

# Diagnosing The Biomass

by Jay B. Hill, Richard D. Bleam, Thomas G. Zitrides  
Bioscience, Inc.

The successful operation of a biological wastewater treatment system depends on the ability of the biomass to degrade the constituents of the incoming waste stream sufficiently to reach effluent permit limits. Operators need quick assessment tools to determine if the treatment process is operating well, just as a doctor listens to a patient's heart through a stethoscope and takes temperature and blood pressure. Such tests may not be sufficient to diagnose illness but serve as a quick evaluation of the basic health of the patient. The pulse of biomass health and stability is biological oxygen uptake, or respiration rate.

Oxygen uptake reflects the ability of the biomass to metabolize wastewater components. High oxygen uptake rates indicate a healthy biomass; low rates indicate an unchallenged or unhealthy microbial population. By measuring the oxygen uptake response of the biomass to various environmental conditions, plant operators can "listen" for symptoms and diagnose potential operating problems. Timely response to such problems can mitigate or eliminate their impact on the treatment plant.

## Dissolved Oxygen Depletion Method (Short-term)

Measurement of the specific oxygen uptake rate (SOUR) is easily accomplished with field instruments. The SOUR of return sludge (RAS) determines the current endogenous (baseline) activity of a wastewater biomass. Low SOUR indicates poor health of the biomass while high SOUR may indicate incomplete removal of organics in the process. SOUR of the mixed liquor suspended solids (MLSS) is used to determine the relative waste strength (loading) of the influent to the plant or the presence of a toxic influent. This test can also be used to evaluate pure compounds or isolated influent streams for biodegradability, inhibition or toxicity to the biomass. SOUR is a direct measure of the current activity and biodegradative ability of the biomass for the extant wastewater.

When using an instrument such as the EZ-BOD Meter\* for SOUR, a sample of mixed liquor or return activated sludge is placed in a standard BOD bottle. A previously calibrated DO probe is inserted into the bottle and the DO concentration is automatically measured over an interval of time. If the rate of decline of dissolved oxygen is

linear, the rate is reported as OUR in milligrams of oxygen per hour. To calculate the SOUR of the sample, which is the OUR standardized to the solids concentration and temperature, the solids concentration of the sample (TSS or VSS) is entered (use of a field suspended solids meter is convenient) and the SOUR normalized to 20 degrees Celsius is calculated automatically. The SOUR is reported as milligrams per liter per hour per gram of biomass.

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Normal, healthy respiration rates for conventional activated sludge mixed liquor can vary from 12-20 milligrams of oxygen per gram of MLSS. Low values indicate a

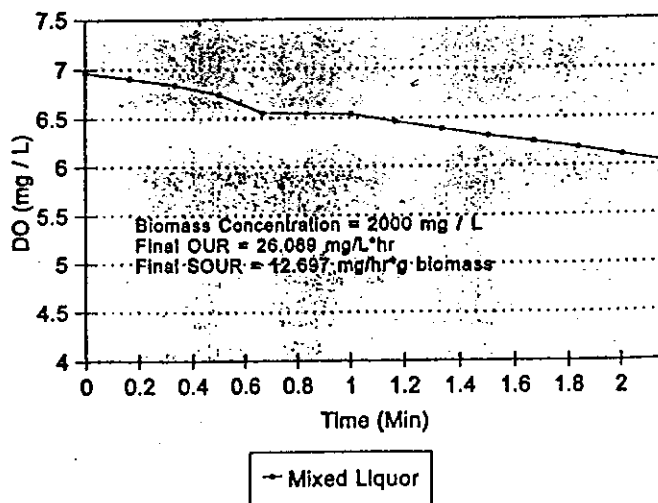
toxic influent, low influent organic content, or non-biodegradable constituents in the wastewater. High values indicate a very active biomass, overloading of the aeration basin or both. Figure 1 shows a typical OUR curve of dissolved oxygen versus time.

