growth and education. Increased concentrations of dissolved organic carbon can create problems in the production of safe drinking water if chlorination is used, as disinfection by-products, such as trihalomethanes and other compounds toxic to humans, may be produced. Increased oxygen consumption poses a potential threat to a variety of aquatic organisms, including fish. It is, therefore, important to monitor organic pollution to identify areas posing a threat to health, to identify sources of contamination, to ensure adequate treatment, and provide information for decision making to enhance water sustainability. BOD is also a useful measure to assess the effectiveness of current water treatment processes.

(c) International Conventions and Agreements: The Resolution II and Plan of the United Nations Water Conference recommended governments reaffirm the commitment made at Habitat to "adopt programmes with realistic standards for quality and quantity to provide water for rural and urban areas". The goal of universal safe water coverage was reiterated at the World Summit for Children in 1990.

(d) International Targets/Recommended Standards: Not available.

(e) Linkages to Other Indicators: Several indicators are directly linked to the concentration of organic material in freshwater. These measures include annual withdrawals of ground and surface water, domestic consumption of water per capita, concentration of faecal coliforms in freshwater, percent of population with adequate excreta disposal facilities, access to safe water, infant mortality rate, nutritional status of children, environmental protection expenditures as a percent of Gross Domestic Product, and expenditure on waste collection and treatment, and ecosystem health.

3. METHODOLOGICAL DESCRIPTION

(a) Underlying Definitions and Concepts: Biochemical oxygen demand (BOD) is an empirical test to provide a measure of the level of degradable organic material in a body of water. There are two main methods for measuring BOD:

Method 1: This is the most common method used. It simply involves the incubation of a water sample over a specified period (usually five days) at a constant temperature of 20°C in the dark.

Method 2: This method involves the incubation of a water sample that is diluted with de-ionised water saturated with oxygen. The incubation of the diluted sample is identical to the first method, i.e., it is conducted over 5 days at a constant temperature of 20°C in the dark.

These tests represent standard laboratory procedures usually referred to as the BOD5 test.

These procedures are used to estimate the relative oxygen consumption of wastewaters, effluents, and other waters affected by organic pollution. Microorganisms (mainly bacteria although other microorganisms, algae, plants and animals can also make significant contributions in some aquatic systems) use the oxygen in the water for oxidation of polluting organic matter and organic carbon produced by algae, plants and animals.

(b) Measurement Methods:

Method 1: This method consists of filling to overflowing an airtight bottle of specified size with the water sample to be tested. It is then incubated at a constant temperature for five days in the dark. Dissolved oxygen is measured initially and after incubation. The BOD5 is then computed from the difference between the initial and final readings of dissolved oxygen.

Method 2: This method consists of filling a bottle with incremental levels of a water sample that is then diluted with de-ionised water. The dilution water contains a known amount of dissolved oxygen. The bottles are completely filled, freed of air bubbles, sealed and allowed to stand for five days at a controlled temperature of 20 °C (68 °F) in the dark. During this period, bacteria oxidize the organic matter using the dissolved oxygen present in the water. At the end of the five-day period, the remaining dissolved oxygen is measured. The relationship of oxygen that was consumed during the five days and the volume of the sample increment are then used to calculate the BOD.

(c) Limitations of the Indicator: The main limitation of the indicator is that it provides empirical and not absolute results. It gives a good comparison among samples, but does not give an exact measure of the concentration of any particular contaminant. Further, it was designed to assess the impact of point-source organic effluents on source waters and is not generally suitable for environmental monitoring. Further, the BOD can increase due to an increase in nutrient (e.g., nitrogen and phosphorus) loads to a water body (eutrophication) without a concomitant increase in external organic carbon loading. The increase in nutrients stimulates the growth of algae and aquatic plants (primary production), which causes an indirect increase in biological (usually mainly bacterial) oxygen consumption. However, bacterial activity can be directly increased in some waters with low nutrient concentrations. It is important to follow laboratory procedures precisely to obtain consistent results. The five-day time frame to obtain results represents the main operational drawback of the indicator. In addition, the methodologies outlined are not indicative of in situ oxygen consumption rates because of the artificial incubation conditions, i.e., bottling water with its associated microbial communities with no air flow, currents, light etc.

(d) Status of the Methodology: Operational.

(e) Alternative Definitions/Indicators: Chemical Oxygen Demand (COD) is an alternative measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical exigent. COD can be empirically related to BOD5. After this correlation is determined for a specific source, it is a useful measure obtained from an instantaneous chemical test. Dissolved oxygen concentration (DO) is a better general environmental monitoring indicator that is also applicable to assessing organic pollution. DO also has known concentration limits for a variety of aquatic species.

4. ASSESSMENT OF DATA

(a) Data Needed to Compile the Indicator: BOD5 results from laboratories.

(b) National and International Data Availability and Sources: Data are normally available on a routine basis from municipal wastewater treatment and discharge facilities, the laboratories of water or public health authorities, water research institutes, and universities. At the national level, the data sources include national water authorities, water supply utilities, ministries of health or environment, and research institutions.

(c) Data References: None.

5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR

(a) Lead Agency: The lead agency is the United Nations Environment Programme (UNEP). The contact point at UNEP is the Director, Division of Environmental Information, Assessment and Early Warning, fax no. (254-2) 62- 4274.

(b) Other Contributing Organizations: Other agencies assisting in the development of this indicator include the World Health Organization (WHO), the UNEP Global Environment Monitoring System (GEMS/Water) Programme, the United Nations Children's Fund (UNICEF); United Nations Centre for Human Settlements (Habitat); and the United Nations Food and Agriculture Organization (FAO).

6. REFERENCES

(a) Readings:

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. *Standard Methods for the Examination of Water and Wastewater*. 20th Edition. 1999.

International Standards Organization. *Water Quality--Determination of Biochemical Oxygen Demand after Five Days (BOD5)*. ISO 5815. 1989.

International Standards Organization. *Water Quality--Determination of the Chemical Oxygen Demand*. ISO 6060. 1989.

(b) Internet site:

UNEP/GEMS Programme for Freshwater Quality Monitoring and Assessment at the National Water Research Institute of Environment Canada:
http://www.gemswater.org.