## Dissolved Oxygen Depletion Method and COD Measurement

Comparison of SOUR to influent COD and control charts of SOUR can help operators to determine if a process is under control or requires modification of operating parameters. Figure 2 shows control charts for influent COD and SOUR with average and limit values (average +/- one standard deviation). Limits warn of abnormal influent waste strength (example: day 34 & 35), abnormal biomass activity or both. For a plant operating at an approximately constant solids level, SOUR will be roughly proportional to influent waste strength. However, when an influent is toxic or nonbiodegradable, SOUR will be low even when the influent COD is high (example: day 41).

Timed rates of DO depletion can also be used to predict the 5-day BOD for specific plant conditions. This test, while not intended to replace the 5-day BOD test for reporting purposes, provides sound, timely information on waste strength and process effectiveness. In the short-term BOD test (STBOD), the difference between the OUR due to endogenous respiration and the

Figure 1. Specific Oxygen Uptake Rate Test



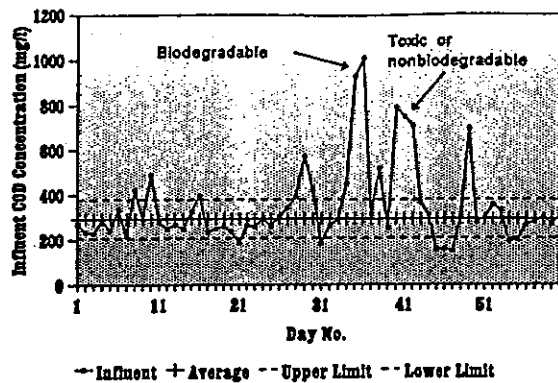
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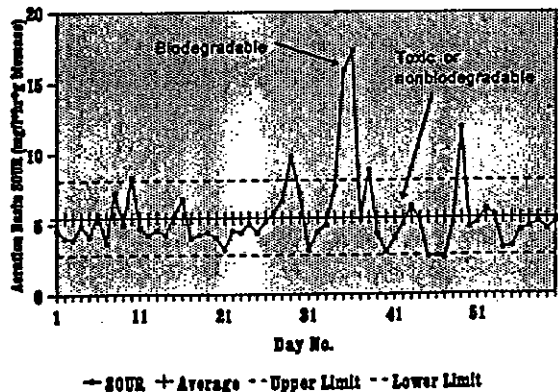
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**Figure 2. Control Charts**  
COD Concentration



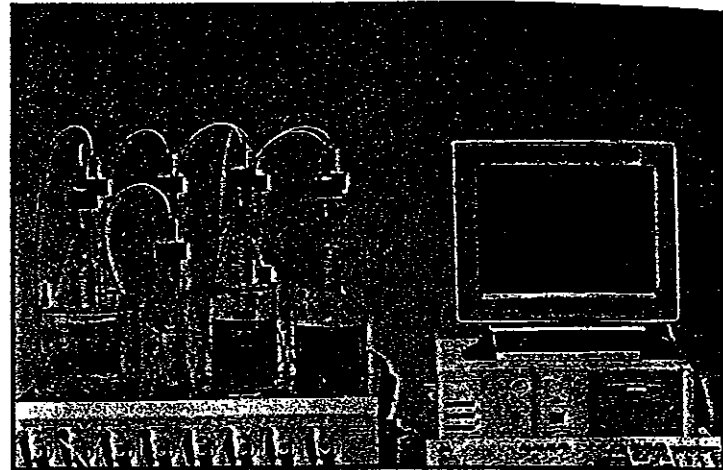
### SOUR



OUR with the addition of an influent sample is compared and integrated. The result is multiplied by a correlation factor to estimate standard 5-day BOD. Figure 3 shows an EZ-BOD meter prediction of BOD5 versus actual 5-day BOD results.

### Continuous Oxygen Resupply Method

Biological oxygen uptake rate can be readily measured in a laboratory by electrolytic respirometry. Data can be acquired quickly for toxicity screening, bio-augmentation evaluations, sludge activity studies and biological process modeling. The test period can be extended to perform long-term treatability tests and biodegradability or standard OECD tests (28 days). The operating principle of an electrolytic respirometer is continuous, automatic resupply of oxygen via electrolysis of



water. ER bioreactors can closely simulate conditions in an operating aeration basin and test both short-term and long-term oxygen uptake rates.

### Short-term Respirometry

For short-term toxicity screening and biomass activity studies, ER can detect changes in the respiration rate of biomass as conditions fluctuate. It measures the ability of the biomass to adapt to changes in influent BOD loading, chemical composition or other ambient conditions. For these tests, the concentrations of activated sludge and influent are selected to simulate the current or potential condition of the treatment system. As conditions in the treatment plant change and loading rates vary, tests can be performed to measure the response of the biomass to the new conditions. These analyzes can be run daily in order to closely monitor biomass changes. Dilutions of the influent can be used to determine if the biomass displays a negative response to increased loading, indicating the onset of inhibition or toxicity, and at what concentration it occurs. Other environmental factors such as temperature, pH and nutrient levels can be varied in order to perform a comprehensive analysis.

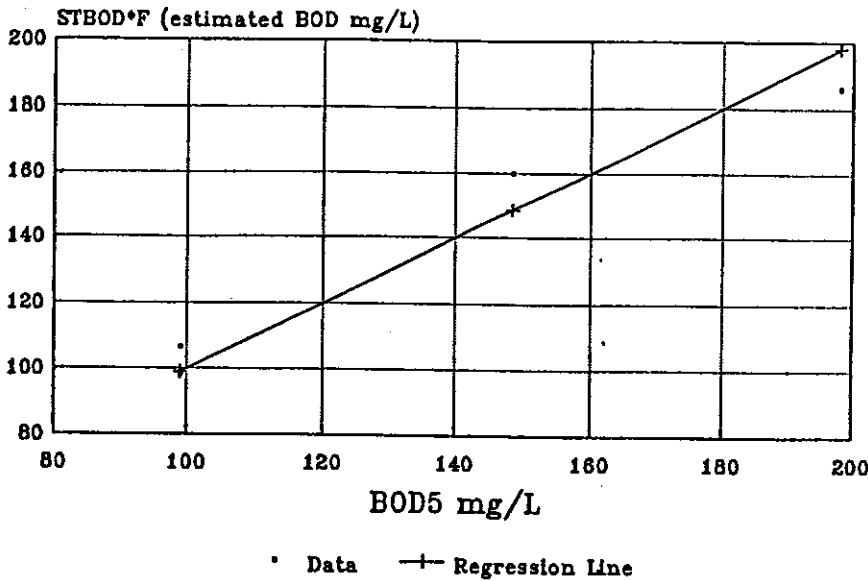
An example of this type of testing is shown in Figure 4. This figure shows the biodegradation of cleaning compounds used in an industrial plant. All one-liter reactors contain a representative mixture of plant biomass and normal influent wastewater. The control reactor receives clean water only; the test reactors receive an equivalent volume of test compound in solution. In Figure 4 the control results have been subtracted from the test results to yield "net oxygen consumption". As shown, compound A is biodegradable and adds BOD to the influent. Compound B is toxic and slows biodegradation of influent BOD. Such compounds are usually tested at (or slightly above) the expected concentration in the aeration basin. Conventional tests which require wastewater dilution (e.g., BOD5) or do not use actual plant biomass may not accurately measure toxicity in the plant.

### Short-Term ER and COD Measurement

Respirometry measurements are particularly useful when combined with measurements of aggregate waste concentration, such as COD. Micro-COD analyzes today can be made in as little as

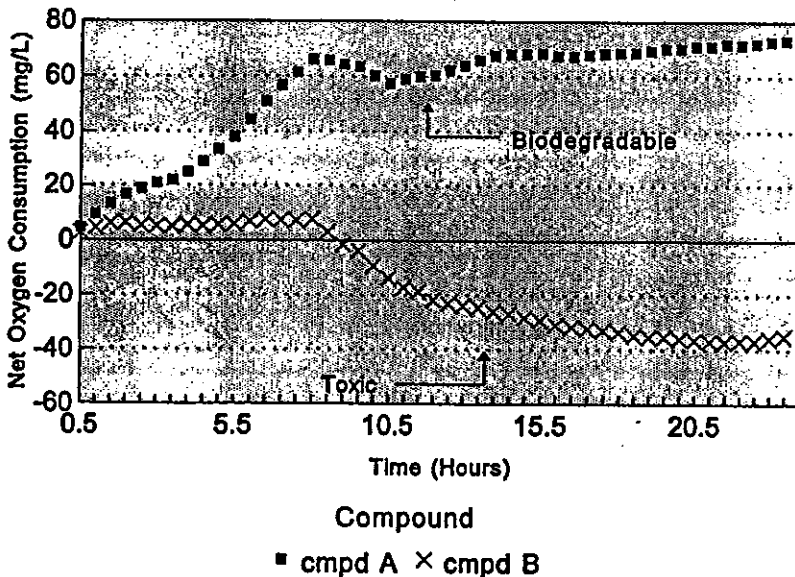
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Figure 3. Short Term BOD Estimate vs BOD



R-2 = 0.94, F = 4.26

Figure 4. Respirometric Toxicity Screening Results. Net Oxygen Consumption for Compounds A and B.



Control = RAS + nontoxic plant influent

15 minutes. The response of the biomass to an influent stream can be categorized by measuring the concentration of waste coming in (COD), and comparing it to the microbial response as measured by oxygen uptake.

An electronics firm used such a combination to determine if process waste from electroplating was biodegradable and whether it was toxic to treatment biomass at high concentrations.

The waste consisted primarily of three low molecular weight organic compounds and high inorganic salt concentrations. All three organic compounds were known to have toxic properties. The total waste strength was over 5000 mg/l as COD and 6 percent salt. It was suspected that the high salt content would also cause toxicity.

An initial respirometric test determined that the waste was biodegraded by commercial bacterial cultures at dilutions of 1:10 or greater. Oxygen consumption was about 80 percent of theoretical after 140 hours. The two major organic compounds were reduced to non-detectable levels.

A second respirometric test determined that the waste was degraded by municipal return activated sludge from the potential receiving plant at the 1:10 dilution. Oxygen consumption was 60 to 80 percent of theoretical after 140 hours, depending on dilution, and reached 90 percent of theoretical after 170 hours.

Toxicity was noted at waste concentrations of 20 percent or greater of the reaction mixture for both the commercial and municipal biomass. One organic compound, a chelating agent present at over 150 mg/l in the waste, was only partially degraded.

A third study determined that salt was not the toxic or inhibitory component, as a synthetic mixture of the organic components without the salt produced similar inhibitory effects - that is, the 10 percent waste solutions were biodegraded and the 20 percent waste concentration was toxic.

**Troubleshooting Guide**

A troubleshooting guide, using the SOUR of the mixed liquor or STBOD and COD, is easy to develop. Figure 5 shows how rapid determination of BOD, COD and dissolved oxygen (DO) can be used for process control of a wastewater treatment plant. When these parameters

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are in the normal range, effluent will meet permit limits. However, when one or more of them varies from the normal range, the cause should be quickly diagnosed and operational decisions made to prevent problems (see Figure 6).

Lower BOD/COD ratio may indicate toxic or non-biodegradable components in the influent. Effluent COD will also probably increase (warning of effluent permit violations). An increase in sludge age, recycle ratio or hydraulic residence time (HRT) or redirection of the troublesome influent to a holding tank may be necessary to avoid a plant failure.

High influent BOD and COD usually indicate an increase in non-toxic, biodegradable organic or inorganic loading. Low DO in the aeration basin will usually result, requiring additional aeration and higher sludge recycle rate. High BOD/COD ratio indicates an increase in easily biodegradable components in the wastewater. Low DO, odor or dispersed floc (new growth) may result, requiring operational changes (increased aeration, higher recycle ratio, change in wastage of RAS) to establish stable plant operation.

Low BOD and COD (normal BOD/COD ratio) and high DO indicate low loading to the treatment plant. Continued low loading values may encourage filamentous organism growth. An increase in wastage of RAS may be used to deter this.

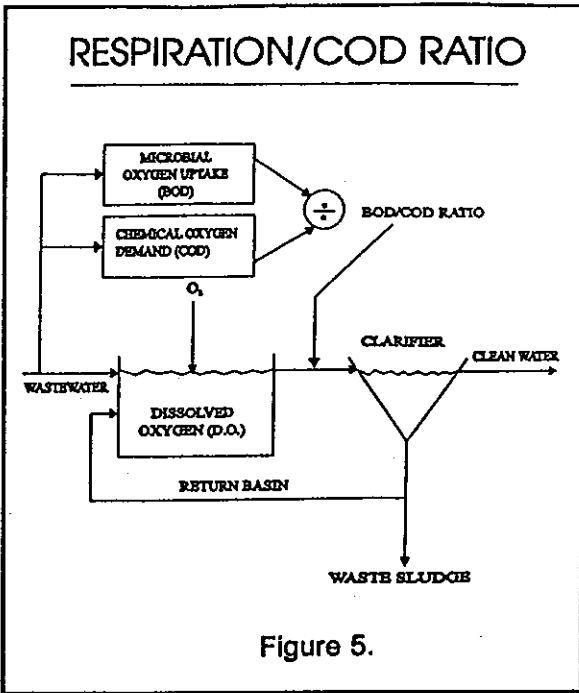
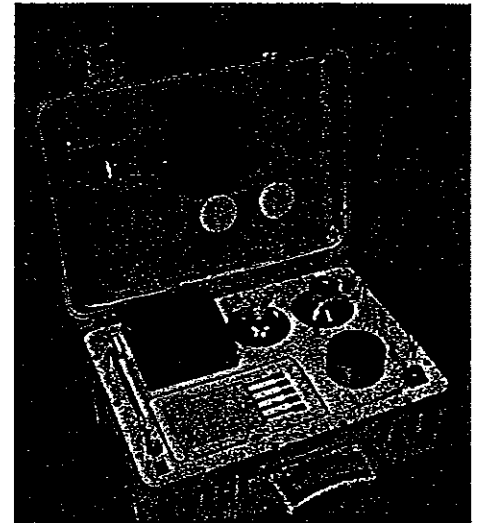


Figure 5.

Figure 6.

WASTEWATER PLANT TROUBLESHOOTING GUIDE

| TYPE OF INDUSTRIAL LOADING |          | BOD                          | COD | BOD/COD | AERATION BASIN D.O. | CLARIFIER SOLIDS FLUX |     |
|----------------------------|----------|------------------------------|-----|---------|---------------------|-----------------------|-----|
| ORGANIC                    | TOXIC    | ↓ (-)                        | ↑   | ↓       | ↑ (-)               | ↓                     |     |
|                            | NONTOXIC | ↑                            | ↑   | -       | ↓                   | ↑                     |     |
| INORGANIC                  | TOXIC    | O <sub>2</sub> CONSUMING     | (↓) | (↓)     | (↓)                 | (↓)                   |     |
|                            |          | NON O <sub>2</sub> CONSUMING | ↓   | -       | ↓                   | ↑                     | ↓   |
|                            | NONTOXIC | O <sub>2</sub> CONSUMING     | (↓) | (↓)     | (-)                 | (↓)                   | (-) |
|                            |          | NON O <sub>2</sub> CONSUMING | -   | -       | -                   | -                     | -   |



# NJWEA

the development of a website allows members to go on-line to access and share information.

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